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Effects of Fat-Free and 2% Chocolate Milk on Strength and Body Composition Following Resistance Training

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by

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ABSTRACT

Nutrition and recovery go hand in hand. After a resistance training workout, it is extremely important for athletes to rebuild and refuel their bodies with the proper nourishment to obtain maximal results. In doing so, they consume different recovery aids or ergogenic aids for gains in muscle mass, an aid in hydration, and a speedy recovery. Ergogenic aids can include many things (i.e., improved equipment, training program), but one of the most popular types of ergogenic aids is nutritional supplements such as protein, carbohydrates, creatine, and vitamins. A nutritional supplement that has recently grown in popularity is chocolate milk. Currently, no studies exist comparing the effects of fat-free chocolate milk and 2% chocolate milk on muscular strength and body composition in collegiate softball players. The purpose of this study will be to determine the effects of fat-free and 2% chocolate milk ingestion on body composition and muscular strength following eight weeks of resistance training. In a randomized (matched according to strength and bodyweight), double blind experimental design, 18 female, collegiate softball players (18.5 ± .7 yrs; 65.7 ± 1.8 inches; 156.2 ± 21.6 lbs) ingested either fat-free chocolate milk or 2% chocolate milk immediately after resistance exercise workouts for an 8-week period. Dependent variables included body fat percentage, lean muscle mass, bench press 1RM, and leg press 1RM. Data was analyzed via a paired samples t-test (to detect difference across both groups over the 8-week training period) and an independent samples t-test (to detect differences between the groups) using SPSS for Windows 15.0. No statistically significant differences were found in bench press strength, leg press strength, body fat %, and lean body mass between the fat-free group and the 2% chocolate milk group. The major finding of this study is that there is no difference between fat-free chocolate milk and 2% chocolate milk in regards to body fat percentage, lean body mass, bench press maximal strength, and leg press maximal strength following an eight week exercise program where the chocolate milk was ingested immediately after each workout. However, there was a significant difference in both groups combined after the eight week training program. Therefore, from a practical sense, consumption of either fat-free chocolate milk or 2% chocolate milk in conjunction with a periodized resistance training program does improve exercise performance in regards to maximal strength as well as improvements in body fat percentage and lean body mass.

Chapter One

Introduction

Nutrition and recovery go hand in hand. After a resistance training workout, it is extremely important for athletes to rebuild and refuel their bodies with the proper nourishment to obtain maximal results. In doing so, they consume different recovery aids or ergogenic aids for gains in muscle mass, an aid in hydration, and a speedy recovery. Ergogenic aids can include many things (i.e., improved equipment, training program), but one of the most popular types of ergogenic aids is nutritional supplements such as protein, carbohydrates, creatine, and vitamins. A nutritional supplement that has recently grown in popularity is chocolate milk. But does the consumption of milk after a resistance training session promote improvements in muscle growth? After an exhaustive workout the body is in a state of stress and it needs nourishment. Specifically, the physiologically post-exercise environment may include [1]:

- dehydration
- low blood insulin levels
- cortisol and other catabolic hormones are elevated
- suppressed immune system
- reduced muscle and liver glycogen or a depletion of glycogen
- muscle is in a catabolic state with increased proteolysis

Purpose of the Study

There is no information on the response of strength and body composition changes in female athletes following resistance training in which 2% chocolate milk and fat-free chocolate milk are ingested post-resistance exercise. Therefore, the purpose of the present study was to determine if fat-free chocolate milk or 2% chocolate milk had beneficial recovery effects post resistance exercise resulting in improvements in muscular strength and body composition.

Independent and Dependent Variables

The independent variables were 16 oz. NESQUIK fat-free chocolate milk containing 320 calories, 0 grams of fat, 64 grams of carbohydrates, and 16 grams of protein. Also used as an independent variable was a 16 oz. NESQUIK reduced fat 2% chocolate milk containing 380 calories, 10 grams of fat, 58 grams of carbohydrates, and 16 grams of protein. Dependent variables will include:

- Body composition (as measured via skin folds)
- Upper body strength (measured via bench press 1RM)
- Lower body strength (measured via leg press 1RM)

Hypotheses

Ho_1: There will be no difference between the fat-free chocolate milk group and the whole chocolate milk group in maximal bench press strength.

Ho_2: There will be no difference between the fat-free chocolate milk group and the whole chocolate milk group in maximal leg press strength.

Ho_3: There will be no difference between the fat-free chocolate milk group and the whole chocolate milk group in body fat percentage

Ho_4: There will be no difference between the fat-free chocolate milk group and the whole chocolate milk group in lean body mass.

Chapter Two

Review of Literature

Low-fat milk is becoming very popular among athletes as a recovery aid after exercise performance. Whitney [2] describes the two main proteins that are found in milk: casein and whey. These proteins are both considered high quality proteins [3]. In relation to hydration after exercise, research has shown that low-fat milk is a better rehydration drink as compared to water and a commercially available sports drink [4]. Research has also shown that milk beverages, both low-fat milk and whole milk, when consumed soon after resistance exercise, can lead to enhanced improvements in protein metabolism following resistance exercise [5]. When comparing fat-free milk vs. soy, the milk-based proteins promote muscle protein accretion to a greater extent than do soy-based proteins when consumed after resistance exercise [6, 7]. The consumption of either milk or soy protein with resistance training promotes muscle mass maintenance and gains, but chronic consumption of milk proteins after resistance exercise likely supports a more rapid lean mass accrual [6].

