EFFECT OF FAT-FREE SKIM CHOCOLATE MILK ON POWER, SPEED, AGILITY, AND BODY COMPOSITION IN FEMALE SOFTBALL PLAYERS

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COMPOSITION FEMALE SOFTBALL PLAYERS

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Abstract: This exploratory research examined the potential effect of fat-free chocolate milk on body composition, power, speed, and agility among trained female collegiate athletes (n = 16) in August/November 2012. Participants were randomly assigned to one of two groups; fat-free chocolate milk (CM; n=8) or carbohydrate (CHO; n=8). Each group received 16oz of the treatment matched for calories and carbohydrate content. The treatment was distributed to participants on three days/week for 12-weeks. Body composition (DEXA; Hologic) and performance tests were assessed at baseline and post-test. A two-way analysis of variance (ANOVA) with repeated measures was used to detect differences in outcome measures. No significant differences in body composition between the two groups were found at baseline and post-test. There were no differences in group-time interaction for any of the performance measures. However, main effect for time was detected for the vertical jump ($p=.030$), 20-yard dash ($p = .028$), and the pro-agility test ($p = .002$). In contrast to some short-term studies, body composition or performance benefits associated with CM were not identified in this study. Utilization of CM for recovery in female collegiate athletes should be investigated further with a particular focus on practicality and feasibility of CM consumption related to training.

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CHAPTER I

INTRODUCTION

Nutrition is an important element of exercise performance and recovery from exercise. Recovery from strenuous exercise, whether resistance training, endurance training, or a combination of the two, is central to the ability of reaching performance potential after practice sessions or competitive events (Ferguson-Stegall, McCleave, Ding, Doerner III, Wang, Liao, Kammer, Liu, Hwang, Dessard, & Ivy, 2011). Because of the well-known importance of effective recovery, a variety of sports beverages have been used by athletes to optimize their performance (Spaccarotella & Andzel, 2011). In recent years, milk has emerged as a post-exercise drink with high recovery potential and has received great attention among both recreational and professional athletes. Several studies examining skim milk and low-fat chocolate milk reported that it has the ability to aid in glycogen re-synthesis, promote lean mass accretion, and aid in rehydration following exhaustive exercise bouts compared to water alone and commercially available sports drinks (Karp, Johnston, Tecklenburg, Mickleborough, Fly, & Stager , 2006; Hartman, Tang, Wilkinson, Tarnopolsky, Lawrence, Fullerton, & Phillips, 2007; Shirreff, Watson, & Maughan, 2007). Due to a wide availability of milk, low cost, taste popularity (especially of chocolate milk), and its macronutrient and micronutrient composition, low-fat milk has a theoretical potential to serve as an effective and convenient beverage for optimizing recovery among a variety of athletes.

The current sports nutrition guidelines for effective recovery suggest consumption of 1.2-1.7 g/kg of carbohydrate with 0.2-0.5 g/kg protein (added in a 3:1 ratio) in addition to the daily adequate carbohydrate and protein intake (Academy of Nutrition and Dietetics, Dietitians of Canada, & The American College of Sports Medicine, 2009; Hausswirth & Le Meur 2011). Based on these recommendations, chocolate milk has arisen as a potential recovery beverage due to its higher carbohydrate content, compared to regular milk, and its protein content (Spaccarotella & Andzel, 2011). Resistance exercise, similar to endurance exercise, has shown to result in significantly decreased muscle glycogen, though the decrease is not as great as during endurance exercise (Roy & Tarnopolsky, 1998). Resistance training also has a profound effect on muscle protein metabolism, often resulting in muscle growth when protein synthesis exceeds breakdown (Tipton, Elliott, Cree, Wolf, Sanford, & Wolfe, 2004). Given the high carbohydrate content and its 3:1 ratio of carbohydrate to protein, it has been suggested that chocolate milk can replenish glycogen better than its alternatives, such as carbohydrate replacement drinks and regular milk (Ivy, Res, Sprague, & Widzer, 2003). In addition, Esmarck, Anderson, Olsen, Richter, Mizuno, & Kjaer, 2001, found that supplementing with a beverage, containing both carbohydrate and milk protein, immediately following resistance exercise resulted in significant hypertrophy of skeletal muscle versus a 2-hour delay in supplementation in untrained men.

The current literature examining the effects of chocolate milk on recovery and other performance-related measures among athletes is limited (Josse, Tang, Tarnopolsky, & Phillips, 2010; Spaccarotella & Andzel, 2011). The majority of the studies utilizing either regular milk or chocolate milk have evaluated its effectiveness in terms of glycogen replenishment after endurance training and used almost exclusively male cyclists or other endurance trained male athletes (Karp et al., 2006; Pritchett, Bishop, Pritchett, Green, & Katica, 2009; Thomas, Morris,

& Stevenson, 2009; Gilson, Saunders, Moran, Moore, Womack, & Todd, 2010). Only a few studies looked at the use of milk in promoting muscle protein synthesis, strength, and/or body composition (Elliot, Cree, Sanford, Wolfe, & Tipton, 2006; Josse et al., 2010; Ferguson-Stegall et al., 2011). For example, a study by Josse (2010) has examined the effects of skim milk consumption on strength and body composition after resistance training sessions in untrained adult females (Josse et al., 2010). Thus, little is known about responses to milk supplementation, either regular or chocolate, after resistance training among female athletes and only one study has looked at the effects of such supplementation among female athletes in practical settings (Spaccarotella & Andzel, 2011). The purpose of this study was to examine the potential effects of skim chocolate milk supplementation on power, speed, agility, and body composition after a 12-week off-season training program among NCAA collegiate softball players.

