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The effect of bovine colostrum supplementation in older adults during resistance training

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Running Head: Colostrum and resistance training

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Abstract

Bovine colostrum is the first milk secreted by cows after parturition and has high levels of protein, immunoglobulins, and various growth factors. We determined the effects of 8 weeks of bovine colostrum supplementation versus whey protein during resistance training in older adults. Males (N = 15, 59.1±5.4y) and females (N=25, 59.0±6.7y) randomly received (double blind) 60g/d of colostrum or whey protein complex (containing 38g protein) while participating in a resistance training program (12 exercises, 3 sets of 8-12 reps, 3d/wk). Strength (bench press and leg press 1-RM), body composition (by dual energy X-ray absorptiometry), muscle thickness of the biceps and quadriceps (by ultrasound), cognitive function (by questionnaire), plasma insulin-like growth factor-1 (IGF-1) and C-reactive protein (CRP, as a marker of inflammation), and urinary N-telopeptides (Ntx, a marker of bone resorption) were determined before and after the intervention. Participants on colostrum increased leg press strength (24±29 kg; $p<0.01$) to a greater extent than participants on whey protein (8±16 kg) and had a greater reduction in Ntx compared to participants on whey protein (-15±40% vs. 10±42%; $p<0.05$). Bench press strength, muscle thickness, lean tissue mass, bone mineral content, and cognitive scores increased over time ($p<0.05$) with no difference between groups. There were no changes in IGF-1 or CRP. Colostrum supplementation during resistance training was beneficial for increasing leg press strength and reducing bone resorption in older adults. Both colostrum and whey protein groups improved upper body strength, muscle thickness, lean tissue mass, and cognitive function. Clincaltrials.gov identifier: NCT01792297

Keywords: muscle, bone, inflammation, cognitive function, IGF-1

Introduction

Skeletal muscle is lost after approximately the age of 50y, potentially leading to sarcopenia and loss of muscle strength and function (International Working Group on Sarcopenia, 2011; Roubenoff, 2003). Muscle loss may be related to a decrease in anabolic hormones and/or increased catabolism driven by inflammation (Roubenoff, 2003; Visser et al., 2002). Older muscle is more sensitive to damage via less effective anti-oxidant systems leading to an altered response of satellite cells in regeneration of damaged muscle (Degens, 2010; Thalacker-Mercer, Dell'Italia, Cui, Cross, & Bamman, 2010). This response is linked to differential expression of skeletal muscle specific genes, with up-regulation of transcripts related to stress, inflammation, and protein degradation, and down-regulation of some transcripts related to protein synthesis in old versus young muscle (Degens, 2010; Thalacker-Mercer et al., 2010). Chronic low-grade systematic inflammation is the main factor contributing to the attenuated hypertrophic response of older muscle to strength training (Degens, 2010) and plays an important role in the development of disability (Visser et al., 2002). Increased inflammation associated with aging diminishes the efficacy of insulin-like growth factor-1 (IGF-1), an anabolic hormone responsible for muscle hypertrophy and regeneration (Degens, 2010) and therefore inflammation is associated with lower muscle mass and strength in older adults (Visser et al., 2002). Insulin-like growth factor-1 is also important for development of brain and bone tissue and reduction in IGF-1 in older adults is associated with cognitive decline (Ceda et al., 2005), and lower bone mass (Ohlsson et al., 2011).

Bovine colostrum is, by definition, the first milk secreted by cows immediately following parturition (Larson, Heary, & Devery, 1980). Bovine colostrum contains essential amino acids and peptide components including whey and casein, and many bioactive components such as

lactoferrin, immunoglobulins, and various growth factors (Klagsbrun & Neumann, 1979; Korhonen, 1977; Larson et al., 1980). Insulin-like growth factor-1 (IGF-1) is the most abundant and well-characterized growth factor in bovine colostrum and is homologous to human IGF-1 (Francis, Upton, Ballard, & McNeil, 1988; Marcotty, Frankenne, van Beeumen, Maghuin-Rogister, & Hennen, 1991). Bioactive components of colostrum are known to stimulate DNA synthesis, protein synthesis, and cellular growth in neonatal and newborn animals (Burrin et al., 1997; Francis et al., 1988) but it is unclear whether this anabolic effect applies to adult humans.

