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Muscle Fiber and Performance Adaptations to Resistance Exercise with MyoVive, Colostrum or Casein and Whey Supplementation

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To determine the effects of 12 weeks of resistance exercise with MyoVive™ and/or colostrum supplementation, 19 male and female recreationally weight-trained subjects (X ± SE; age = 28.3 ± 6.9 yrs; hgt = 68.2 ± 3.8 cm) were divided into MyoVive™ + colostrum (n = 4), MyoVive™ + casein & whey (n = 4), colostrum + casein & whey (n = 6), and casein & whey (n = 5) groups. All groups similarly increased (p < .05) 1 repetition maximum (RM) leg press (kg; pre = 158.6 ± 12.8, post = 189.3 ± 11.3), body mass (kg; pre = 79.0 ± 3.2, post = 80.7 ± 3.8), and lean body mass (kg; pre = 60.1 ± 3.1, post = 62.2 ± 2.8). Increases were observed for peak force (N; all loads), peak velocity ($m \cdot s^{-1}$; 70% & 40% 1 RM), and peak power (W; 70% & 40% 1 RM) for all groups for the leg press exercise, with no differences between groups. When performance data were adjusted for body mass, lean body mass, lower body lean mass as determined by DEXA, or % change, no group differences were observed. Relative (%) fiber type content, cross-sectional areas (μm^2), % fiber type areas, or % myosin heavy chain expression did not change for any group. These data suggest that MyoVive™ and colostrum supplementation have no greater effect on cellular and performance adaptations when compared to casein and whey protein.

Keywords strength, force, power, myosin heavy chain, mATPase, protein

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Introduction

Recent years have witnessed a meteoric increase in the use of dietary supplements as ergogenic aids for sport performance as well as body composition regulation (Bradley-Popovich, Stout, and Antonio 2001). Among the most popular are protein supplements, which are available in a variety of forms. Some of the most effective forms of dietary protein supplements are casein and whey, both derived from milk (Incledon and Antonio 2001). Whey protein is derived from the fluid portion of milk after the coagulated portion is removed. It consists of almost 25% of all milk proteins and provides high amounts the essential amino acids, which include the branched-chain amino acids (Smith 1976, Smithers, Ballard, Copeland et al. 1996). Whey protein is readily absorbed (Boirie, Dangin, Gachon et al. 1997), and may positively affect body composition and muscular performance (Lands, Grey, and Smountas 1999). Casein protein is precipitated from bovine milk sources and represents over 75% of all milk proteins (Incledon and Antonio 2001). It is readily absorbed, can increase circulating concentrations of amino acids, and enhances protein metabolism (Silk, Clark, Marrs et al. 1975; Jenkin, Yang, and Anderson 1979; Reecy, Williams, Kerley et al. 1996). Both of these forms of dietary protein are relatively inexpensive, compared to newer dietary supplements now being marketed.

Bovine colostrum recently has been touted as a superior form of supplemental protein. This readily absorbed source of protein is suggested to enhance lean body mass (Antonio, Sanders, and VanGammern 2001) and enhance physical performance (Brinkworth, Buckley, Bourdon et al. 2002; Buckley, Abbott, Brinkworth et al. 2002; Coombes, Conacher, Austen et al. 2002; Hofman, Smeets, Verlaan et al. 2002), although these data are equivocal. In addition, a potentially important ingredient of colostrum is insulin-like growth factor-1 (IGF-1) (Ginjala and Pakkanen 1998), and colostrum ingestion appears to elevate circulating concentrations of IGF-1 (Mero, Miikkulainen, Riski et al. 1997). It also has been reported to influence the immune system via cytokines (Bocci, von Bremen, Corradeschi et al. 1991) and to function as an antioxidant (Buescher and McIlhern 1988). Because colostrum is a critical source of dietary proteins for neonatals and has been shown to enhance protein synthesis in young pigs (Burrin, Shulman, Reeds et al. 1992), it has been surmised that this form of protein may be an excellent source of dietary protein for humans as well. One drawback to this product, however, is the relatively high cost.

MyoVive™ is a product that has received attention as a dietary supplement for patients with coronary arterial disease (Jeejeebhoy, Keith, Freeman et al. 2002). The ingredients, however, include several substances that may enhance skeletal muscle quantity or performance, or both, particularly creatine monohydrate (Nissen and Sharp 2003). As such, MyoVive™ has been marketed as a dietary supplement for the sport and exercise community. The safety and effectiveness of creatine supplementation for enhancing lean mass and muscular performance are well

documented (Bemben, Bemben, Loftiss et al. 2001; Nissen and Sharp 2003; Schilling, Stone, Utter et al. 2001). Furthermore, creatine supplementation combined with chronic resistance exercise has been shown to increase contractile protein synthesis and mRNA expression (Willoughby and Rosene 2001). Few data are available, however, as to the effectiveness of MyoVive™ for enhancing lean mass or muscular performance in humans.