Significance of the Study

Given the very limited research in this area, the effect of chocolate milk consumption after resistance training on performance-related outcomes such as power, speed, agility, and body composition in trained females has yet to be established. To our knowledge, there are no published reports examining the effects of fat-free chocolate milk, given immediately post-exercise resistance training, on muscular power, speed, and agility, and body composition in a practical setting. Several studies have shown the benefits of chocolate milk on endurance exercise and few have shown the benefits of chocolate milk on recovery from resistance training, however, the vast majority of the studies were conducted in laboratory settings and have utilized a volume of regular or chocolate milk supplementation that is not realistic for competitive athletes. Considering the relatively low energy needs of females compared to their male counterparts, evaluation of potential chocolate milk benefits on power, speed, agility and body composition, in a feasible volume and frequency for collegiate athletes is warranted.

Hypotheses

The study hypotheses are as follows:

Hypothesis 1: In the chocolate milk group (CM), consumption of fat-free chocolate milk immediately post-exercise will result in significantly greater muscular power compared to the consumption of a commercially available carbohydrate alternative in the carbohydrate (CHO) group at the end of the 12-week study.

Hypothesis 2: In the CM group, consumption of fat-free chocolate milk immediately post-exercise will result in significantly faster times in speed compared to the consumption of a commercially available carbohydrate alternative in the CHO group at the end of the 12-week study.

Hypothesis 3: In the CM group, consumption of fat-free chocolate milk immediately post-exercise will result in significantly faster pro-agility times compared to the consumption of a commercially available carbohydrate alternative in the CHO group at the end of the 12-week study.

Hypothesis 4: Gains in muscle mass will be greater with the consumption of fat-free chocolate milk in the CM group versus consumption of a carbohydrate alternative in the CHO group at the end of the 12-week study.

Hypothesis 5: Loss of fat mass will be greater with the consumption of fat-free chocolate milk in the CM group versus consumption of a carbohydrate alternative in the CHO group at the end of the 12-week study.

Assumptions

-Subjects accurately reported dietary intake.

-Subjects did not change dietary intake throughout the study.

-The Diet Analysis program computed accurate analysis of food and drinks from subjects' food records.

-All beverages were calculated correctly to contain the same amount of calories for each subject.

-All subjects consumed their beverage within 60 minutes following resistance exercise.

-Subjects did not engage in additional resistance training sessions beyond what was provided by the strength and conditioning coach.

-All testing and analysis equipment was calibrated and reported accurately.

Limitations of the Study

-Subjects' normal dietary intake (other than the post-workout treatment in both groups) was not altered during the study.

-Due to the nature of the study, the training protocol could change any given week.

-Subjects were instructed to follow their typical eating and exercise behaviors; however their exercise habits were not controlled during the study.

-The sample cannot be generalized to other female athletes.

-Treatments were only given once, within 60 minutes, immediately post-exercise.

-Treatment volumes were based on the minimum amount shown to be beneficial in previous research and the amount that can be feasibly consumed by athletes.

-Subjects' performance on exercise tests could be affected by the timing of their test and/or their energy or desire to perform at their best.

Definition of Terms

Body Composition: Refers to the body's chemical composition that includes lean mass, fat mass, and bone density (Kenney, 2012).

Broad Jump: An explosive-type of movement that is commonly used in the training of athletes in various sports. This movement correlates well with other types of explosive movements such as the vertical jump and sprinting (Kocj, O'Bryant, Stone, Sanborn, Proulx, Hruby, Stannonhouse, Boros, & Stone, 2003).

Dietary Supplement: Any pill, capsule, tablet, liquid, or powder that contains vitamins, minerals, herbs, or amino acids; intended to increase dietary intake of these substances (Whitney & Rolfes, 2013).

Dual X-ray Absorptiometry: A technique that has become the clinical standard to measure bone density, which is based on the absorption of low-energy x-rays. It is also used to measure lean mass and percent (%) body fat (Visser, 1999).

Lean Body Mass: The body weight minus the body fat composed primarily of muscle, bone, and other nonfat tissue (Williams, Anderson, & Rawson, 2013).

Pro-agility: The ability to change speed and direction rapidly, without losing balance, using a combination of strength, power, and neuromuscular coordination (Young, James, & Montgomery, 2002; Jullien, Bisch, Largouet, Manovrier, Carling, & Amiard, 2008).

Recovery: An inter-individual and intra-individual multi-level (e.g. psychological, physiological, social) process in time for the re-establishment of performance abilities (Kellmann & Kallus, 2001; Kellmann, 2010).

Speed: The ability to rapidly increase velocity (acceleration) (Cronin & Hansen, 2005).

Vertical Jump: A crucial skill in the performance of several sports in which execution of this motor task depends on the coordination of the segmental actions of the human body. Success in sport depends upon the development of strength as well as power, both of which contribute to vertical jump performance (Rodacki, Flower, & Bennett, 2002; Kraska, Ramsey, Haff, Fethke, Sands, Stone, & Stone 2009).