Low-Fat Milk and Rehydration

Low-fat milk has shown to be as effective, if not more effective, than commercially available sports drinks as a rehydration beverage. Shirreffs et al. [4] looked at low-fat milk restoring whole-body net fluid balance following mild exercise-induced dehydration in eleven healthy volunteers. The response to milk was compared to water, a commercially available sports drink, and milk with additional NaCl. Twenty minutes after the end of exercise (consisting of a series of ten minutes of cycle exercises), one of the four drinks was ingested. The drink volume consumed was equal to 150% of the volume of the body mass lost during exercise and was provided in four equal boluses at 15min intervals, giving a total drinking time of 60 minutes. Results suggested low-fat milk was effective in replacing sweat loss and maintaining euhydration by more than 2% than that of water and the commercial sports drink following exercise-induced dehydration. It is likely that the presence of sodium along with a relatively large quantity of potassium (approximately 45mmol/l) in milk accounts for the effectiveness of milk at restoring fluid balance following exercise-induced dehydration. The naturally high electrolyte content of milk (Na 38mmol/l; K 45mmol/l; Cl 35mmol/l) aided in the retention of fluid and the maintenance of euhydration 4 hours after the end of drinking, although differences in gastric emptying rates due to the presence of protein and fat in the milk cannot be discounted.

Low-Fat Milk and Resistance Exercise

Resistance exercise characterized by repeated high intensity contractions of varying muscle groups lead to well characterized adaptations in muscles [8]. One of the most obvious adaptations resulting from resistance exercise is skeletal muscle hypertrophy. For muscle hypertrophy to occur there must be an increase in muscle protein net balance. Muscle protein balance is a function of muscle protein synthesis and muscle protein breakdown. Thus, for an increase in net balance to occur, there must be an increase in protein synthesis, a decrease in muscle protein break-down or simultaneous increase in synthesis and decrease in break down. Over the last decade there has been considerable investigation into the influence of various factors that influence the protein metabolism response to resistance exercise. Resistance exercise alone results in both an increase in protein synthesis and protein breakdown. The increase in synthesis is greater than the increase in breakdown, resulting in a less negative net balance [9]. Interestingly, Phillips et al. [9] demonstrated a less negative protein balance following resistance exercise, but the net balance was still negative since participants were in a fasted state. These observations emphasize the importance of supplying macronutrients for influencing protein metabolism following exercise. Several studies have documented the provision of macro-nutrients soon after resistance exercise in an attempt to optimize the protein metabolic response. Intake of amino acids, [10] protein, [11] carbohydrates, [12,13] or mixed macronutrient compounds, [14,15,16] contribute to enhanced protein metabolism following resistance exercise. This work has documented that the protein-related metabolic response following resistance exercise can be influenced through the nutritional intake of the main macronutrient constituents of low-fat milk; protein and carbohydrates. Follow-up studies have directly investigated the impact of milk consumption on the acute protein metabolic response following resistance exercise. Elliot and colleagues investigated the influence of consuming differing milk beverages on the protein metabolic response following an acute bout of resistance exercise [5]. They compared the influence of non-fat milk (237 g), whole milk (237 g) and an amount of non-fat milk with the same amount of energy (kJ) as the whole milk condition (393 g) following a bout of leg resistance exercise. They assessed amino acid net balance across the exercise leg for 5 hours following the leg resistance exercise. All of the different milk beverages resulted in a significant increase in net balance of the measured amino acids.

This study did not determine what contributed to the change in net balance (change in synthesis, change in breakdown, or both), however, the evidence did show that protein metabolism was enhanced with a single bolus intake of milk after the resistance exercise. Therefore, it is reasonable to hypothesize that milk beverages, when consumed soon after resistance exercise, can lead to enhanced improvements in protein metabolism following resistance exercise. Such acute increases in protein net balance and synthesis could possibly enhance the more chronic adaptations that occur with resistance training. Based on the acute changes in protein metabolism with milk consumption following resistance exercise, a number of questions arise [15]. First, what would be the application of this information over the long term and secondly, how can this be applied to athletes who are training on a regular basis. Recent research has addressed the long term influence of milk consumption after resistance training. The first study to investigate the interaction of resistance training and milk consumption over a more prolonged period compared the effects of 3 days per week (for 10 weeks) of progressive resistance training with consumption of either low-fat chocolate milk (5 kcal/kg bodyweight) (composition described in table 1) or a commercially available carbohydrate and electrolyte beverage (5kcal/kg body weight) within 5 min of completing each workout [17]. The post-exercise beverages contained the same amount of energy, but varied in macronutrient composition. The training resulted in improvements in strength and body composition, however all of these changes where similar between the two groups. Essentially, no differences were observed for any of the measured variables when the group that consumed milk post exercise was compared to the group that consumed the commercial sports drink. However, there was an interesting trend for the milk group to have a greater increase in fat-free soft tissue mass. The milk group gained 1.6 ± 0.4 kg of fat-free soft tissue mass, while the carbohydrate electrolyte beverage group only gained 0.8 ± 0.5 kg of fat-free soft tissue mass. This was the first study to look at the long-term interaction of milk consumption and resistance training [16].