It is well established that chronic resistance exercise in humans produces adaptations at the cellular and molecular levels (Staron, Karapondo, Kraemer et al. 1994; Staron, Malicky, Leonardi et al. 1990). As skeletal muscle is quite plastic, it is able to readily respond to current functional demands. For example, it has been proposed that fiber type classifications, based on myosin ATPase (mATPase) histochemistry, actually represent a continuum of fiber types that span the functional demands of the muscular system, as illustrated below (Staron and Johnson 1993).

$$I \leftrightarrow IC \leftrightarrow IIC \leftrightarrow IIAC \leftrightarrow IIA \leftrightarrow IIAB \leftrightarrow IIB$$

Fiber type transitions due to exercise tend to go in the direction from type IIB to type IIA, with little or no change to type I fibers, regardless of the modality of exercise (Staron and Johnson 1993). Myosin heavy chain (MHC) is one of the proteins that makes up the myosin filament, forms the cross bridge according to the sliding filament theory, and is the site of mATPase activity. The MHC isoform (I, IIa, or IIb) that the mature human skeletal muscle fiber contains has been shown to significantly correlate with the relative fiber type areas (I, IIA, or IIB; Fry, Allemeier, and Staron 1994). Furthermore, MHC isoform expression changes along with the fiber type transitions consequent to resistance training (Fry, Allemeier, and Staron 1994; Staron, Karapondo, Kraemer et al. 1994). The differing isoforms with their unique mATPase activity have been found to correlate with speed of contraction in both animals and humans, MHC I being the slowest and MHC IIb the fastest and most powerful (Bottinelli, Betto, Schiaffino et al. 1994; Trappe, Costill, and Thomas 2001). Because fibers containing predominantly MHC IIb are not well suited for consistent activity, current exercise literature suggests that these fibers convert to type IIA due to heavy resistance exercise (Fry, Allemeier, and Staron 1994; Staron and Johnson 1993; Staron, Karapondo, Kraemer et al. 1994).

Muscular performance consequent to a resistance exercise regimen often is assessed via tests of maximal muscular strength such as one repetition maximum (1 RM) for the trained exercises (Kraemer and Fry 1995). Recent pilot data from our laboratory suggested that assessments of muscular power (force x velocity) may be more sensitive measures than 1 RM strength (unpublished data). Because power is the product of both force and velocity, it is likely that these two variables also may be sensitive to a training protocol, although to a lesser extent.

The purpose of the present study, therefore, was to compare the effectiveness of MyoVive™ or colostrum dietary supplementation, or both, with more readily available forms of supplemental protein (i.e., casein and whey). Variables of inter-

est included body composition, muscular performance, and muscle fiber adaptations at the cellular and molecular levels.

Methods

Design

This study utilized a pre–post test design comparing four different groups. The intervention included a heavy resistance exercise program performed by all four groups. Independent variables were the supplements ingested during the 12-week period. A complete test battery was performed at the beginning and end of the study.

Subjects

Nineteen subjects (X ± SE; age = 28.3 ± 6.9 yrs; hgt = 68.2 ± 3.8 cm) were randomly divided into groups ingesting MyoVive™ + colostrum (Myo+Col; $n = 4$), MyoVive™ + control (Myo; $n = 4$), colostrum + control (Col; $n = 6$), and casein/whey only (control; C + W; $n = 5$). Subjects included both males ($n = 13$) and females ($n = 6$). All subjects signed an informed consent statement and completed a health history questionnaire, as approved by the Institutional Review Board. All subjects were currently performing regular resistance exercise training for both the upper and lower body.

Supplementation

Each subject orally ingested daily a dietary supplement for the 12-week duration of the study. Supplements were administered in a double-blind manner and contained isocaloric doses of one of the following: MyoVive™ (General Nutrition Centers, Pittsburgh, PA, U.S.) + Colostrum (Intact™) (Northfield Laboratories, Oakden, South Australia), MyoVive™ + control, Colostrum (Intact™) + control, and control supplement only. Casein and whey protein served as the control supplement. Subjects returned empty supplement packets to verify supplementation compliance. Supplement ingredients for each group are listed in Table 1.