Abbreviations

BJ- Broad Jump

CHO- Carbohydrate

CM- Chocolate Milk

CK- Creatine Kinase

DEXA- Dual X-ray Absorptiometry

VJ- Vertical Jump

CHAPTER II

LITERATURE REVIEW

Emergence of Chocolate Milk as a Recovery Drink

Adequate nutritional intake is important for optimizing sport and exercise performance and for optimizing adaptations to training (Roy, 2008). Recovery, from prolonged aerobic exercise and anaerobic resistance training, consists of many components including muscle glycogen repletion, muscle protein synthesis, and rehydration (Shirreffs et al., 2007; Roy, 2008; Cockburn, Robson-Ansley, Hays, & Stevenson, 2011; Spaccarotella & Andzel, 2011). Muscle and liver glycogen are the predominant fuel utilized for energy during heavy endurance exercise, and the ability to replenish these stores as quickly as possible during recovery is of great interest for endurance athletes (Karp et al., 2006). Adequate nutritional intake can also increase muscle protein synthesis, leading to an improved net muscle protein balance and better recovery (Roy, 2008). Furthermore, when post-exercise protein consumption is combined with resistance training, greater increases in muscle hypertrophy and lean mass have been observed (Roy, 2008). Thus, individuals involved in power and strength exercise can also benefit tremendously from a balanced blend of nutrients after their workouts (Rankin, Goldman, Puglisi, Nickols-Richardson, Earthman, & Gwazdauskas, 2004).

A study by Karp et al. (2006) was one of the first to use chocolate milk as a potentially effective post-exercise recovery beverage. The study observed endurance trained athletes during a four hour recovery period following an exhaustive interval workout. Karp and colleagues found that supplementation of low-fat chocolate milk immediately after exercise and two hours into the recovery period resulted in significantly greater time to exhaustion and total work compared to equal amounts of Gatorade and carbohydrate replacement drink. The study opened the door for other researchers to observe the effects of chocolate milk on endurance performance examining glycogen replenishment, performance-based outcomes, as well as hydration markers in different exercise settings (Shirreffs et al., 2007; Gilson et al., 2010; Ferguson-Stegall et al., 2011; Spaccarotella & Andzel, 2011). For example, Shirreffs et al. (2007) examined the effects of milk on rehydration in individuals engaged in multiple training sessions. Chocolate milk was suggested to serve as an effective recovery drink not only because of its macronutrient composition and hydrating abilities, but also because of its convenience and wide availability and accessibility both inside and outside of the households of athletes at all levels (Karp et al., 2006).

Endurance Exercise

From a nutritional standpoint, there are three primary times when nutrition is considered for endurance based activities; before exercise, during exercise, and after exercise (Roy, 2008). In terms of recovery after endurance exercise, the main goal of a nutritional intervention is usually to promote muscle glycogen resynthesis and fluid recovery (Roy, 2008).

Early research showed the effect of two hours of cycling at 30% maximum oxygen consumption (VO_{2max}), depleted muscle glycogen only 20%, however performing at 75% VO_{2max} almost completely depleted stores (Costill, 1988). High-intensity, short-duration athletes perform in sports that average between 1.5-30minutes and usually train at intensities up to 75% VO_{2max}, with interval training increasing up to 85%-100% VO_{2max} (Dunford, 2006). This increased exercise intensity; however, only lasts a few seconds and is primarily dependent on carbohydrate (Neiman, 2007). As the exercise intensity decreases and the duration increases, as in prolonged long distance running, fat becomes the major preferred fuel source (Neiman, 2007). In typical endurance events, exercise intensity can average 65% VO_{2max} and uses lipids as the primary fuel source (Seebohar, 2006). Exercise intensities may range between 50% and 90% VO_{2max} for endurance events lasting 4 or more hours (Seebohar, 2006). Although fat is utilized to the greatest extent during prolonged endurance exercise, studies have shown exercise can only be maintained for extended periods without the onset of fatigue if adequate carbohydrate is sufficient prior to exercise (Laursen & Rhodes, 2000).

Body carbohydrate stores (glycogen) are critical because they are the primary fuel for working muscles. The liver, which is a major site of glycogen storage at approximately 7% wet weight, is important because it helps maintain blood glucose homeostasis (Gropper, Smith, & Groff , 2009). Skeletal muscle glycogen storage accounts for approximately 1% wet weight; however 75% of the body's stored glycogen is in the muscle (Gropper et al., 2009). During the first few minutes of intensive exercise, muscle glycogen stores are rapidly broken down to ATP and quickly become depleted (Spaccarotella & Andzel, 2011). Glycogen levels of athletes can be reduced up to 50% after a 2-hr workout (Neiman, 2007). When these stores fall too low, fatigue can set in, leaving the athlete feeling tired, stale, and more prone to injury (Neiman, 2007). Fatigue during physical activity occurs when muscle fibers cannot maintain the power output that is required to continue to work at a given intensity (Wilmore, Costill, & Kenney, 2008). In addition to depleted glycogen stores, fatigue from endurance exercises may result from a combination of factors including lactate and hydrogen ion accumulation, increased temperatures, and neural factors (Spaccarotella & Andzel, 2011).

Liver glycogen stores are also limited and hypoglycemia can develop if working muscle glucose uptake exceeds hepatic production (Spaccarotella & Andzel, 2011). The resynthesis of glycogen is a critical component of recovery from endurance exercise training, and with multiple training sessions occurring with many sports, recovery must be as complete as possible in a short amount of time in order to maintain performance (Ivy et al., 2002). Carbohydrates with a higher glycemic index, such as glucose and sucrose which are found in chocolate milk, promote greater muscle glycogen storage than carbohydrates that have a lower glycemic index (Burke, Collier, & Hargreaves, 1993; Karp et al., 2006). Moderate to high glycemic index carbohydrates are often recommended post-exercise (Spaccarotella & Andzel, 2011).