Fat-Free Milk vs. Soy Following Resistance Exercise

Hartman et al. [6] investigated the acute consumption of fat-free fluid milk and soy protein after resistance exercise and reported that there was a greater positive protein balance with the milk ingestion as compared to the soy protein. Participants were 56 healthy young men who trained 5 days/week for 12 weeks on a rotating split-body resistance exercise program in a parallel 3-group longitudinal design. Subjects were randomly assigned to consume drinks immediately and again 1 h after exercise: fat-free milk (n=18); fat-free soy protein (n=19) that was isoenergetic, isonitrogenous, and macronutrient ratio matched to milk; or maltodextrin that was isoenergetic with milk and soy (control group; $n = 19$). Muscle fiber size, maximal strength, and body composition by dual-energy X-ray absorptiometry (DXA) were measured before and after training. No between-group differences were seen in strength. Type II muscle fiber area increased in all groups with training, but there were significantly greater increases observed in the milk group as compared to the soy and control groups. Type I muscle fiber area increased after training only in the milk and soy groups, with the increase in the Milk group demonstrating significantly greater increases than the control group. DXA-measured fat- and bone-free mass significantly increased in all groups, with the milk group demonstrating significantly greater increases than the control group. Results also showed chronic post exercise consumption of milk promotes greater hypertrophy during the early stages of resistance training in novice weightlifters when compared with isoenergetic soy or carbohydrate consumption. In a similar study, Wilkinson and colleagues [7] concluded that the consumption of fluid skim milk promotes greater muscle protein accretion after resistance exercise than does the consumption of an isonitrogenous and isoenergetic soy-protein beverage. Eight healthy men performed two trials in random order separated by a week. On each trial day, the participants received either a soy or milk beverage (18g protein) after a unilateral resistance exercise bout. Results showed that ingestion of both soy and milk resulted in a positive net protein balance. Analysis of area under the net balance curves indicated an overall greater net balance after milk ingestion. The fractional synthesis rate in muscle was also greater after milk consumption than after soy consumption. The milk-based proteins promote muscle protein accretion to a greater extent than do soy-based proteins when consumed after resistance exercise. The consumption of either milk or soy protein with resistance training promotes muscle mass maintenance and gains, but chronic consumption of milk proteins after resistance exercise likely supports a more rapid lean mass accrual.

Chocolate Milk as a Post-Exercise Recovery Aid

Karp and coworkers [18] looked at chocolate milk as a post-exercise recovery aid. Nine male, endurance-trained cyclists performed an interval workout followed by four hours of recovery, and then underwent a subsequent endurance trial to exhaustion at 70% VO2max, on three separate days in which three separate beverages were ingested. Immediately following the first exercise bout and 2 h of recovery, subjects drank isovolumic amounts of chocolate milk, a fluid replacement drink, or carbohydrate replacement drink, in a single-blind, randomized design. Carbohydrate content was equivalent for chocolate milk and the carbohydrate replacement drink. Time to exhaustion, average heart rate, rating of perceived exertion, and total work for the endurance exercise were compared between trials. Time to exhaustion and total work were significantly greater for chocolate milk and fluid replacement trials compared to carbohydrate replacement trials. The results of this study suggest that chocolate milk is an effective recovery aid between two exhausting exercise bouts.

In a study of 13 male college players, Gilson et al. [19] looked at the effects of chocolate milk consumption on markers of muscle recovery during intensified soccer training. The college soccer players participated in "normal" training for one week, and then were given low-fat chocolate milk or a high-carbohydrate recovery beverage daily after intense training for four days. After a two week break, the athletes went through a second round of "normal" training, followed by four-day intensified training to compare their recovery experiences following each beverage (with the same amount of calories). Prior to the intense training, at day two and at the completion of this double-blind study, the researchers conducted specific tests to evaluate markers of muscle recovery (i.e., serum creatine kinase). All of the athletes increased their daily training times during the intensified training, regardless of post-exercise beverage yet after two and four days of intensified training, chocolate milk drinkers had significantly lower levels of creatine kinase – an indicator of muscle damage – compared to when they drank the carbohydrate beverage. There were no differences between the two beverages in soccer-specific performance tests, subjective ratings of muscle soreness, mental and physical fatigue and other measures of muscle strength. The results indicate that low-fat chocolate milk is effective in the recovery and repair of muscles after intense training for these competitive soccer players.

Resistance Training Effects on Females

Strength gains with resistance training are due to muscle hypertrophy and nervous system adaptations. The contribution of either factor may be related to the complexity of the exercise task used during training. Chilibeck and colleagues [12] looked to measure the degree to which muscle hypertrophy contributes to gains in strength during exercises of varying complexity. Nineteen young women resistance trained twice a week for 20 weeks, performing exercises designed to provide whole-body training. The lean mass of the trunk, legs and arms was measured by dual energy x-ray absorptiometry and compared to strength gains (measured as the 1-repetition maximum) in bench press, leg press and arm curl exercises, pre-, mid- (10 weeks) and post-training. No changes were found in a control group of ten women. For the exercise group, increases in bench press, leg press and arm curl strength were significant from pre- to mid-, and from mid- to post-training. In contrast, increases in the lean mass of the body segments used in these exercises followed a different pattern. Increases in the lean mass of the arms were significant from pre- to mid-training, while increases in the lean mass of the trunk and legs were delayed and significant from mid- to post-training only. It was hypothesized that a more prolonged neural adaptation related to the more complex bench and leg press movements may have delayed hypertrophy in the trunk and legs. With the simpler arm curl exercise, early gains in strength were accompanied by muscle hypertrophy and, presumably, a faster neural adaptation.