Bovine colostrum increases anti-inflammatory cytokines (Shing, Peake, Suzuki, Jenkins, & Coombes, 2007). Athletes have used bovine colostrum as a nutritional supplement during training to reduce upper respiratory tract infection, although no effects on either saliva or plasma immunoglobulin levels were found (Brinkworth & Buckley, 2003; Crooks, Cross, Wall, & Ali, 2010); however, respiratory tract symptoms, often experienced during periods of heavy training, may actually result from inflammation rather than suppressed immune function (Bachert, van Kempen, Höpken, Holtappels, & Wagenmann, 2001). Exercise training with bovine colostrum supplementation is also beneficial for improving exercise performance (Buckley, Brinkworth, & Abbott, 2003; Hofman, Smeets, Verlaan, v.d. Lugt, & Verstappen, 2002) and increasing lean tissue mass (Antonio et al., 2001), but the effects on strength remain unclear (Shing, Hunter, & Stevenson, 2009). It is possible beneficial effects of bovine colostrum during exercise training may be from decreased inflammation.

The purpose of this study was to determine the effect of bovine colostrum supplementation during a resistance training program on inflammatory status, serum IGF-1 levels, lean tissue mass, strength, cognitive function, and bone turnover in men and women 50y and older. It was hypothesized that bovine colostrum supplementation during resistance training

would prevent inflammation, increase IGF-1 levels, lean tissue mass, strength, and cognitive function, and reduce bone turnover.

Methods

Participants

Forty participants (15 males 59.1 ± 5.4 y; 25 females, 59.0 ± 6.7 y) were recruited via an advertisement in a local newspaper. The sample size was based on studies of young individuals where change in lean tissue mass with bovine colostrum supplementation was 1.5-2 kg compared to 0-1.2 kg with whey protein with a standard deviation for this change of 0.5 to 1.0 kg (Antonio et al., 2001; Kerksick et al., 2007), an alpha of 0.05 and power of 0.8. This sample size calculation indicated 10 participants per group (i.e. 20 in total) were required. The sample size was doubled because older individuals have greater variability in their physiological measurements (i.e. muscle mass and strength) compared to younger individuals (Candow & Chilibeck, 2005). The study was approved by The University of Saskatchewan's Research Ethics Board and participants gave informed consent for the study. Participants completed the Physical Activity Readiness Questionnaire (Thomas, Reading, & Shephard, 1992) prior to baseline testing to ensure there were no contra-indications to exercise participation.

Intervention

After completion of baseline testing (described below) participants were randomly assigned, by use of a computerized random number generator, to either bovine colostrum (N = 12 females, 7 males) treatment or the control group (whey protein; N = 13 females, 8 males). The study was double blinded: researchers, participants, and all individuals conducting outcome assessments were unaware of group assignments. Both groups were provided a 4 kg container

and consumed 3 doses of 20g per day (60g/day total) colostrum or whey protein complex (containing about 38g of protein per 60g of complex) measured with a scoop provided. This dose was chosen because it is effective in young individuals for increasing lean tissue mass (Antonio et al., 2001; Kerksick et al., 2007). The bovine colostrum used in this study was a heat-treated spray-dried >25% IgG commercially available product (trade-named Eterna Gold™ manufactured and marketed by the Saskatoon Colostrum Co. Ltd., Saskatoon, Canada). The product is derived from first day post partum excess colostrum collected from Canadian dairy cows and is licensed by Health Canada as a natural health product for immune system and athletic support (Natural Health Product Number 80035324; full details on the product can be viewed at: http://www.saskatooncolostrum.com/english/Article/Details/4779_Eterna-Gold--Colostrum-For-People.html). Whey protein was used as the placebo because it matches bovine colostrum for protein content but does not have substantial effects on muscle size and strength or bone resorption in older adults (Candow, Chilibeck, Facci, Abeysekara, & Zello, 2006). The whey placebo was purchased commercially from Cereal By Products Co., Mt. Prospect, Illinois and was selected to match to the colostrum in overall nutritional composition (Table 1). The composition of the bovine colostrum and whey protein supplements was verified by an independent laboratory (SunWest Food Laboratory Ltd., Saskatoon SK, Canada). On exercise days participants were instructed to take one dose within 30 minutes before and another dose within 30 minutes after their exercise session with a third dose at their discretion; on non-exercise days all doses were taken at the participant's discretion. Participants mixed supplement with liquid of choice (e.g. water, juice, or milk) in a provided blender. All participants were assigned a full body resistance program of 12 machine-based exercises. Participants were required to attend an orientation session to be familiarized with the machines and exercises prior