Research has established that the timing of nutritional intake is also very important in optimizing adaptations to exercise, as well as recovery from endurance exercise (Roy, 2008). A study that included 12 male cyclists reported findings that showed the rate of glycogen storage in the cyclists given a carbohydrate supplement (2.0g•kg body weight^{-1}•hr^{-1}) 2hr post exercise was 45% slower than when the same group was given the carbohydrate supplement immediately after the 70 min exercise bout on a separate occasion (Ivy, 1988). It was reasoned that the increased glycogen synthesis immediately following carbohydrate consumption post-exercise was partly due to a greater activation of muscle glucose transport via a non-insulin-dependency induced by exercise (Ivy, 1988). The second phase occurred over the period of several hours and in the presence of high insulin (Ivy, 1991; Zawadzki, Yaspelkis, Ivy, 1992). Insulin stimulates the dephosphorylation of glycogen synthase, the rate-limiting enzyme in the glycogen synthesis pathway (Zawadski et al., 1992; Gropper et al., 2009). Insulin is also an activator of muscle glycogen synthesis in that it increases glucose transport in skeletal muscle through the stimulation of GLUT 4 transporter (Gropper et al., 2009).

Earlier studies reported glycogen resynthesis occurred most rapidly when carbohydrate was consumed within 30 minutes to 1 hour after exercise (Costill, 1988; Freidman, Neufer , Dohm, 1991; Ivy, 1991 & 1998), and current research is also utilizing this method of post-exercise carbohydrate ingestion timing; however, the amounts of carbohydrate used is varying (Ivy, 2001). In 2009, it was the position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine that following exercise, athletes should consume a carbohydrate intake of 1.0-1.5 $g \bullet kg^{-1}$ body weight within the first 30 minutes and again every 2 hours for a total of 4-6 hours to adequately replenish glycogen stores. Blom, Hostmark, Vaage, Kardel, & Maehlum (1987) found that the rate of glycogen synthesis was greatest following an intake of 0.70g/kg body weight of a glucose supplement compared to 0.35g/kg body weight of glucose. Results also found that there was no difference in glycogen synthesis between 0.70 g/kg and 1.4g/kg supplement administration. This study was conducted with cyclists in a depleted glycogen state, and as stated by Spaccarotella & Andzel (2011), athletes usually perform in a fed, non-glycogen depleted state. Therefore these recommendations may be too abundant for low-endurance precision based sports.

Milk and Recovery from Endurance Exercise:

Low-fat milk and chocolate milk have a number of characteristics that theoretically make it a potentially good recovery beverage (Roy, 2008). Studies have found that ingesting protein, along with carbohydrate, have been shown to enhance the rate of glycogen synthesis and improve endurance performance, than with carbohydrate alone (Ivy et al., 2002). A recent study by Gilson et al. (2010) looked at chocolate milk consumption on muscle recovery in twenty-two NCAA Division I male soccer players. This study was unique in that the training protocol was similar to the type of training the athletes would usually receive during off-season. Subjects were required to complete one week of baseline training followed by four days of increased training duration (ITD). The ITD period was designed to increase total training duration by >25% and consisted of both strength training and sport-specific training drills. Immediately following each training session of the ITD protocol, subjects received one of two recovery drinks; low-fat chocolate milk (CM) or an isocaloric, isovolumetric carbohydrate beverage (CHO: Cliff Shots) that had a similar color and taste to the CM drink. Although no significant treatment•time interactions were found for muscle soreness, ratings of energy and/or fatigue or muscle function, and no treatment effects on serum myoglobin, there was a significant decrease in serum creatine kinase (CK) levels in CM vs. CHO supplementation. Serum CK is often used as an indicator of muscle damage (Gilson et al., 2010). This finding is interesting due to the fact that muscle fiber damage associated with exhaustive eccentric exercise, such as running, may delay glycogen resynthesis 7-10 days, thus delay recovery (Costill, 1988).

Spaccarotella & Andzel (2011) also observed the effects of low-fat chocolate milk on post-exercise recovery in Division III male and female soccer players, (n=5 and n=8 respectively). The randomized crossover design was unique in that the experiment was conducted in a practical setting, where the athletes were in a fed-state and trained in a way that was similar, if not exact, to their regular preseason training. The athletes participated in both morning and afternoon preseason practice sessions, with the intervention occurring two days during the middle of the preseason separated by a 2-day washout. During the intervention days, participants received either low-fat chocolate milk, providing 1.0g per kilogram body weight, or an equal amount of a carbohydrate-electrolyte beverage (CE: Gatorade). Both drinks were consumed immediately after the first practice and again two hours later. Results showed that as a group, there was no significant difference in time to fatigue between the chocolate milk consumption and the carbohydrate drink consumption. For the men only, there was a reported trend of increased time to fatigue with chocolate milk consumption compared with the carbohydrate drink.

Resistance Training

Resistance training is a type of exercise that is designed to increase strength, power, and muscle endurance (Kenny, Wilmore, & Costill, 2012). At one time, resistance training was considered inappropriate for many athletes, except those involved in weightlifting or weighted events in track and field (Kenney et al., 2012). Resistance training has; however, become an essential part of strength and conditioning training for many types of sports and has been included in programs for both male and female competitive athletes.