Training Program

Each subject performed a heavy resistance exercise program 4 $d \cdot wk^{-1}$ for 12 weeks, using a 2-day split routine (2 d upper body, 2 d lower body). Exercises for all major muscle groups were included. Lower body sessions included leg press or barbell squat, leg extensions, and leg curls. Upper body sessions included bench press, shoulder press, bent-over rows, biceps curls, and triceps extensions. All subjects performed 4 sets x 8–10 repetitions using approximately 10 RM loads

Table 1
Ingredients of the Supplements Ingested by the Four Groups of Subjects

Nutrients		MyoVive™ + Colostrum (Intact™)	MyoVive™ + Casein & Whey	Colostrum (Intact™) + Casein Whey	Casein & Whey
Protein	Casein	7.5 g	43.5 g	7.5 g	43.5 g
	Whey	7.5 g	31.5 g	7.5 g	31.5 g
	Colostrum	60 g		60 g	
Carbohydrates	Lactose	1.525 g	1.525 g	1.525 g	1.525 g
	Sacharose	15.1 g	15.1 g	15.1 g	15.1 g
	Organic acids	0.9 g	0.9 g	0.9 g	0.9 g
	Others	0.2 g	0.2 g	0.2 g	0.2 g
Fats	Saturates	1.3 g	1.3 g	1.3 g	1.3 g
	Monousaturates	4.4 g	4.4 g	4.4 g	4.4 g
	Linoleic acid	1.73 g	1.73 g	1.73 g	1.73 g
	Alpha linolenic acid	0.37 g	0.37 g	0.37 g	0.37 g
Minerals	Na^+	108 mg	108 mg		
	K^+	750 mg	750 mg		
	Cl^-	203 mg	203 mg		
	Ca^{++}	315 mg	315 mg		
	P^+	183 mg	183 mg		
	Mg^+	20 mg	20 mg		
Trace elements	Fe	1 mg	1 mg		
	Zn	15 mg	15 mg		
	Cu	1.5 mg	1.5 mg		
	Mn	3.0 mg	3.0 mg		
	F	1.0 mg	1.0 mg		
	Mo	50 µg	50 µg		
	Se	50 µg	50 µg		
	Cr	33 µg	33 µg		
	I	100 µg	100 µg		
Vitamins	Vitamin A	668 µg RE	668 µg RE		
	Vitamin D	5 µg	5 µg		
	Vitamin E	538 mg a-TE	538 mg a-TE		
	Thiamin	25 mg	25 mg		
	Riboflavin	3.0 mg	3.0 mg		
	Niacin	20 mg NE	20 mg NE		
	Pantothenate	4.0 mg	4.0 mg		

(Continued)

Table 1 *(Continued)*

Nutrients		MyoVive™ + Colostrum (Intact™v)	MyoVive™ + Casein & Whey	Colostrum (Intact™) + Casein Whey	Casein & Whey
	Vitamin B-6	6.0 mg	6.0 mg		
	Folate	600 µg	600 µg		
	Vitamin B-12	3.0 µg	3.0 µg		
	Biotin	100 µg	100 µg		
	Vitamin C	250 mg	250 mg		
Other Nutrients	Carnitine	3 g	3 g		
	Choline	100 mg	100 mg		
	Creatine	3 g	3 g		
	Taurine	3 g	3 g		
	Coenzyme Q-10	50 mg	50 mg		

(70%–85% 1 RM). Interset rest intervals were approximately 2 min, and interexercise rest intervals were approximately 3 min. Because training was performed at numerous training sites, compliance with the program was verified by prior arrangement with supervisory personnel at each training site. Individual exercises were modified for some subjects due to equipment limitations at some training sites.

Body Composition

Body composition was determined using a calibrated Hologic 4500W dual energy X-ray absorptiometer (DEXA). A three-compartment model (bone, lean, fat) was used to determine total body and segmental body composition measures (i.e., mass, % fat, bone-free lean mass, and fat mass). Strength measures were adjusted for lower body mass and lower body bone-free lean mass, using the pelvis and right and left lower limb segments.

Muscular Performance

One repetition maximum (1 RM) performance was assessed for lower body strength using an AMF Hip Sled/Leg Press (Jefferson, IA, U.S.). The 1 RM test protocol has been described in detail by Kraemer and Fry (1995). Reliability for 1 RM testing in our laboratory has been established at $r > 0.94$ (unpublished data). A Fitrodyne dynamometer (Bratislava, Slovakia) was interfaced with an AMF Hip

Sled to determine peak force, peak velocity, and peak power during the leg press exercise (see Figure 1). Loads used were 100%, 70%, and 40% of each subject's 1 RM. The subjects were instructed to accelerate the weight as fast as possible. Wooden stops were attached to the track of the hip sled, based on each subject's height. These allowed the subjects to move the weight as fast as possible without the weight leaving their feet at the end of the range of motion. Reliability of the Fitrodyne dynamometer using inanimate objects has been established at CV = 1.4% for force (N) and 0.9% for velocity ($m \cdot s^{-1}$) (unpublished data).