to starting their program. Following orientation, participants were instructed to complete three sets of 8-12 repetitions (working to fatigue) for each exercise, under supervision on three separate days, again for familiarization with the exercises and to reduce any "learning" effects prior to strength testing. Participants were then tested for 1-RM strength. The exercise intervention was conducted three non-consecutive days per week and included three sets of 8-12 repetitions on Lever machines (Pulse Fitness Systems; Winnipeg, Manitoba, Canada) (with exception of abdominal crunches) for the following exercises: bench press, iso-lateral lat pulldown, shoulder press, biceps curl, triceps extension, leg press, leg flexion and extension, back extension, and hip adduction and abduction. All sets were performed to fatigue and resistance was progressively increased once a participant could complete 12 repetitions with good form. All exercise sessions were supervised by Canadian Society for Exercise Physiology-Certified Exercise Physiologists to ensure proper form and resistance; this ensured compliance to each prescribed exercise and the appropriate sets and repetitions. In addition to tracking workouts and recording supplement compliance in logs, participants were required to sign an attendance sheet at each visit. Adverse events during the study were recorded on adverse event forms.

Following the intervention participants were asked which supplement they thought they were receiving (to test if blinding was effective) and asked to return remaining supplement to be weighed as confirmation of supplement compliance.

Outcome Measures

All variables were assessed at baseline and after the eight-week intervention. Variables assessed included muscle thickness of the elbow flexors and knee extensors by ultrasound, IGF-

1, and C-reactive protein (CRP; as a marker of inflammation) from blood samples, urinary cross-linked N-telopeptides of Type 1 collagen (i.e. Ntx; bone resorption), body composition by dual energy X-ray absorptiometry (DXA), strength by determination of 1-repitition maximum (1-RM) on bench press and leg press, and cognitive function with the Telephone Interview of Cognitive Status (TICS; de Jager, Budge, & Clarke, 2003) questionnaire. Strength testing was always done last so as not to influence muscle thickness or body composition testing because of muscle swelling. Measurement techniques are described in detail below.

Body Composition. Body composition was assessed with DXA in array mode (QDR Discovery Wi, Hologic, Inc., Bedford, Md.) using QDR software for Windows XP (QDR Discovery). Lean tissue mass, fat mass, and bone mineral content were assessed from whole-body scans. The coefficients of variation for these measurements are 0.5%, 3%, and 0.5% respectively (Chilibeck et al., 2013).

Strength. Strength (1-RM) was assessed during the bench press and leg press exercises, which were chosen as representative exercises for upper- and lower-body strength. We have previously described these assessments elsewhere (Chrusch, Chilibeck, Chad, Davison, & Burke, 2001). The coefficients of variation for these measurements are 3.0% and 3.6% for leg press and bench press, respectively (Chrusch et al., 2001).

Muscle Thickness. Ultrasound was used to assess muscle thickness of the elbow flexors and knee extensors of the dominant limb prior to 1RM testing. We have described these methods in detail elsewhere (Farthing & Chilibeck, 2003; Candow & Chilibeck, 2005). The coefficients of variation (CVs) for muscle thickness measurements are 2.5% for elbow flexors and 2.1% for knee extensors (Candow & Chilibeck, 2005).

Serum Assessment. Blood samples were drawn from an anticubital vein, centrifuged and plasma harvested and separated into aliquots, which were frozen at -80 degrees C. Samples were thawed and analyzed for: a) IGF-1 using ELISA (Enzo Life Sciences) (intra-assay CV = 3.6%) and b) CRP as a marker of inflammation using ELISA (ALPCO Diagnostics) (intra-assay CV = 3.8%). Samples from all time points for each individual were analyzed in the same assay to eliminate between-assay variability.

Bone Resorption. Participants were instructed to collect 24-hour urine samples as previously described (Pinkoski et al., 2006). Baseline urine collection was completed prior to starting the study and post-intervention urine collection was completed in the 3 days after the exercise intervention. Participants continued consuming the supplement during these 3 days. Alcohol and intense exercise was prohibited during the 24 hours of collection and the 24 hours prior. Returned urine containers were measured for urine volume, and aliquots were removed and frozen at -80 degrees C prior to being thawed and analyzed in duplicate within the same assay by ELISA (Osteomark NTx test, Ostex International, Inc., Seattle, WA) (intra-assay CV = 6.7%) for bone resorption via Ntx. The concentration of Ntx in urine samples [expressed as bone collagen equivalents (BCE)] was corrected for urinary creatinine and multiplied by 24-h urine volume to produce a value for daily Ntx excretion relative to daily creatinine excretion. Creatinine was assessed by a commercially available colorimetric kit (Cayman Chemical Co., Ann Arbor, MI) (intra-assay CV = 6.0%). The concentration was multiplied by 24-hr urine volume to determine the amount excreted over 24 hr.