For a long time, gains in muscular strength were thought to occur as a result of increases in muscular size, or hypertrophy (Kenney et al., 2012). Early studies looking at muscular changes resulting from resistance exercise defined hypertrophy as an increase in the number and size of myofibrils per cell (Komi, 1986). It has been reported that strength gains during the first 6-8 weeks of weight training are associated with neurological changes and are accompanied with little to no hypertrophy (Chilibeck, Calder, Sale, & Webber, 1998). These neurological adaptations are reported to occur within the nervous system as increases in motor unit activation and synchronization (Sale, Webber, Jacobs, & Garner, 1988; Chilibeck et al., 1998). Not only have studies shown resistance exercise induces muscle hypertrophy but also that it affects net protein balance (Josse et al., 2010). In fact, dietary administration of amino acids with resistance training has been shown to enhance protein synthesis, which could result in greater muscle hypertrophy over a period of time (Anderson et al., 2005). Gains in muscle size are generally paralleled by gains in strength; however, the exact mechanisms associated with strength gains are not completely understood and one should not assume a cause-and-effect relationship (Kenny, Wilmore, & Costill, 2012).

Timing and Nutrient Composition of Recovery after Resistance Exercise:

Over the last decade, there has been substantial interest and research into various factors that stimulate protein metabolism in response to resistance training. It has become increasingly clear that amino acids are required to activate metabolic pathways leading to muscle hypertrophy when combined with exercise, and it has also become apparent that the timing of dietary protein intake following exercise is crucial in maximizing muscle growth, minimizing muscle damage, and promoting strength recovery (Crittenden et al., 2009). It has been suggested positive net protein balance is the result of increased protein synthesis and decreased protein breakdown; however, it has also been suggested that the more positive net balance could be attributed to a change in synthesis with no change in degradation (Borsheim, Tipton, Wolf, & Wolfe 2006). One study found that 20g of protein was sufficient to maximally stimulate muscle protein synthesis when taken immediately after an intense bout of leg-based resistance exercise (Moore et al., 2009). Tipton et al. (2004) reported that acute ingestion of both whey protein and casein 60m following resistance exercise resulted in similar increases in muscle protein net balance, resulting in net protein synthesis. These results support the theory that protein synthesis is maximized within the first two hours following resistance exercise and the ingestion of low-fat milk (Tipton et al., 1999 & 2001; Rankin et al., 2004; Elliot et al., 2006; Cockburn, Hayes, French, Stevenson, & Gibson, 2008).

Nutrient timing following resistance exercise on net protein synthesis seems to follow a similar timing as that of carbohydrate intake on glycogen resynthesis after aerobic exercise (Levenhagen et al., 2001). For example, a greater stimulation of net protein synthesis was observed when a mixed supplement was given immediately following aerobic exercise compared to three hours later (Levenhagen et al., 2001). In addition, Miller, Tipton, Chinkes, Wolf, & Wolfe (2003) reported that the combined effect on net protein synthesis of carbohydrate and amino acids given together immediately after resistance exercise is roughly equivalent to the sum of the independent effects of either given alone. Consumption of carbohydrate with the addition to protein, even a small amount of protein, has been shown to augment recovery in terms of stimulating muscle protein synthesis following resistance exercise (Rasmussen, Tipton, Miller, Wolf, & Wolfe, 2000; Borsheim, Tipton, Wolf, & Wolfe, 2001). A study conducted by Elliot et al. (2006), investigated the consumption of protein from a food source which consisted of two types of milk (fat-free and whole) on the response of protein metabolism following resistance exercise. Twenty four untrained subjects, both male and female, were divided into three groups; fat-free milk (FM), whole milk (WM), and fat-free milk (IM) matched for calories with whole milk. The IM and WM groups were isocaloric (627 kJ) and the FM and WM groups were matched for protein (~8-9g). Subjects consumed respective drinks one hour following an exercise bout of leg extensions, 10 sets with 8 repetitions, at 80% of 1RM. The primary result from the study showed that the ingestion of milk stimulated net uptake of amino acids that represent net muscle protein synthesis following resistance exercise (Elliot, Cree, Sanford, Wolfe, & Tipton, 2006). The optimal amount of supplementation needed in order to maximally stimulate muscle protein synthesis is still under investigation; however several studies have concluded that intake of amino acids, protein, carbohydrates, or a mixture of these macronutrients improved protein metabolism before or after resistance exercise (Rankin et al., 2004; Tipton et al., 1999 & 2001).

Milk and Resistance Training:

To date, most research on milk supplementation has focused on recovery from endurance exercise; only few studies have examined the effect of milk or chocolate milk on recovery and body composition changes after resistance workouts. In 2008, Cockburn and colleagues demonstrated that 1,000 mL of milk and milk-based carbohydrate-protein supplements, consumed immediately following damaging exercise, reduced exercise-induced muscle damage. For three days, subjects in this study consumed 500mL of either a milk-based carbohydrate-protein shake (CHO-P), milk (M), a carbohydrate sports drink (CHO), or water (CON) immediately and again within 2h post exercise. The primary results of the study indicated that both the M and CHO-P groups displayed decreased blood markers associated with muscle damage. Creatine kinase values were significantly lower at 48h in the M and CHO-P groups, while concentrations significantly increased from 0-48h in the CHO and CON groups only (Cockburn et al., 2008). Myoglobin concentrations in the M and CHO-P groups were also found to be significantly lower than the CHO group. Results from this study suggest that the intake of protein and carbohydrate may have led to the lessening of exercise induced muscle damage by altering protein metabolism; thus leading to a better maintenance of cell membrane integrity, myofibrillar disruption, and contractile protein loss (Cockburn et al., 2008).