In a study comparing men and women, Staron et al. [20] looked at skeletal muscle adaptations during early phase of heavy-resistance training in men and women. An 8-week progressive resistance training program for the lower extremity was performed twice a week to investigate the time course for skeletal muscle adaptations in men and women. Maximal dynamic strength was tested biweekly. Muscle biopsies were extracted at the beginning and every 2 weeks of the study from resistance-trained and from non-trained (control) subjects. The muscle samples were analyzed for fiber type composition, cross-sectional area, and myosin heavy chain content. In addition, fasting blood samples were measured for resting serum levels of testosterone, cortisol, and growth hormone. With the exception of the leg press for women (after 2 weeks of training) and leg extension for men (after 6 weeks of training), absolute and relative maximal dynamic strength was significantly increased after 4 wk of training for all three exercises (squat, leg press, and leg extension) in both sexes. Resistance training also caused a significant decrease in the percentage of type IIb fibers after 2 weeks in women and 4 wk in men, an increase in the resting levels of serum testosterone after 4 weeks in men, and a decrease in cortisol after 6 weeks in men. No significant changes occurred over time for any of the other measured parameters for either sex. These data suggest that skeletal muscle adaptations that may contribute to strength gains of the lower extremity are similar for men and women during the early phase of resistance training and, with the exception of changes in the fast fiber type composition that they occur gradually.

Resistance Training Effects on Female Body Composition

Bale [21] looked at the relationship of physique and body composition to strength in a group of physical education students. Fifty-three female physical education students were measured anthropometrically and from these measurements somatotype and body composition were estimated. Leg, back and grip strength dynamometers were used to measure strength indices. Arm strength was calculated from each subject's pull-ups and push-ups and lung capacity was measured using a spirometer. The somatotype ratings and percent fat measurements indicate that the physical education students are generally more muscular and less fat for their age than non-physical education students. There was a strong relationship between percent fat and the endomorphy rating and a moderate relationship between lean body weight and mesomorphy. The moderate relationship of the strength variables with the muscular rating, whether expressed as mesomorphy or lean body weight, suggests that the higher a subject's muscular component the greater their dynamic strength.

Summary

Low-fat milk is becoming very popular among athletes as a recovery aid after exercise performance. Research has shown, compared to water and commercially available sports drinks, low-fat milk is a better rehydration drink after exercise [4]. Research has also demonstrated that milk beverages, both low-fat milk and whole milk, when consumed soon after resistance exercise, can lead to enhanced improvements in protein metabolism following resistance exercise [5]. When comparing fat-free milk vs. soy, the milk-based proteins promote muscle protein accretion to a greater extent than do soy-based proteins when consumed after resistance exercise [6, 7]. The consumption of either milk or soy protein with resistance training promotes muscle mass maintenance and gains, but chronic consumption of milk proteins after resistance exercise likely supports a more rapid lean mass accrual [6].

Although low-fat milk has proven to be an affective recovery aid, chocolate milk is a popular choice for athletes to ingest post exercise. Compared to a carbohydrate drink, research shows that low-fat chocolate milk is effective in the recovery and repair of muscles after intense training [19, 22, 23]. It has also been shown that chocolate milk is an effective recovery aid between two exhausting exercise bouts [18]. Therefore, potential research into drinking chocolate milk post exercise is high, especially the effects of chocolate milk following resistance exercise. Although chocolate milk is an effective recovery beverage for post endurance exercises, more research needs to be conducted in relation to fat-free and 2% chocolate milk ingestion and its effects on muscular strength and body composition.

Chapter Three

Methodology

Participants and Study Design

Eighteen female collegiate fast-pitch softball players, (18.5 ± .7 yrs; 65.7 ± 1.8 inches; 156.2 ± 21.6 lbs) physically active at least four times a week, participated in the study. The study was conducted using a randomized (matched according to strength and bodyweight), double blind experimental design (the researchers as well as the participants did not know who was receiving fat-free or 2% chocolate milk).

Entry and Physician Clearance Session

Each participant obtained prior approval by a physician to engage in the sport of softball and in activities that are associated with developing softball performance. In addition to having physician approval to engage in physical activity/collegiate athletics, a comprehensive health history form and assessment of resting heart rate and blood pressure was administered.

Familiarization to the exercise tests

All familiarization, baseline and post-testing assessments were conducted at the St. Petersburg College Clearwater campus Fitness Center. Each participant was familiarized to each of the two exercise tests prior to baseline testing. Familiarization occurred approximately one-week prior to baseline testing and was done to offset any learning curve that may have been gained from performing the tests. The two exercise tests that were performed during the familiarization session (and the pre-and post testing sessions) were the 1-repetition maximum (1RM) bench press and the1-repetition maximum (1RM) leg press.

Baseline and Post Testing Sessions

Baseline testing and the post-testing sessions were separated by 8 weeks and were conducted in the morning after an overnight fast. All pre-exercise and exercise tests were done in accordance with the American College of Sports Medicine and National Strength and Conditioning Association guidelines. Both of the testing sessions were identical and consisted of the following tests in the following order:

Pre-Exercise Testing Assessments:

- Resting heart rate assessment
- Resting blood pressure assessment
- Body weight assessment
- Body composition assessment

Exercise Testing Assessments

- Bench Press 1RM
- Leg Press 1RM

Supplementation Protocol

Participants were matched and then randomized to one of two groups: fat-free chocolate milk group or 2% chocolate milk group. Immediately following the resistance training workout or within a 5 minute span, participants consumed 16 ounces of either fat-free chocolate milk or 2% chocolate milk, which was pre-determined by random matching. There were two to three resistance training workouts per week for eight weeks, totaling 16-24 resistance training workouts over the course of the study. All beverage ingestions were supervised by a member of the research team to ensure the drink was fully consumed.