Muscle Biopsies

Muscle biopsies (80–160 mg) were extracted from the vastus lateralis muscle, oriented in tragacanth gum, frozen in isopentane cooled by liquid nitrogen to –159° C, and stored at –80° C (Bergstrom 1962). To ensure adequate sample sizes, large pieces were obtained using the double-chop method combined with suction (Evans, Pinney, and Young 1982). The frozen biopsy samples were thawed to –20° C and serially sectioned for the determination of muscle protein content (40 µm thick sections) and fiber type composition (12 µm thick sections). A mean of 1,108 fibers were obtained for each biopsy.

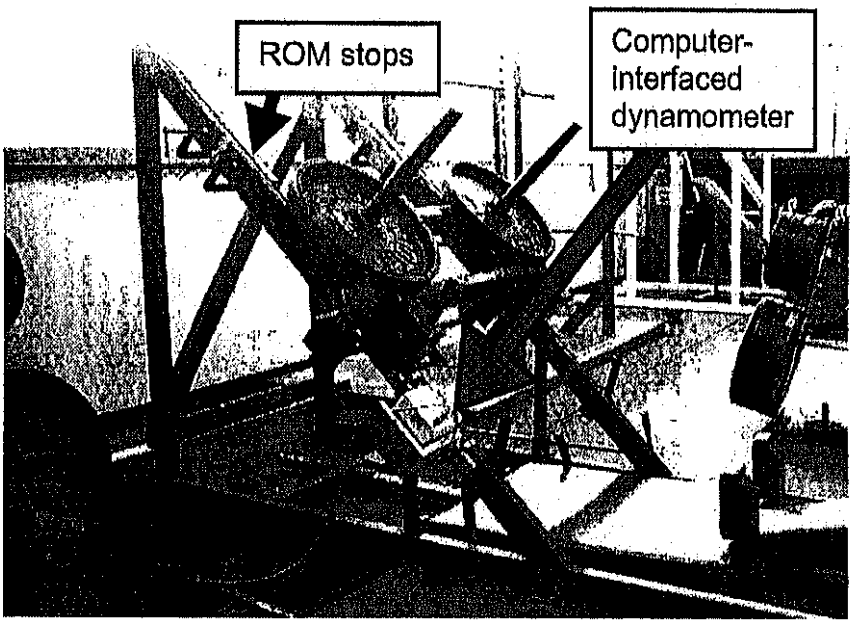

Figure 1. Hip sled interfaced with computerized dynamometer.

Fiber Type Distribution

Routine myofibrillar adenosine triphosphatase (mATPase) histochemical analysis using the methods of Brooke and Kaiser (1970) and modified for fiber subtype analyses (Staron and Hikida 1992) were performed using preincubation pH values of 4.3, 4.6, and 10.2 to determine the muscle fiber type distribution. Although seven fiber types (I, IC, IIC, IIAC, IIA, IIAB, and IIB) can be distinguished based on their staining intensities, due to the small number of some of the hybrid fibers, types IIC and IIAC were grouped together. A composite hard copy image of each mATPase preparation (preincubation at pH 4.6) was made using the NIH Image software. These were used in combination with the other histochemical preparations (preincubation pH values of 4.3 and 10.6) to determine fiber type percentages and total fiber number in each biopsy. The present study utilized the fiber type classification originally developed for humans, as has been previously suggested (Staron 1997).

Percentage Fiber Type Area

The cross-sectional areas of at least 50 fibers per major type (I, IIA, and IIB) per biopsy were determined by the use of public-domain NIH software (McCall, Byrnes, Dickson et al. 1998). Although seven fiber types may be distinguished, the "hybrid" fiber types (IC, IIC, IIAC, and IIAB) comprise such a small percentage of the total muscle fibers that it is not possible to identify 50 of these fibers in a typical biopsy sample (Staron and Hikida 1992). As such, fiber types areas were determined for only the major fiber types (i.e., I, IIA, and IIB).

Myosin Heavy Chain Analysis

Myosin heavy chain (MHC) analysis was performed using SDS-polyacrylamide gel electrophoresis (SDS-PAGE). This protocol is based on the procedures of Carraro and Cantani (1983), and Perrie and Bumford (1986). Briefly, 3–5 serial cross-sections (40 μm thick) from each biopsy were placed in 0.5–1.0 mL of a lysing buffer containing 10% (w/v) glycerol, 5% (v/v) b-mercaptoethanol, and 2.3% (w/v) sodium dodecylsulfate (SDS) in 62.5 mM Tris/HCl buffer (pH 6.8) and heated for 10 min at 60°C. Small amounts of the extracts (3–5 μL) were loaded on 4%–8% gradient SDS polyacrylamide gels with 4% stacking gels (12), run overnight (19–21 hr) at 120 V and stained with Coomasie blue. MHC isoforms were identified according to their apparent molecular masses compared with those of marker proteins and migration patterns from single fiber analysis. Relative MHC content (%) was determined by densitometric scanning of the resulting gels using NIH Image software. The resulting scans were further analyzed using Peakfit software.