Josse et al. (2010) measured changes in strength in untrained women who consumed either 500 mL of skim milk or a carbohydrate drink both immediately and 1h post resistance exercise. After twelve weeks of resistance training, results showed that strength gains were seen within each group in all exercises performed, and although not significant, researchers reported a trend toward significance for greater increases in strength for both bench press and chest flies in the milk group versus the carbohydrate group. While the results of this study and the study by Cockburn et al. (2008) are promising, the amount of supplementation is very high for athletes to consume in a practical setting.

To address the low feasibility of the milk supplementation in her previous study Cockburn et al. (2012), in a follow up study, looked to see if a smaller amount of milk, supplemented immediately following exercise-induced muscle damage, would result in the same conclusion as the previous study. Twenty-four male participants were assigned to one of three groups: 1) 500 mL milk, 2) 1,000 mL milk, or 3) placebo (1,000 mL water). Each participant completed six sets of ten repetitions of unilateral eccentric-concentric knee flexion using an isokinetic dynamometer. Results showed that the lower amount of milk consumed (500 mL) was just as effective in attenuating decrements in isokinetic muscle performance and increases in creatine kinase as the larger 1,000 mL amount. This study compared the amount of protein from the two treatments (17g and 34g) and found no difference for the attenuation of muscle damage suggesting that consuming the larger amount of protein does not provide extra amino acids for utilization into new proteins (Moore et al., 2009; Cockburn et al., 2008 & 2012).

Chocolate Milk and Resistance Exercise:

Given its nutrient composition and palatability, chocolate milk may serve as an effective post-resistance exercise beverage that results in favorable recovery results; however, current research in this area is limited to a few studies (Roy, 2008). A recent pilot study examined the effects of chocolate milk on perceived exertion and muscular strength, over a four-day period, in seven recreationally strength trained males following four days of resistance exercise and testing. Wallace & Able (2010), using a randomized experimental crossover design, provided subjects one of two drinks; skim chocolate milk and a non-caloric artificially sweetened placebo. This study was original in that the skim chocolate milk volume provided contained 0.5g of carbohydrate per kilogram of body weight, an amount much less than current recommended amounts for recovery. Results from this study showed that the rate of perceived exertion was significantly lower when consuming skim chocolate milk than when the subjects consumed the placebo. Knee flexion peak torque, but not knee extension, was also significantly greater with skim chocolate milk consumption that with placebo, as was knee flexion fatigue.

Milk Supplementation, Resistance Training, and Body Composition

Body composition and body weight are two of the many factors that contribute to optimal exercise performance (Academy of Nutrition and Dietetics, Dietitians of Canada, & The American College of Sports Medicine, 2009). Body weight can affect an athlete’s speed, endurance, and power, whereas body composition can influence an athlete’s strength, agility, and appearance (Academy of Nutrition and Dietetics, Dietitians of Canada, & The American College of Sports Medicine, 2009). Muscle mass is an important determinant of performance in sports that depend on muscular strength or power (Garthe, Raastad, Refsnes, & Sundgot-Borgen, 2013). There is limited research measuring resistance training effects on body composition with the consumption of milk in females in general and women athletes.

A recent study, conducted by Josse and colleagues (2010), examined the effects of a twelve week resistance training program with the consumption of fat-free milk, on body composition in an untrained group of women. It was postulated that when the women were divided into two groups, one receiving 500mL of a carbohydrate drink and the other receiving 500mL of fat-free milk, the group that received the milk supplement, immediately and one hour after each training session, would have greater lean muscle mass accretion than the carbohydrate group. Results from this study showed a significant decline in fat mass in the group consuming the low-fat milk in comparison to the carbohydrate group. Both groups gained lean mass due to the training regimen; however results showed a greater net increase in the milk group versus the carbohydrate group. Based on these results, it was concluded that consuming low-fat milk, both immediately and 1hr post exercise, resulted in significantly greater fat mass loss and lean mass accretion in young healthy women performing resistance training over a twelve week period (Josse et al., 2010).

In the study by Josse et al. (2010), it was suggested that the proteins in milk promoted muscle anabolism by inducing muscle protein synthesis; however the reasons behind the loss in fat mass were unclear (Josse et al., 2010). It has been suggested that dietary calcium plays a role in the regulation of energy metabolism, and interactions involving parathyroid hormone, vitamin D (1-25-$[OH]_2D$) and serum calcium may have contributed to the loss of fat mass (Zemel, 2004; Josse et al., 2010). Given the lack of research on body composition as a result of milk consumption among athletes, further research is warranted to evaluate potential benefits among trained female individuals. Despite the favorable results from this study, the palatability of regular milk consumption after training sessions is a question whereas chocolate milk maybe more acceptable (Gilson et al., 2010; Spaccarotella & Andzel, 2011).

Given the nutrient composition and popularity of skim chocolate milk, it may have potential benefits on the recovery of female athletes not only in terms of power and strength that may relate to changes in speed and agility, but also on changes in body composition over time.