Cognitive Function. Cognitive function was assessed via the TICS (de Jager et al., 2003) questionnaire, administered in person. TICS assesses four domains: a) orientation, b) registration, recent memory and delayed recall (memory), c) attention and calculation, and d)

semantic memory, comprehension and repetition (language). TICS was originally developed as a dementia screen, but is useful for tracking cognitive function over time (de Jager et al., 2003).

Diet and Physical Activity Monitoring

Participants completed the Godin Leisure-Time Exercise Questionnaire (Godin & Shephard, 1985) during baseline testing and at the end of the intervention, and were asked to include only physical activities outside of the intervention. Participants were told at the start of the study not to change their diets substantially during the study. Participants were given two 3-day food logs; one to be completed prior to starting the supplement and one during the last week of the intervention to ensure diets remained consistent throughout the intervention. Food logs were entered and analyzed via United States Department of Agriculture Center for Nutrition Policy and Promotion (USDA, Alexandria, VA) online food tracker SuperTracker.

Data Analysis

An independent t-test was used to assess baseline characteristics and to compare compliance between groups. Repeated-measures ANOVA with within-factor defined as time and between-factors defined as gender and group was used to assess all dependent variables. The following assumptions were tested and met: a) independence of observations, b) normality, and c) sphericity. All analyses were done using IBM SPSS (Statistics version 20, Chicago). To ensure statistical results for the leg press strength measurement were not due to differences between baseline means, we also ran an analysis of covariance for this variable, testing for differences between groups at 8 weeks, using baseline strength as a covariate. Analysis was done on an intent-to-treat basis. Results are expressed as means and standard deviations. Significance was accepted when $p \leq 0.05$.

Results

Baseline characteristics were not significantly different between groups. Participants in the colostrum group were on average 78.6±17.6 kg, 171±7 cm, and 61.8 ±4.8 y as compared to participants in the whey group who were on average 74.0±19.2 kg, 169±9 cm, and 57.5 ± 6.3 y.

Compliance and Blinding. One female participant from the whey group withdrew due to personal reasons and was lost to follow-up. Two participants from the whey group discontinued use of supplement due to gastrointestinal reflux the investigators classified as "definitely" related to the supplement, but continued with the exercise training. Exercise and supplement compliance was not significantly different between groups. Participants in the colostrum group were 86 ± 20% compliant to the exercise and 97 ± 12% compliant to the supplement compared to participants in the whey group who were 84 ± 21% compliant to the exercise and 88 ± 23% compliant to the supplement. Thirty-seven percent of the participants in the colostrum group and 25% of participants in the whey protein group correctly guessed their group assignment.

Gender Differences. As expected, there were several gender-based effects. Males had greater leg press and bench press strength, IGF-1 levels, bone mineral content, lean tissue mass, elbow flexors and knee extensors muscle thickness, and kcal, protein, and carbohydrate intake compared to females ($p<0.05$). Males had lower percent body fat and cognitive scores compared to females ($p<0.01$).

Body Composition. Over time, there was a significant increase in lean tissue mass ($p<0.001$) and bone mineral content ($p=0.012$) and a significant decrease in percent fat ($p<0.01$) with no differences between groups (Table 2). There were no significant changes in fat mass (Table 2).

Strength. There was a significant group by time interaction for leg press strength, with strength increasing more in the colostrum group than the whey protein group ($p = 0.026$; Figure 1).

Baseline and post-intervention strength measures for the colostrum group were 121 ± 40 and 145 ± 53 kg, and for the whey protein group were 143 ± 51 kg and 151 ± 58 kg. An analysis of covariance with baseline leg press strength as the covariate indicated that adjusted means at the end of the intervention were significantly greater in the colostrum compared to the whey protein group (165 ± 5 kg vs. 149 ± 5 kg; p=0.045). There were no differences for changes in bench press strength between groups (Figure 2). There was a significant time main effect for bench press strength ($p < 0.001$) with the colostrum group increasing from 57 ± 31 to 69 ± 35 kg and the whey protein group increasing from 63 ± 37 to 79 ± 46 kg. There was a gender by time interaction for leg press and bench press strength, ($p < 0.05$), with males increasing more than females (data not shown).

Muscle Size. Muscle thickness of the knee extensors and elbow flexors increased over time ($p<0.001$) with no difference between groups (Table 2).

Serum & Urine Measurements. There was a group by time interaction for urinary Ntx, with the colostrum group decreasing more than the whey protein group ($p = 0.024$; Table 2). There were no differences between groups over time, nor were there any time main effects for levels of CRP and IGF-1 (Table 2).