Resistance Training Protocol

Participants performed resistance training circuits three times a week, for an eight week span. For each circuit, 2 sets of 10 repetitions were completed for each exercise for the first four weeks, and then 2 sets of 8 repetitions were completed for the final four weeks. There was approximately one minute of rest between each exercise set. Appendix 1 displays the exercises used during the 8-week resistance training study.

Methods and Materials

Height and Bodyweight

Participant's height and body weight were obtained using the "Health-O-Meter" Professional height and weight scale.

Heart Rate and Blood Pressure

All heart rate measurements were determined by palpation of the radial artery using standard procedures [24]. All blood pressure measurements were determined in the seated position using a mercurial sphygmomanometer using standard procedures [24]. After the participants arrived at the Fitness Center and rested for 5 minutes, and prior to body composition assessment, resting heart rate and blood pressure were determined.

Body Composition (7-Site Skin-folds)

Participant's body compositions were tested using the ACSM's 7-site skin-fold testing procedures [24]. The tester pinched the skin at the location site and pulled the fold of skin away from the underlying muscle so only the skin and fat tissue were being held. Special skin-fold calipers were then used to measure the skin-fold thickness in millimeters. Two measurements were recorded and averaged. Testing was measured on the right side of the body.

- SITE 1 - CHEST. A diagonal fold taken one half of the distance between the nipple and the anterior auxiliary. (The anterior auxiliary line is the crease where the top of the arm, when hanging down, meets the chest.)

- SITE 2 - ABDOMINAL. A vertical skin-fold measurement taken 2.5 cm (one inch) to the right of the umbilicus (navel).

- SITE 3 - THIGH. Vertical skin-fold measurements taken half the distance between the patella (knee cap) and the inguinal crease (the skin crease between the thigh and the hip). The leg should be straight and relaxed.

- SITE 4 - AXILLA. A vertical fold taken on the midaxillary line (a vertical line descending directly from the center of the armpit) at the level of the nipple.

- SITE 5 - TRICEPS. With the arm resting comfortably at the side, take a vertical fold parallel to the long axis of the arm midway between the prominent bone at the top of the shoulder (acromion process) and the tip of the elbow (olecranon process).

- SITE 6 - SUBSCAPULA. A diagonal fold taken on the upper back, just below the inferior (lower) angle of scapula (shoulder blade) at a 45-degree angle approximately parallel to the inferior angle of the scapula.

- SITE 7 - SUPRAILIAC. Take a diagonal fold following the natural line of the iliac crest, just above the hip bone.

Resistance Exercise Tests

Bench Press 1-repetition maximum (1-RM): A spotter (research team member) was present to ensure the safety of this exercise performed on the Smith machine. After instruction on proper form, the participant warmed up with a light resistance that easily allowed for 5 to 10 repetitions, followed by a 1-minute rest period. Next, 5-10% more weight was added so that the participant could complete 3 to 5 repetitions followed by a 2-4 minute rest period. Next, an additional 5-10% load increase was added and the participant attempted a 1RM (the heaviest load that one can lift for one complete repetition). The load continued to increase or decrease until the participant completed one repetition with proper exercise technique. The maximum weight that the participant successfully lifted (without failing), using proper form, was their 1RM for the bench press. The aforementioned protocol utilized for attaining bench press 1RM is the standard method recommended by the National Strength and Conditioning Association.

Leg Press 1-repetition maximum (1-RM): A spotter (research team member) was present to ensure the safety of this exercise. After instruction on proper form, the participant warmed up with a light resistance that easily allowed for 5 to 10 repetitions, followed by a 1-minute rest period. Next, 10-20% more weight was added so that the participant completed 3 to 5 repetitions followed by a 2-4 minute rest period. Next, an additional 10-20% load increase was added and the participant attempted a 1 RM (the heaviest load that one can lift for one complete repetition). The load continued to increase or decrease until the participant completed one repetition with proper exercise technique. The maximum weight that the participant successfully lifted (without failing), using proper form was their 1RM for the leg press. The aforementioned protocol utilized for attaining leg press 1RM is the standard method recommended by the National Strength and Conditioning Association.

Research Design and Data Analysis

Null hypotheses were tested via an independent samples t-test and the criterion for significance for all tests was set at $p < 0.05$. Effect sizes were calculated by subtracting mean one from mean two and dividing by the average of the two standard deviations involved (Cohen's d).

Chapter Four

Results

Eighteen physically active female collegiate softball players participated in the study. Descriptive statistics for age, height, and weight are presented in Table 1. Paired Samples t-tests were used to analyze differences between baseline and post-testing across both groups. Data from this analysis are presented in Table 2. Descriptive statistics for 1 RM in both exercises are presented in Table 3. To test the null hypotheses, dependent samples *t*-tests were conducted to determine if there were significant differences in bench press strength between the two groups, in leg press strength between the two groups, body weight, body fat percentage, and in lean body mass between the two groups. Effect sizes (Cohen's *d*) for each dependent variable were also calculated to determine if there is any practical significance in the outcomes of the *t*-tests. These values are summarized and listed in Table 4. There were also no significant differences between the two groups at baseline and post-test for macronutrient intakes presented in Table 5.