Summary

Chocolate milk has gained popularity as potential post-exercise recovery drink among recreational, college as well as professional athletes. In recent years, it has been heavily advertised to the athletes through media. Because of its nutritional content, rehydration potential, wide availability, and relatively inexpensive cost, researchers have examined the effects of chocolate milk in different exercise settings. For endurance training, the carbohydrate content has shown to be beneficial for replacing glycogen stores (Zawadzki et al., 1992; Ivy et al., 2002). The protein in chocolate milk is complete, thus providing adequate amounts of both essential and non-essential amino acids for those engaged in resistance training. Some studies have demonstrated that a 3:1 carbohydrate:protein ratio, the present in chocolate milk, can maximize recovery better than either carbohydrate or protein alone in both endurance and resistance exercises (Ivy et al., 2003; Karp et al., 2006; Cockburn et al., 2008).

Although previous research has established some evidence about the benefits of chocolate milk as a recovery drink, the existing studies utilized primarily male subjects, untrained individuals with very limited or no regular training schedule, and/or utilized individuals participating in endurance type activities. Thus, it is not known whether chocolate milk has similar beneficial effects in trained individuals, females, and/or those participating in non-endurance sports that focus on strength and/or power, speed, and agility. The purpose of this study was to examine the effects of chocolate milk post-resistance workout consumption on changes in body composition, muscular power, and speed and agility in a sample of NCAA Division I collegiate female athletes.

CHAPTER III

METHODOLOGY

Research Design and Subject Recruitment

This experimental study assessed the influence of skim chocolate milk on performance-related outcomes and body composition utilizing a convenience sample of competitive Division I female collegiate softball players at Oklahoma State University (OSU). The study was completed between August and December of 2012, the official off-season training phase of the OSU softball team.

A written approval to conduct the study was obtained from the strength and conditioning coach as well as the head coach of the softball team prior to the beginning of the study (Appendix A). In order to recruit subjects, a group meeting with the Principal Investigator (PI) and the OSU softball players was scheduled by a certified athletic trainer. Potential subjects were informed of the purpose, nature and details, as well as any risks associated with participation in the study during a meeting. Interested individuals were asked to return the signed informed consent form to the PI at the end of the group meeting (Appendix B). The subject inclusion criteria included: current member of the OSU softball team and no injury or illness that would prevent the individual from completing any part of the study (e.g., vertical jump, broad jump, speed and agility, and strength and conditioning training). If a lactose intolerant player volunteered for the study, she was automatically assigned to a carbohydrate group that consumed lactose-free treatment during the study. After the completion of the subject recruitment, a list of subject pairs, matched for height (in), weight (kg), and age (yrs), was created and subjects from each pair were randomly assigned to one of two groups: Chocolate Milk (CM) group or Carbohydrate (CHO) group. Subjects' ethnicities were mainly white, with two being of mixed race (Native American/white and black/white), and one of Hispanic descent. Data collection days and times were coordinated with the assistance of the team's certified athletic trainers and strength and conditioning coach. All of the study procedures related to subject participation and outcome measures were reviewed and approved by the University Institutional Review Board (IRB) prior to any data collection (Appendix C).

Upon the approval from the IRB, the group meeting with potential subjects was scheduled. As NCAA student athletes, subjects had already completed a medical physical exam and received medical clearance from the OSU sports physician. This clearance served as the medical approval to participate in the study. In addition, any subjects who consented to participation in the study and were cleared with no apparent medical conditions as indicated on the medical clearance form was asked to participate. Subjects participated in two separate data collection sessions, one at the beginning (pretest) and end (post-test) of the 12-week training period. The first data collection was scheduled upon return to the fall semester (Aug. 2012). The second session was scheduled at the end of the fall season (November 2012). Testing consisted of measurement of height and weight, 7-day food records, whole-body scan using DEXA, vertical jump, broad jump, speed (20 yard dash), and agility (T-test). Detailed verbal and written instructions were provided to all subjects prior to all testing. All power, speed, and agility tests were measured by the strength and conditioning coach in the OSU weight room located in OSU Athletic Center. Height, weight, and the whole-body scan using DEXA were performed in Nutrition Assessment lab located in the Nutritional Sciences Department.

Anthropometric Measures

For each subject, a folder was created with an assigned ID for confidentiality. Anthropometric data, including height (cm), weight (kg), age (yrs), and whole body composition using Dual-Energy X-ray Absorptiometry (DEXA; QDR 4500A Hologic, Inc), was assessed during each visit. DEXA is noninvasive and is currently the most accurate scan that measures body composition and bone density (Visser, Fuerst, Lang, Salamone, & Harris, 1999). DEXA scanners uses a fan-beam X-ray source coupled with multiple detectors, which give them the advantage of a faster scanning speed (Visser et al., 1999). As the scanner passes over the body, data is recorded by the software accompanying the system, detailing the soft tissue composition and bone density. Subjects were asked to dress comfortably, as scrubs were provided, and to remove any metal (including belly rings, nose rings, bracelets, ear piercings and rings). Prior to scanning, subjects were asked to complete a pregnancy test. Refusal of the test was permitted; however subjects that refused to submit a pregnancy test were not allowed to have the DEXA scan. Subjects that did not receive the DEXA scan could still participate in other measurements if they choose to do so. During the scan, subjects laid on an examination table while a machine arm passed over their body. Analysis of the scan included a comparison of fat mass (kg) and lean body mass (kg), both pretest and posttest, as well as a comparison of % body fat. There was no discomfort associated with the scan and it lasted approximately 10-15 minutes including all of the preparation procedures. The x-ray exposure from DEXA is smaller than the exposure received from a chest x-ray (approximately 10 times less). The patient radiation dose from a DXA examination depends on a number of parameters, such as the number of images, the size of the patient, the specific design of the device, beam filtration, the tube current, the tube potential, the imaging speed and the imaging length and width (Damilakis, Adams, Guglielmi, & Link, 2010). There are potential risks associated with DEXA for the females participating in this study, however, the potential risk to an individual associated with techniques used for the assessment of bone status is very small because radiation doses are low (Damilakis et al., 2010). Subjects could not be pregnant while participating in this study. Although the radiation dose from the DEXA scan is low, there may be some risks to an embryo or fetus, including birth defects (Damilakis et al., 2010). Because of this possible risk, pregnancy tests (urine tests) were provided for all participants in this study. If pregnancy was confirmed, subjects were not allowed to have the DEXA scan performed.