Statistical Analyses

Results are reported as X ± SE. Mixed model analyses of variance were used to determine differences between groups and across time. Significance for this investigation was $p < 0.05$. Where appropriate, effect sizes were analyzed to account for potentially important results that were not significant due to low statistical power (Cohen 1977; Vincent 1995; Wilson, Becker, Tinker 1995).

Results

Tables 2–7 list the physical characteristics, muscle performance, and muscle fiber data. All groups exhibited significant increases in body mass and lean body mass, with no differences between the group responses. In general, all groups improved muscle force, velocity, and power due to the training program. No between-group differences were observed (i.e., interactions). Furthermore, when performances were adjusted for lower body mass or lower body bone-free lean mass, no between-group differences were observed. There were no significant changes for any of the fiber or protein variables, and no differences were reported between groups. In addition, when the data were calculated as relative changes (% D), th results were identical (data not shown).

Discussion

The primary results of this study suggest that supplementation with either MyoVive™, colostrum, or both, do not augment resistance training-induced ad-

Table 2
Physical Characteristics (Mean ± SE)

Variable	Test	Myo + Col	Myo + C&W	Col + C&W	Cas + Whey
Body mass (kg)	Pre	70.2 ± 7.1	80.6 ± 7.1	82.8 ± 5.8	80.4 ± 6.3
	Post*	73.2 ± 7.1	81.1 ± 7.1	84.5 ± 5.8	81.7 ± 6.3
Lean body mass	Pre	54.1 ± 7.2	59.2 ± 7.2	63.2 ± 5.9	62.0 ± 6.5
	Post*	59.3 ± 6.5	60.0 ± 6.5	64.5 ± 5.3	63.6 ± 5.8
Percent fat (%)	Pre	15.9 ± 4.7	22.9 ± 4.7	19.8 ± 3.9	19.9 ± 4.2
	Post	15.8 ± 4.2	22.6 ± 4.2	19.9 ± 3.4	19.1 ± 3.8

Note: Myo + Col = MyoVive™ + colostrum group ($n = 4$), Myo + C&W = MyoVive™ + casein & whey group ($n = 4$), Col + C&W = bovine colostrum + casein & whey group ($n = 6$), and Cas + Whey = casein & whey only group ($n = 5$). * sig. main effect ($p < 0.05$)

Table 3
Leg Press Performances (Mean ± SE)

Variable	Load	Test	Myo + Col	Myo + C&W	Col + C&W	Cas + Whey
1 RM (kg)		Pre	138.3 ± 25.6	125.5 ± 25.6	185.8 ± 20.9	166.0 ± 22.9
		Post*	170.3 ± 26.0	179.5 ± 26.0	204.5 ± 21.2	194.2 ± 23.3
Peak force (N)	100%	Pre	1071.6 ± 260.2	984.0 ± 225.3	1495.7 ± 201.5	1278.5 ± 225.3
		Post*	1234.0 ± 257.6	1346.6 ± 223.1	1541.5 ± 199.5	1422.2 ± 223.1
	70%	Pre	758.5 ± 260.9	731.2 ± 184.5	1105.0 ± 165.0	941.1 ± 184.5
		Post*	1057.6 ± 272.1	1072.6 ± 192.4	1218.7 ± 172.1	1213.8 ± 192.4
	40%	Pre	496.3 ± 183.3	429.9 ± 129.6	726.5 ± 105.8	660.5 ± 129.6
		Post*	734.4 ± 186.7	683.2 ± 132.0	753.8 ± 107.8	827.2 ± 132.0
Peak velocity ($cm \cdot s^{-1}$)	100%	Pre	47.7 ± 7.2	50.5 ± 6.3	52.8 ± 5.6	45.8 ± 6.3
		Post	44.8 ± 8.8	41.5 ± 7.6	35.1 ± 6.8	50.0 ± 7.6
	70%	Pre	70.8 ± 17.8	77.2 ± 12.6	73.3 ± 11.2	82.9 ± 12.6
		Post*	89.9 ± 11.3	100.6 ± 8.0	85.6 ± 7.1	102.8 ± 8.0