Table 1: Characteristics of Study Participants (*N* = 18)

Variable	**Mean**	**Standard Deviation**
Age (yrs)	18.5	.7
Height (inches)	65.7	1.8
Bodyweight (lbs)	156.2	21.6

Table 2: Paired Samples T-Test from Baseline to Post-Testing.

Variable	Mean ± SD	p Value	Effect Size (Cohen's D)
Bodyweight			
Baseline	156 ± 21.64		
Post-Testing	154 ± 20.80	.003	.1
Body Fat %			
Baseline	24 ± 4.00		
Post-Testing	21 ± 4.15	.001	.7
Lean Body Mass			
Baseline	118 ± 12.03		
Post-Testing	121 ± 11.95	.001	.3
1 RM Bench Press			
Baseline	82.5 ± 15.71		
Post-Testing	94.4 ± 18.70	.001	.7
1 RM Leg Press			
Baseline	281.3 ± 58.84		
Post-Testing	310 ± 73.82	.001	.4

RM= repetition maximum

Table 3: Descriptive Stats for Bench Press 1RM and Leg Press 1RM

Variable	**N**	**Min**	**Max**	**Mean**±SD
BP 1RM T1 (lbs)	17	60	135	85.59 ± 19.8
BP 1RM T2 (lbs)	16	65	135	94.38 ± 18.7
LP 1RM T1 (lbs)	18	210	395	280.28 ± 56.8
LP 1RM T2 (lbs)	16	220	485	310.00 ± 73.8

BP = bench press; LP = leg press.T1=baseline.T2=post-testing

Table 4: Test Comparisons for Dependent Variables

Variable	FF (mean + SD; lbs)	2% (mean + SD; lbs)	*p Value*	Effect Size (Cohen's d)
Training Volume (lbs)	51220+11069.1	44830+5362.4	*.140*	.8
T1 Bodyweight	159 + 18.8	154 + 25.0	*.63*	.2
T2 Bodyweight	156 + 18.2	152+ 24	*.65*	.2
T1 Body Fat %	25 + 4	24 + 4.3	*.80*	.1
T2 Body Fat %	21 + 4.1	20 + 4.4	*.65*	.2
T1 Lean Body Mass	119+ 11.4	116 + 13.1	*.55*	.3
T2 Lean Body Mass	122+ 11.3	120 + 13.1	*.65*	.2
T1 BP 1RM	87.5+ 18.7	83.9 + 21.8	*.72*	.2
T2 BP 1RM	98.1 + 22.8	90.6 + 14	*.44*	.4
T1 LP 1RM	279.4 + 66.6	281.1 + 49.2	*.95*	.02
T2 LP 1RM	316.9 + 94.53	303.1 + 51.33	*.72*	.2

Note: Data were analyzed using Dependent Samples *t*-Tests

BP = Bench Press; LP = Leg Press; T1=baseline.T2=post-testing; FF=fat=free

Table 5: Characteristics of Macronutrient Intake at Baseline and Post-Testing.

Variable	Baseline (mean ±SD)	Post-Testing (mean ±SD)	p Value
Total Calories			
Fat Free	2,080	2,157	
2%	2,403	2,328	.594
Total Carbohydrates			
Fat Free	236	246	
2%	272	263	.649
Total Protein			
Fat-Free	97	85	
2%	112	87	.839
Total Fat			
Fat-Free	84	94	
2%	99	106	.566

Bench Press Total Volume

Ho_1 stated there will be no difference between the fat-free chocolate milk group and the 2% chocolate milk group in maximal bench press strength. No statistically significant differences were found in bench press strength between the fat-free group and the 2% group (FF = 98.13 ± 22.83 lbs; 2% = 90.63 ± 14.00 lbs; *p* = .441; effect size = .4). Therefore, based on the non-significant results, we fail to reject the null hypothesis (Ho_1).

Leg Press Total Volume

Ho_2 stated there will be no difference between the fat-free chocolate milk group and the 2% chocolate milk group in maximal leg press strength. No statistically significant differences were found in leg press strength between the fat-free group and the 2% group (FF = 316.88 ± 94.53 lbs; 2% = 303.13 ± 51.33 lbs; *p* = .723; effect size = .2). Therefore, based on the non-significant results, we fail to reject the null hypothesis (Ho_2).

Body Fat %

Ho_3 stated there will be no difference between the fat-free chocolate milk group and the 2% chocolate milk group in body fat percentage. No statistically significant differences were found in body fat % between the fat-free chocolate milk group and the 2 % chocolate milk (FF = 21.42 $\pm$ 4.06; 2% = 20.49 $\pm$ 4.44; p = .651; effect size = .2). Therefore, based on the non-significant results, we fail to reject the null hypothesis (Ho_3).

Lean Body Mass

Ho_4 stated there will be no difference between the fat-free chocolate milk group and the 2% chocolate milk group in lean body mass. No statistically significant differences were found in lean body mass between the fat-free group and the 2% group (FF = 122.45 $\pm$ 11.29; 2% = 119.80 $\pm$ 13.13; p = .652; effect size = .2). Therefore, based on the non-significant results, we fail to reject the null hypothesis (Ho_4).