Questionnaires. There was a significant increase in cognitive function over time ($p = 0.015$) with no differences between groups (Table 2). There were no significant differences over time or between groups for leisure time physical activity (Table 2).

Nutrition. Both groups decreased dietary protein intake (excluding the nutritional supplement) over time ($p = 0.047$) (Table 3). There were no differences between groups over time for any nutritional variables (Table 3).

Adverse Events. Five participants reported adverse events related to gastrointestinal problems. Two participants consuming colostrum reported adverse events classified as 'mild' in severity included bloating, nausea, diarrhea, and unsettled stomach. The researchers classified the adverse events as either 'probable' or 'possible'. The two participants continued taking the colostrum supplement for the remainder of the study; however one reduced the dosage. The other three adverse events were also related to gastrointestinal problems in participants consuming whey. Two of these three adverse events were classified as 'moderate' in severity (gastro esophageal reflux). These adverse events were considered "definitely" related to the supplement based on cessation of symptoms upon stopping the supplement and reappearance of the adverse event upon re-introduction. Both participants discontinued the supplement. The other participant's adverse event was 'mild' in severity (nausea), and considered 'possibly' related to the supplement. This participant continued taking the supplement.

Discussion

The present study is the first to examine the effects of bovine colostrum supplementation during a resistance training program in older adults. Colostrum supplementation promoted greater increases in leg press strength than did whey protein. Colostrum supplementation also reduced bone resorption compared to whey protein. Both colostrum and whey protein supplemented groups significantly increased bench press strength, muscle size, cognitive function, lean tissue mass, and bone mineral content over time. Males had greater baseline values for most outcome measures, which was to be expected and is supported by previous studies (Chilibeck, Stride, Farthing, & Burke, 2004). Despite this, male and female participants

298 responded equally to the supplementation (i.e. there were no supplement group x gender x time
299 interactions).

300 The increase in leg press strength associated with colostrum supplementation is
301 important because older adults lose strength in the lower body to a greater extent than in the
302 upper body (Candow & Chilibeck, 2005; IWGS, 2011). The group supplemented with colostrum
303 increased leg press strength by about 21% whereas the group supplemented with whey protein
304 had a non-significant increase in leg press strength of about 5%. The increase in the colostrum
305 group might be clinically significant because a 20% decline in leg press strength with aging is
306 associated with increased functional limitations (Brill, Macera, Davis, Blair, & Gordon, 2000).
307 The mechanism for the greater increase in leg press strength in the colostrum group is unclear
308 because the groups did not differ in changes in lean tissue mass or knee extensor muscle
309 thickness. A possible explanation as to the lack of increase in leg press strength in the whey
310 group is they had slightly (but not statistically) higher baseline strength and therefore may have
311 been closer to their physiological ceiling and had less room for improvement. The greater
312 increase in leg press strength in the colostrum group could be due to statistical error (i.e. type I
313 error with multiple statistical tests). Both groups increased equally in bench press strength. Males
314 increased leg press and bench press strength more than females; this is supported by previous
315 studies (Chilibeck et al., 2004). Further research is needed to determine if there is a true increase
316 in strength due to colostrum supplementation or whether other factors such as an increase in
317 muscle quality may be responsible for the apparent increase in strength.

318 The participants receiving bovine colostrum had a greater decrease in bone resorption
319 (assessed by urinary Ntx) compared to participants consuming whey protein. This suggests
320 bovine colostrum might have benefits for bone health. Previously Brinkworth, Buckley,

Slavotinek, & Kurmis (2004) showed a trend (p=0.06) toward a greater increase in bone cross-sectional area in the trained upper arm of participants supplemented with colostrum compared to whey protein for eight weeks. A number of studies using animal models have also suggested a positive effect of bovine colostrum on bone. Supplementation with proteins extracted from bovine colostrum (i.e. osteopontin, lactoferrin, epidural growth factor, and IGF-2) increased mineral density, micro-architectural properties, and mechanical strength of bones from ovariectomized rats (a model for postmenopausal osteoporosis), and reduced markers of bone resorption and increased markers of bone formation in serum (Du et al., 2011; Hou, Xue, & Lin, 2012). Bovine colostrum or proteins derived from colostrum (i.e. lactoferrin) increase the proliferation of osteoblasts (i.e. cells involved in bone formation) and the release of growth factors from osteoblasts derived from rats (Lee et al., 2008; Nakajima et al., 2011), and bovine colostrum reduces activity of osteoclasts (i.e. cells involved in bone resorption) derived from rabbits (Vidal, van den Broek, Lorget, & Donnet-Hughes, 2004).