	40%	Pre	63.6 ± 19.2	99.0 ± 13.6	115.3 ± 11.1	110.8 ± 13.6
		Post*	135.7 ± 29.8	132.0 ± 21.1	97.8 ± 17.2	165.0 ± 21.1
Peak power (W)	100%	Pre	529.1 ± 173.2	527.3 ± 150.0	799.2 ± 134.2	609.3 ± 150.0
		Post	573.8 ± 195.3	615.9 ± 169.1	553.9 ± 151.3	699.5 ± 169.1
	70%	Pre	502.0 ± 359.4	599.3 ± 254.1	897.1 ± 227.3	784.6 ± 254.1
		Post*	918.7 ± 332.9	1076.0 ± 235.4	1052.5 ± 210.5	1311.5 ± 235.4
	40%	Pre	346.8 ± 297.7	426.3 ± 210.5	880.4 ± 171.9	782.1 ± 210.5
		Post*	979.5 ± 415.0	894.4 ± 293.4	777.4 ± 239.6	1454.6 ± 293.4

Note: Myo + Col = MyoVive™ + colostrum group ($n = 4$), Myo + C&W = MyoVive™ + casein & whey group ($n = 4$), Col + C&W = bovine colostrum + casein & whey group ($n = 6$), and Cas + Whey = casein & whey only group ($n = 5$). Load = % one repetition maximum (1 RM). * sig. main effect ($p < 0.05$)

Table 4
Relative mATPase Fiber Types (%; Mean ± SE)

Fiber Type	Test	Myo + Col	Myo + C&W	Col + C&W	Cas + Whey
Type I	Pre	46.8 ± 7.0	58.7 ± 7.7	51.1 ± 6.2	50.8 ± 4.5
	Post	44.9 ± 5.1	53.5 ± 10.0	46.2 ± 5.0	45.0 ± 3.7
Type IC	Pre	0.7 ± 0.6	0.3 ± 0.2	0.7 ± 0.3	0.3 ± 0.1
	Post	1.9 ± 0.6	0.9 ± 0.7	1.3 ± 0.4	0.9 ± 0.4
Type IIC/AC	Pre	2.8 ± 0.6	0.7 ± 0.4	0.6 ± 0.3	0.2 ± 0.1
	Post	1.9 ± 0.9	0.1 ± 0.1	2.6 ± 1.1	0.4 ± 0.2
Type IIA	Pre	35.7 ± 10.9	26.0 ± 4.0	23.8 ± 4.2	30.2 ± 1.7
	Post	34.5 ± 5.1	30.9 ± 9.0	30.2 ± 5.8	36.3 ± 4.1
Type IIAB	Pre	3.7 ± 1.8	6.8 ± 3.3	11.0 ± 1.6	9.0 ± 1.2
	Post	7.0 ± 2.5	8.4 ± 3.4	8.1 ± 2.5	7.5 ± 1.3
Type IIB	Pre	10.2 ± 4.5	7.5 ± 4.4	12.8 ± 4.3	9.5 ± 2.5
	Post	9.8 ± 3.3	6.2 ± 3.1	11.6 ± 2.4	9.9 ± 3.1

Note: Myo + Col = MyoVive™ + colostrum group ($n = 4$), Myo + C&W = MyoVive™ + casein & whey group ($n = 4$), Col + C&W = bovine colostrum + casein & whey group ($n = 6$), and Cas + Whey = casein & whey only group ($n = 5$). No sig. differences ($p > 0.05$)

aptations beyond those attained with casein and whey protein supplementation. This appears to be the case for either body composition (see Table 2), muscular performance (see Table 3), or cellular and molecular adaptations (see Tables 4–7). The effectiveness of the training program is evident based on the significant main effect increase over time for body mass and bone-free lean body mass (see Table 2), and for most of the kinetic variables (i.e., force, velocity, and power; see Table 3). The efficacy of the readily absorbed (Boirie, Dangin, Gachon et al. 1997) casein and whey protein supplementation for enhancing muscular performance (Lands, Gray, and Smountas 1999), increasing circulating concentrations of amino acids, and positively influencing protein metabolism (Jenkin, Yang, and Anderson 1979; Reecy, Williams, Kerley et al. 1996; Silk, Clark, Marrs et al. 1975) has been reported in the literature. Due to their cost and effectiveness, casein and whey protein supplements are readily available commercially.