Chapter Five

Discussion

Strength and Body Composition

The major finding of this study is that there is no difference between fat-free chocolate milk and 2% chocolate milk in regards to body fat percentage, lean body mass, bench press maximal strength, and leg press maximal strength following an eight week resistance training program where the chocolate milk was ingested immediately after each workout. However, there was a significant difference in both groups combined in regards to body fat percentage, lean body mass, bench press maximal strength, and leg press maximal strength after the eight week training program. Therefore, from a practical sense, consumption of either fat-free chocolate milk or 2% chocolate milk in conjunction with a periodized resistance training program does improve exercise performance in regards to maximal strength as well as improvements in body fat percentage and lean body mass.

In a previous study involving consumption of either low-fat chocolate milk or a commercially available carbohydrate and electrolyte beverage, training resulted in improvements in strength and body composition. Each group ingested their beverages within 5 minutes of completing each workout 3 days per week for 10 weeks [9]. However, like the present 8 week study, all of these changes where similar between the two groups. In the present study there were improvements in both the bench press 1RM and leg press 1 RM as well as body composition, but the results were not statistically significantly different between the fat-free and 2% chocolate milk groups. In another previous study, Elliot et al. [5] investigated the influence of consuming differing milk beverages on the protein metabolic response following an acute bout of resistance exercise. They compared the influence of non-fat milk (237 g), whole milk (237 g) and an amount of non-fat milk with the same amount of energy (kJ) as the whole milk condition (393 g) following an acute bout of leg resistance exercise. They assessed amino acid net balance across the exercise leg for 5 hours following the leg resistance exercise. All of the different milk beverages resulted in a significant increase in net balance of the measured amino acids. In the present study there was no difference between the fat-free and 2% chocolate milk groups due to the fact that the fat content likely did not increase the availability of amino acids as discussed in the Elliot [5] study where there was a significant increase in net balance between the different milk groups. Also, another reason for the difference in the two groups could be due to the same amount of protein content both groups. The two groups were very similar in that they conducted the same workouts and lifted approximately the same lifting volume throughout the workout study.

Females and Resistance Training Performance

Although there is limited research with chocolate milk and female athletes as in the present study, there are several published studies that have investigated the effects of resistance training programs in female athletes [12, 20]. A previous study by Kreamer et al. [25] looked at comparing the physiological and performance adaptations between periodized and nonperiodized resistance training in women collegiate tennis athletes.

Thirty collegiate women were assigned to either a periodized resistance training group, nonperiodized training group, or a control group. Assessments for body composition, anaerobic power, and maximal strength were performed before and after 4, 6, and 9 months of resistance training performed 2–3 days a week. Nine months of resistance training resulted in significant increases in fat-free mass; anaerobic power; grip strength; jump height; one-repetition maximum (1-RM) leg press, bench press, and shoulder press. Percent body fat decreased significantly in the periodized resistance group and nonperiodized training groups after training. During the first 6 months, periodized resistance training elicited significantly greater increases in 1-RM leg press (2%), bench press (8%), and shoulder press (6%) as compared to the nonperiodized training group. The absolute 1-RM leg press and shoulder press values in the periodized resistance training group were greater than the nonperiodized training group after 9 months. They concluded that these data demonstrated that periodization of resistance training over 9 months was superior for enhancing strength and motor performance in collegiate women tennis players. As with the present study, improvements in strength and body composition were achieved after an 8 week resistance program. Increases were seen in bench press 1RM (13%), leg press 1RM (9%), lean body mass (3%) and a decrease in body fat percentage (3%). The previous study mentioned above and the present study, are similar in regards to testing collegiate woman athletes. Taken together, female athletes engaged in resistance training are likely to experience increases in muscular performance following resistance exercise programs.

The present study did not find a significant difference in body fat percentage between the two groups, however, when the groups were combined, it was observed that the training program (in conjunction with the chocolate milk ingestion) resulted in a significant reduction on body fat percentage. From baseline testing to post-testing, the two groups combined lost 3% of body fat. The same was found with lean body mass. In relation to lean body mass, there was no significant difference between the two groups, but both groups combined gained 3.5 lbs of lean muscle mass (117.6 lbs at baseline to 121.12 lbs), which was a significant difference ($p < .01$). Taken together, it can be inferred that an 8-week periodized resistance training program in conjunction with fat-free or 2% chocolate milk ingestions results in improvements in body fat percentage and lean body mass.

Resistance Training on Female Body Composition and Performance

To the best of our knowledge, there is no current research other than the present study comparing collegiate women who engaged in resistance training and that consumed chocolate milk in terms of assessing changes in body composition. However, previous studies have shown the impact that resistance training alone exerts on female body composition [21, 25]. A previous study by Bale [21] looked at the relationship of physique and body composition to strength in a group of physical education students. Fifty-three specialist women physical education students were measured anthropometrically and from these measurements somatotype and body composition were estimated. Leg, back and grip strength dynamometers were used to measure strength indices. Arm strength was calculated from each subject's pull-ups and push-ups and lung capacity was measured using a spirometer. The somatotype ratings and percent fat measurements indicate that the physical education students are generally more muscular and less fat for their age than non-physical education students. There was a strong relationship between percent fat and the endomorphy rating and a moderate relationship between lean body weight and mesomorphy [21].