Bovine colostrum contains substantial amounts of IGF-1 (Marcotty et al., 1991). IGF-1 is the major mediator of growth hormone (GH) and is linked to muscle hypertrophy (Allen & Boxhorn, 1989). Participants in this study had no increase in serum IGF-1 levels with colostrum supplementation. While Mero et al. (2002) showed that levels of plasma IGF-1 increased after 2 weeks of bovine colostrum supplementation and training in male and female athletes, most other studies have shown levels of plasma IGF-1 did not increase after bovine colostrum supplementation and training (Buckley et al., 2003; Buckley, Abbott, Brinkworth, & Whyte, 2002; Shing et al., 2009). It is theorized that the increase in IGF-1 in the Mero et al. (2002) study may have been transient due to the short supplementation period, whereas studies that have longer supplementation periods may allow enough time for the body to facilitate a negative

feedback and return the plasma concentrations to normal (Buckley et al., 2003). It should also be noted that Mero et al. (2002) used carbohydrate as a control; whereas other studies used protein as a control. This may also account for differences in IGF-1 responses between studies.

We found no significant differences between colostrum and whey protein groups for changes in systemic inflammation (i.e. C-reactive protein). Similarly Crooks et al. (2010) found no significant differences in C-reactive protein after 10 weeks of daily 50g supplementation of either colostrum or skim-milk powder during intense swim training (both in water and on-land).

It was hypothesized that bovine colostrum would improve cognitive function in older adults by increasing IGF-1 levels. There was an increase in cognitive function over time for both groups. This indicates the exercise training itself may have increased cognitive function. Physical activity is well known to enhance cognitive function (Forte et al., 2013) and reduce risk of cognitive decline and dementia (de Bruijn et al., 2013). It is also possible that there was a learning effect with our specific cognitive test, as participants may have strategized for the word recall portion of the TICS questionnaire administered at the end of the intervention.

The decrease in protein intake over time for both groups is likely due to participants compensating for the additional protein provided by the supplement by reducing protein consumption elsewhere in their diet. As the food logs analyzed did not include the supplement, the post values for protein consumption do not include the 38 grams of protein provided by the colostrum or the whey.

Conclusion

Bovine colostrum may have benefits over whey protein for increasing lower body strength and reducing bone resorption in older adults but had no effect beyond those seen with whey supplementation and resistance training on measurements of upper body strength, IGF-1,

inflammation, or body composition. Our finding that short-term colostrum supplementation decreased bone resorption compared to whey protein suggests that the long-term effects of bovine colostrum on clinically relevant measures of bone health (i.e. hip or lumbar spine bone mineral density) should be investigated.

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525

526 **Figure Captions**

527

528 Figure 1. Change in leg press strength for colostrum and whey-protein treatment groups. Data are

529 means and SD. *Difference between the colostrum vs. the whey protein group ($p<0.05$).

530

531 Figure 2. Change in bench press strength for colostrum and whey-protein groups. Data are means

532 and SD. *Time main effect ($p<0.05$).