Colostrum supplementation has been suggested as an ergogenic supplement based on several physiological mechanisms. Colostrum has been reported to enhance protein synthesis (Burrin, Shulman, Reeds et al. 1992) and increase lean

Table 5
Muscle Fiber Cross-Sectional Areas for the Major Fiber Types (μm^2; Mean ± SE)

Fiber Type	Test	Myo + Col	Myo + C&W	Col + C&W	Cas + Whey
Type I	Pre	4000 ± 681	4319 ± 357	4243 ± 695	5069 ± 431
	Post	4044 ± 263	5244 ± 576	4676 ± 557	4820 ± 421
Type IIA	Pre	5037 ± 842	6161 ± 961	5428 ± 802	7908 ± 1042
	Post	5293 ± 770	6790 ± 1308	6588 ± 529	7688 ± 789
Type IIB	Pre	3875 ± 824	3355 ± 317	4012 ± 689	6019 ± 665
	Post	2952 ± 1009	3799 ± 1147	5171 ± 321	5271 ± 697

Note: Myo + Col = MyoVive™ + colostrum group ($n = 4$), Myo + C&W = MyoVive™ + casein & whey group ($n = 4$), Col + C&W = bovine colostrum + casein & whey group ($n = 6$), and Cas + Whey = casein & whey only group ($n = 5$). No sig. differences ($p > 0.05$)

body mass (Antonio, Sanders, and VanGammern 2001). Several mechanisms are possible for these effects, including elevating circulating concentrations of IGF-1 (Mero, Miikkulainen, Riski et al. 1997), altering immune system function via cytokines (Bocci, von Bremen, Corradeschi et al. 1991), and acting as an antioxidant (Buescher and Mellhern 1988). None of these variables was measured in the present study, but the apparent lack of a greater training effect due to colostrum ingestion suggests that none of these mechanisms was a contributing factor. Additionally, no performance measures appeared to be influenced by the colostrum supplementation. Although some previous research suggests an ergogenic effect of colostrum supplementation (Brinkworth, Buckley, Bourdon et al. 2002; Buckley, Abbott, Brinkworth et al. 2002; Coombes, Conacher, Austen et al. 2002; Hofman, Smeets, Verlaan et al. 2002), the most common result suggested is enhanced recovery, perhaps due to an augmented lactate buffering mechanism (Brinkworth, Buckley, Bourdon et al. 2002; Buckley, Abbott, Brinkworth et al. 2002; Coombes, Conacher, Austen et al. 2002). Although none of the performance measures used in the present study was dependent on buffering capabilities, it was possible that enhanced recovery could have affected the training sessions, resulting in a greater training effect. The present data, however, do not support this scenario.

To the authors' knowledge, no previous studies have examined the effect of MyoVive™ supplementation on skeletal muscle responses to chronic resistance exercise. Data exist suggesting a beneficial effect on myocardial function (Jeejeebhoy, Keith, Freeman et al. 2002), possibly due to the effects of several ingredients critical to aerobic metabolism (see Table 1). Perhaps the most likely ergogenic ingredient in MyoVive™ is creatine monohydrate (Bemben, Bemben,

Table 6
Relative Fiber Type Areas for the Major Fiber Types (%; mean ± SE)

Fiber Type	Test	Myo + Col	Myo + C&W	Col + C&W	Cas + Whey
Type I	Pre	49.5 ± 9.0	57.9 ± 5.2	53.6 ± 6.8	47.1 ± 3.2
	Post	46.3 ± 5.6	56.5 ± 9.8	44.9 ± 5.8	40.0 ± 3.5
Type IIA	Pre	41.3 ± 11.0	36.3 ± 5.4	33.4 ± 6.1	42.8 ± 2.1
	Post	44.5 ± 4.9	39.7 ± 9.7	41.6 ± 6.7	50.5 ± 4.5
Type IIB	Pre	9.2 ± 3.3	5.8 ± 3.2	13.0 ± 4.7	10.1 ± 2.5
	Post	9.2 ± 3.1	3.8 ± 2.1	13.5 ± 3.2	9.4 ± 3.0

Notes: Myo + Col = MyoVive™ + colostrum group ($n = 4$), Myo + C&W = MyoVive™ + casein & whey group ($n = 4$), Col + C&W = bovine colostrum + casein & whey group ($n = 6$), and Cas + Whey = casein & whey only group ($n = 5$). No sig. differences ($p > 0.05$)

Loftiss et al. 2001; Nissen and Sharp 2003). Although creatine monohydrate has been associated with increased protein synthesis and mRNA (Willoughby and Rosene 2001), increased lean mass (Bemben, Bemben, Loftiss et al. 2001; Nissen and Sharp 2003), and enhanced muscular performance (Bemben, Bemben, Loftiss et al. 2001; Nissen and Sharp 2003), such results are equivocal. It is possible that the dosage in the present study was not adequate for an ergogenic effect, but previous use of such a dosing strategy suggests this should not be the case (Nissen and Sharp 2003). It is possible that the training program was inadequate to produce the desired effect of creatine, but the fact that all the subject groups exhibited strength and mass improvements suggests this is not the case.