In a more recent study, Josse et al. [26] investigated the impact on lean muscle mass gain and fat loss among female resistance athletes of drinking a sports beverage and a skimmed milk drink after resistance exercise. To establish this they gave either fat-free skimmed milk or carbohydrates drink to women immediately after resistance training and then again an hour later. The women exercised 5 days a week for 12 weeks and changes in their body composition were measured. The results showed that muscle mass increased in both those drinking milk and the carbohydrate drink but women drinking milk gained more muscle mass. In addition, milk drinkers were the only ones to experience a reduction in fat mass after training. They concluded that heavy, whole-body resistance exercise with the consumption of milk versus carbohydrate in the early post-exercise period resulted in greater muscle mass accretion, strength gains, and fat mass loss, in women after 12 weeks. Their results highlight that milk is an effective drink to support favorable body composition changes in women with resistance training. As with any resistance training program, studies have shown that females will have an increase in muscle mass [21, 25, 26]. In the present study, after 8 weeks of training, participants had a 3% increases in lean body mass as well as a decrease of 3% body fat after ingesting chocolate milk.

Direction of Future Investigations

In light of these findings, more research on the effects of fat-free chocolate milk and 2% chocolate milk on resistance training performance is recommended. These future studies need to focus on the factors behind the actions of chocolate milk. Specifically, the exercises performed (i.e., the type, intensity, and duration), the training status of the participants, individual differences of the participants (i.e., specific chocolate milk consumption status), and the amount of chocolate milk consumed. For exercises performed, future studies should include other common exercise and not just the bench press and leg press.

As for the participants themselves, future research should focus on examining trained versus untrained participants in the same study. This would allow for comparison in training status of the participants, that is, those experienced with resistance exercise and those with no experience, and in addition, including participants based on a more specific analysis of their chocolate milk consumption status (i.e., the actual amount they consume each week) may provide a different insight into the effects of chocolate milk on exercise performance. An advantage of the present study was the 4 weeks of training prior to any chocolate milk being ingested. This gave the participant's an opportunity to become accustomed to the exercise program and served to equalize strength gains that may be due to neuromuscular adaptations.

Lastly, a control group should be added in future studies. The present study only looked at fat-free chocolate milk vs. 2% chocolate milk. In future studies regarding chocolate milk, a control group would add an important variable to seeing how much the chocolate milk improves performance. Suggestions would include a commercially available carbohydrate drink to compare to the chocolate milk. A disadvantage to the present study is the 8 weeks of training. It would have been more ideal to have a longer training session to see the effects of the chocolate milk. However, since chocolate milk and resistance exercise performance as well as body composition is still in its infancy, and due to the many different factors behind milk consumption, the future research potential is quite large.

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Appendices

Appendix A: Workout Charts

Player Name:________________________								
	Week 1		Week 2		Week 3		Week 4	
Circuit 1- Monday	Weight	2 x 10	Weight	2 x 10	Weight	2 x 10	Weight	2 x 10
Chest: Nautilus Vertical Press		/		/		/		/
Biceps: Hammer Curls		/		/		/		/
Legs: Leg Curl		/		/		/		/
Back: Lat Pulldown		/		/		/		/
Triceps: Tricep Pushdown		/		/		/		/
Legs: Walking Lunge w/DB		/		/		/		/
Shoulders: Seated DB Press		/		/		/		/
Circuit 2- Wednesday	Weight	2 x 10	Weight	2 x 10	Weight	2 x 10	Weight	2 x 10
Chest: DB Press		/		/		/		/
Biceps: 21's		/		/		/		/
Legs: Leg Press		/		/		/		/
Back: Nautilus Row		/		/		/		/
Triceps: DB overhead extension		/		/		/		/
Legs: Step-ups w/DB		/		/		/		/
Shoulders: Machine Press		/		/		/		/
Circuit 3- Friday	Weight	2 x 10	Weight	2 x 10	Weight	2 x 10	Weight	2 x 10
Chest: Nautilus Flat Bench		/		/		/		/
Biceps: DB Curls		/		/		/		/
Legs: Leg Extension		/		/		/		/
Back: Reverse Fly		/		/		/		/
Triceps: Bench Dips		/		/		/		/
Legs: Smith Squats		/		/		/		/
Shoulders: Lateral Raise		/		/		/		/

Player Name:________________________								
	Week 5		Week 6		Week 7		Week 8	
Circuit 1- Monday	Weight	2 x 8	Weight	2 x 8	Weight	2 x 8	Weight	2 x 8
Chest: Nautilus Vertical Press		/		/		/		/
Biceps: Hammer Curls		/		/		/		/
Legs: Leg Curl		/		/		/		/
Back: Lat Pulldown		/		/		/		/
Triceps: Tricep Pushdown		/		/		/		/
Legs: Walking Lunge w/DB		/		/		/		/
Shoulders: Seated DB Press		/		/		/		/
Circuit 2- Wednesday	Weight	2 x 8	Weight	2 x 8	Weight	2 x 8	Weight	2 x 8
Chest: DB Press		/		/		/		/
Biceps: 21's		/		/		/		/
Legs: Leg Press		/		/		/		/
Back: Nautilus Row		/		/		/		/
Triceps: DB overhead extension		/		/		/		/
Legs: Step-ups w/DB		/		/		/		/
Shoulders: Machine Press		/		/		/		/
Circuit 3- Friday	Weight	2 x 8	Weight	2 x 8	Weight	2 x 8	Weight	2 x 8
Chest: Nautilus Flat Bench		/		/		/		/
Biceps: DB Curls		/		/		/		/
Legs: Leg Extension		/		/		/		/
Back: Reverse Fly		/		/		/		/
Triceps: Bench Dips		/		/		/		/
Legs: Smith Squats		/		/		/		/
Shoulders: Lateral Raise		/		/		/		/