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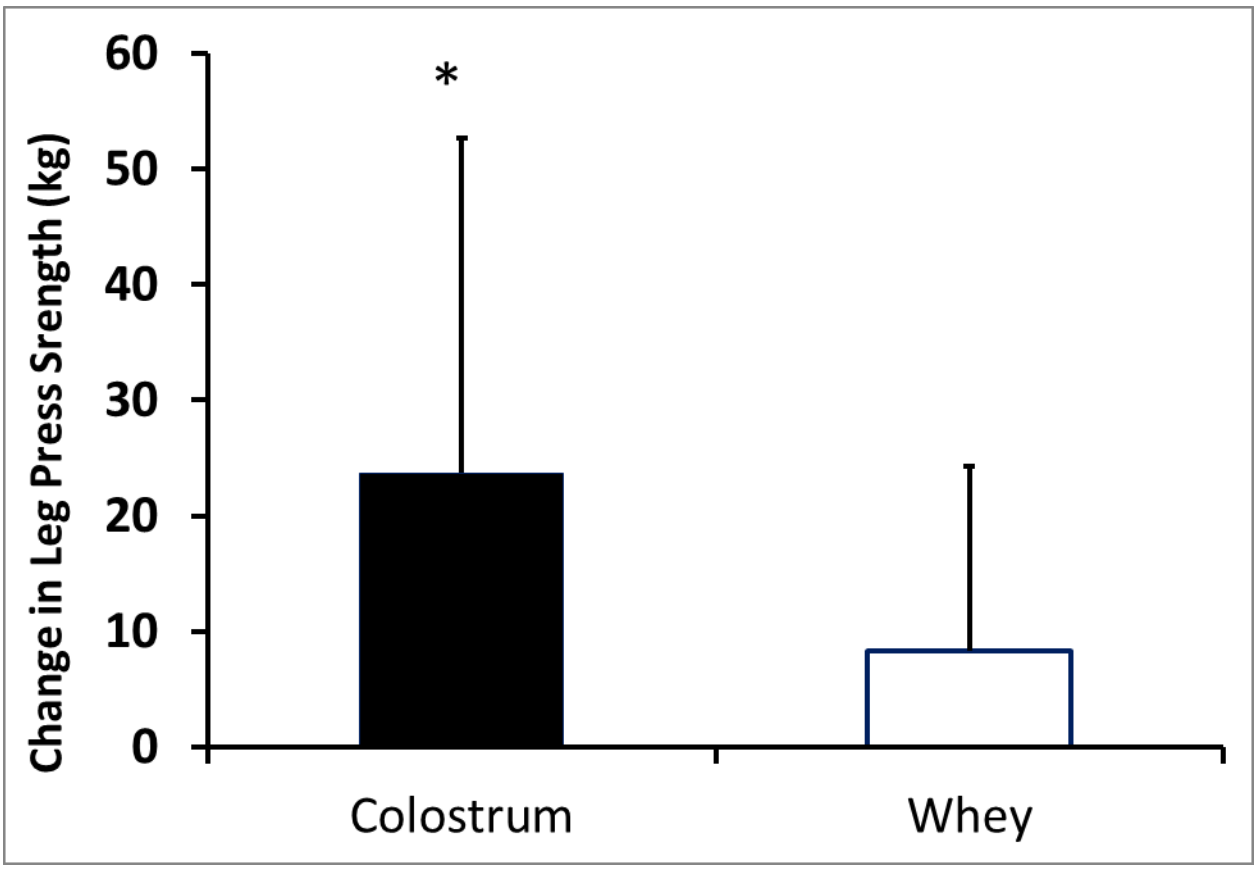
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Change in Leg Press Srength (kg)
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Colostrum
Whey

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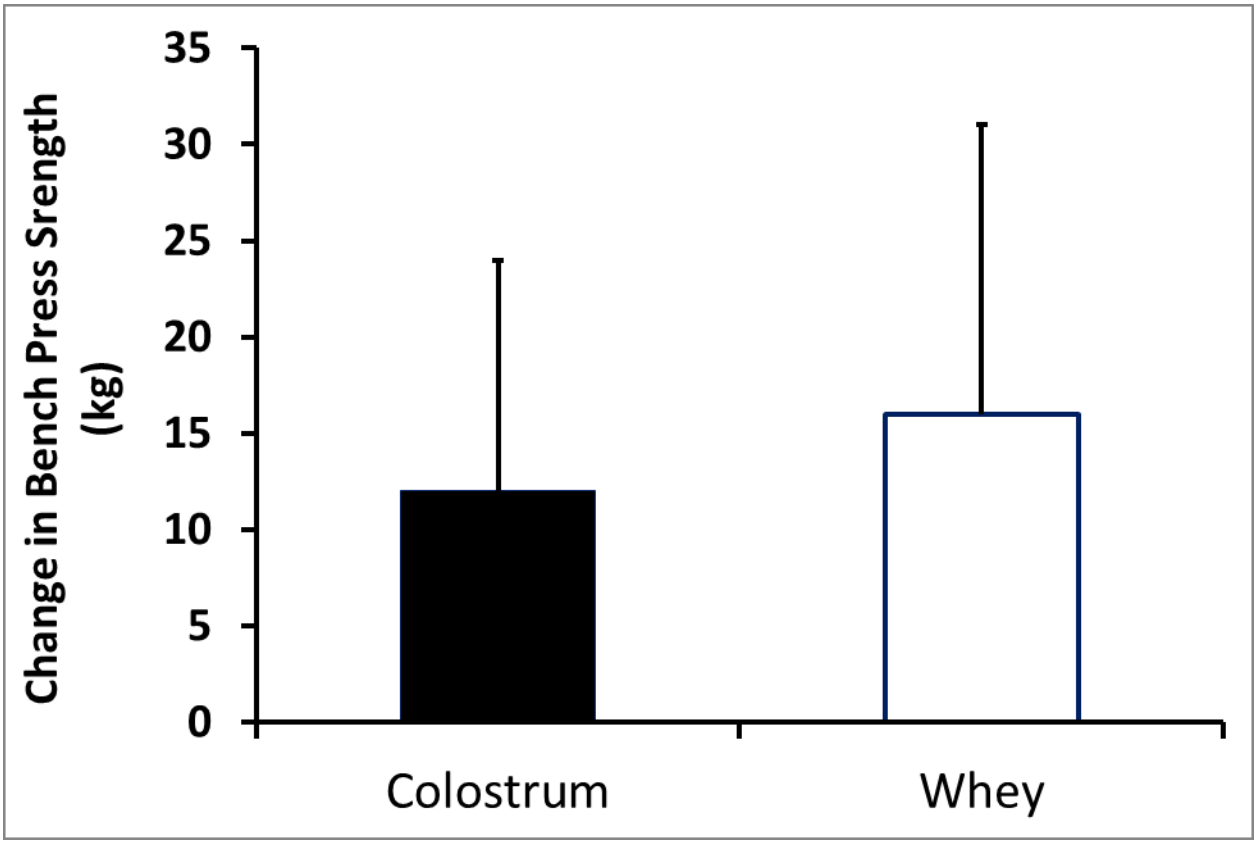
Change in Bench Press Srength (kg)
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Colostrum
Whey