Muscular performances were improved during the 12-week training program for all subjects. Because approximately 10 RM loads were used for training (approximately 70%–85% 1 RM), one might expect that the greatest improvements would be observed for the 70% 1 RM load tests. The present data, however, suggest that peak force, velocity, and power also were increased for 40% 1 RM loads, and peak velocity and power were increased for 100% 1 RM loads. As has been recently suggested, it appears that although improvements are typically specific to training loads and velocities, this relationship is not absolute, and training effects carry over somewhat to other velocities and loads (Cronin, McNair, and Marshall 2002). Additionally, it has been reported recently that supervised resistance training sessions result in greater strength and body composition improvements when compared with those training in an unsupervised environment (Mazetti, Kraemer, Volek et al. 2000). As such, it is possible that none of the subjects in the present study achieved optimal improvements in the measured variables. It is now apparent that future research must address this concern.

Table 7
Relative Myosin Heavy Chain (MHC) Expression (%; Mean ± SE)

MHC Isoform	Test	Myo + Col	Myo + C&W	Col + C&W	Cas + Whey
MHC I	Pre	35.3 ± 6.9	51.2 ± 6.9	41.8 ± 5.6	48.0 ± 6.1
	Post	41.8 ± 6.8	48.6 ± 6.8	36.2 ± 5.6	50.2 ± 6.1
MHC IIa	Pre	53.8 ± 5.6	37.7 ± 5.6	45.3 ± 4.6	40.5 ± 5.1
	Post	45.2 ± 6.3	39.6 ± 6.3	50.7 ± 5.1	39.5 ± 5.6
MHC IIb	Pre	10.9 ± 2.6	11.1 ± 2.6	12.7 ± 2.1	10.5 ± 2.3
	Post	13.0 ± 2.8	11.8 ± 2.8	13.1 ± 2.2	10.3 ± 2.5

Note: Myo + Col = MyoVive™ + colostrum group ($n = 4$), Myo + C&W = MyoVive™ + casein & whey group ($n = 4$), Col + C&W = bovine colostrum + casein & whey group ($n = 6$), and Cas + Whey = casein & whey only group ($n = 5$). No sig. differences ($p > 0.05$)

The muscle fiber and MHC data indicate no differential effect of any of the supplements in conjunction with a 12-week resistance exercise program. Untrained men and women beginning a structured resistance exercise program typically exhibit a transition from type IIB to IIA fiber types, an increase in fiber cross-sectional areas, as well as a protein expression shift from MHC IIb to IIa (Fry, Allemeier, and Staron 1994; Staron and Johnson 1993; Staron, Karapondo, Kraemer et al. 1994; Staron, Malicky, Leonardi et al. 1990). Elite competitive weightlifters and power lifters, on the other hand, actually exhibit little or no type IIB fibers or MHC IIb (Fry, Staron, Hagerman et al. in press; Fry, Webber, Weiss et al. in press). Although bone-free lean mass increased for all groups in the present study, such hypertrophy was not evident at the cellular level. It is possible that the enhanced lean mass was due to an increased intracellular fluid component, which has been suggested as a mechanism of adaptation for creatine, but such a response has not been suggested for the other supplements used. It also is possible that much of the increase in lean mass occurred in the upper body, whereas the biopsies were simply indicative of adaptations of the lower body.

Another important consideration is that the present study included both men and women in all subject groups. Gender differences for absolute strength are well documented, although the differences disappear or greatly diminish when adjusted for lean mass (Staron, Karapondo, Kraemer et al. 1994). Although it has been reported that there is no gender difference in the % fiber types, there may be a

gender difference in the sizes of the various fiber types (Staron, Hagerman, Hikida et al. 2000). Several factors must be considered here. First, when fiber data were reported as % change scores, thus examining relative changes, no group differences were observed (data not reported). Such a treatment of the data would reduce or eliminate the effect of gender differences. And second, when performance data were adjusted for body mass or bone-free lean mass, no group differences were observed (data not reported). Thus, no matter how the data were treated, no differential effects of supplementation were observed. As a further precaution due to the group sample sizes, effect sizes were calculated for all comparisons (Cohen 1977; Vincent 1995; Wilson, Becker, and Tinker 1995), resulting in only small effect sizes.

In total, the results of the present study suggest that any ergogenic effect of MyoVive™ or colostrum supplementation is not different from that of casein and whey protein supplementation. As such, within the scope of the present study, these data do not support supplementing with either MyoVive™ or colostrum in replacement of casein and whey protein supplementation. Further study would be necessary to more clearly determine the role of training status and the acute training variables (i.e., choice of exercise, order of exercise, volume, intensity, and interset rest intervals).

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