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Table 1

Colostrum versus Whey Nutritional Breakdown

	Colostrum	Whey
Crude Protein (%)	62.4	64.6
Crude Fat (%)	13.9	14.7
Carbohydrates (g/100g)	13.5	12.5
Calories/100g	429	441

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Table 2

Body Composition, Muscle Thickness, Serum, Urine, Leisure Time Activity and Cognitive Function Results

	Colostrum		Whey	
	Baseline	Post	Baseline	Post
BMC (kg)*	2.44 ± 0.39	2.47 ± 0.40	2.41 ± 0.59	2.42 ± 0.61
Fat mass (kg)	27.5 ± 13.0	27.4 ± 13.1	25.0 ± 9.3	24.8 ± 9.0
Lean tissue mass (kg)*	47.8 ± 9.4	48.5 ± 9.0	46.3 ± 12.7	46.8 ± 12.8
Total mass (kg)	77.7 ± 18.0	78.4 ± 17.5	73.7 ± 19.3	74.1 ± 19.1
Fat (%)*	34.1 ± 10.5	33.7 ± 10.6	33.7 ± 7.9	33.3 ± 7.8
Biceps (cm)*	2.64 ± 0.75	2.91 ± 0.76	2.54 ± 0.59	2.81 ± 0.65
Quadriceps (cm)*	2.73 ± 0.53	2.95 ± 0.65	2.57 ± 0.47	2.78 ± 0.53
CRP (mg/l)	2.3 ± 2.6	2.4 ± 3.2	2.1 ± 2.9	2.5 ± 3.5
IGF-1 (ng/ml)	155.3 ± 35.4	156.1 ± 36.1	162.3 ± 44.1	159.0 ± 42.0
Ntx (nmol BCE/mmol Crn)	1085 ± 585	770 ± 359**	1074 ± 614	1172 ± 762
LTEQ	29 ± 30	29 ± 25	33 ± 22	29 ± 21
TICS*	28 ± 2	29 ± 2	28 ±3	30 ± 4

Data are means ± standard deviation; BMC = bone mineral content; CRP = C-reactive protein; IGF-1 = Insulin-like growth factor-1, Ntx = cross-linked n-telopeptides of type I collagen; BCE = bone collagen equivalents; Crn= creatinine; TICS = Telephone Interview of Cognitive Status

*Time main effect ($p<0.05$).

**The change in the colostrum group was greater than the whey protein group ($p<0.05$)

551 Table 3

552 *Nutrition*

	Colostrum		Whey	
	Baseline	Post	Baseline	Post
Calories (g/day)	2001 ± 472	1886 ± 292	1726 ± 506	1673 ± 522
Fat (g/day)	68 ± 20	67 ± 18	62 ± 24	58 ± 32
Carbohydrates (g/day)	256 ± 68	234 ± 44	215 ± 53	212 ± 59
Protein (g/day) without supplement *	85 ± 20	81 ± 23	73 ± 22	63 ± 21
Protein (g/day) with supplement		119 ± 23		98 ± 31
Protein (g/kg) without supplement	1.16 ± 0.44	1.08 ± 0.38	0.91 ± 0.39	0.79 ± 0.36
Protein (g/kg) with supplement		1.59 ± 0.47		1.34 ± 0.36

553

554 Data are means ±standard deviations

555 *Time main effect ($p<0.05$)

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