Upon completion of DEXA, subjects were given detailed instruction on how to accurately record consumption of all foods and beverages on a 7-day food record, including portion size, cooking preparation, and location of restaurant if eating out (Appendix D). The food record was completed by each subjects at home, thus a one-week deadline was given to all subjects for completion of the 7-day food records. Food records were submitted to the strength and conditioning coach or the athletic trainer in a sealed envelope and delivered to the PI as soon as possible. Subjects completed a set of 7-day food records at baseline, at week 6, and week 12 of the 12-week study.

Power Tests

Upon completion of all anthropometric assessments, subjects were asked to report to the

OSU athletic weight room located in the OSU Athletic Center, at a scheduled date and time to complete baseline exercise testing for power, speed, and agility. Modifications in performance data collection received approval from the University Institutional Review Board. All testing was monitored by the strength and conditioning coach. Muscular power testing was scheduled to take place in the OSU athletic weight room located in the OSU Athletic Center, and involved the vertical jump test (using the Vertec Floor Model) and the broad jump. For the vertical jump test, subjects were instructed to lower to a self-selected depth and accelerate as rapidly as possible with the intent of jumping for maximal height for a total of two jumps per trial. A measuring stick and tape measure were used to record the measurements for the broad jump. These exercise tests were repeated again at the end of the twelve week period. Due to pre-existing injuries that some of the subjects had been treated for prior to the study, scheduling conflicts, and other undisclosed reasons by the head coach, only 6 of the subjects in the CM group and 4 of the subjects in the CHO group were able to complete both the vertical jump and broad jump tests.

Speed and Agility Tests

Baseline testing for speed was measured by the 20-yard sprint test using Electronic 40-timers. The distance of 20 yards, measured out by the strength and conditioning coaching staff, was used as this is the distance from home plate to first base. Each subject completed two trials with 60 second rest in between each run. The average time between the two runs was recorded for each participant. Agility is defined as the ability to change speed and direction rapidly, without losing balance, using a combination of strength, power, and neuromuscular coordination. The agility test the participants performed was the t-test, which consisted of placing four cones in a t-shape. When given the signal to start, subjects sprinted from cone #1 to cone #2, touched the base of the cone with dominant hand, shuffled to the left 5 yards and touched the base of cone #3. From there, the subject shuffled 10 yards to the right and touched the base of cone #4; shuffled 5 yards back to cone #2 and touched the base, then sprinted back to cone #1. The test was timed with a stopwatch, and the average of two trials was recorded. As with the vertical jump and broad jump test, these exercise tests were repeated again at the end of the twelve week period. Due to pre-existing injuries that some of the subjects had been treated for prior to the study, scheduling conflicts, and other undisclosed reasons by the head coach, only 5 of the subjects in the CM group and 3 of the subjects in the CHO group were able to complete the 20 yard dash test and 5 in the CM group and 4 in the CHO group completed the pro-agility tests.

Treatment Groups

Subjects were randomly assigned to two groups: CM or CHO, and each group received 16oz of treatment (Table 3.1). Due to the practical nature of this study, it was determined that 500mL would be a sufficient and most feasible amount for the subjects to consume as a one-time treatment following resistance training, over a three day period (Elliott et al., 2006; Cockburn et al., 2012). For the CHO group, 8oz of water was added to the container with 8oz of carbohydrate drink concentrate (two 4oz packets), to keep both treatments isovolumetric and similar in calorie and carbohydrate content. Both groups received their respective drinks immediately following resistance training and were asked to consume them within 60 minutes of the workout. Subjects were instructed by the PI to maintain normal dietary patterns throughout the duration of the study.

Training Regimen

Subjects participated in a regular 12-week off-season training program, consisting of both resistance and conditioning sessions. For the purpose of this study, subjects were provided with either CM or CHO treatment immediately after resistance workout session, 3 times a week. They were asked to consume the assigned treatment within 60 min of the workout. PI and research assistants were present to ensure compliance with the treatment consumption and to record the volume of treatments that were not consumed if needed.

Table 3.1: Nutrient Composition of Fat-Free Chocolate Milk and Carbohydrate Drink

Nutrition Ingredient	Fat-Free Chocolate Milk 16oz	Commercially available carbohydrate concentrate 16oz
Energy (kcal)	260	200
Protein (g)	16	0
Fat (g)	0	0
Carbohydrate (g)	48	50

Calcium (%)	60	0
Vitamin D (%)	25	0
Sodium (mg)	360	220

Note: Data above obtained from www.wallmart.com

Softball is classified as a low-endurance, precision skill sport that requires fine motor control, coordination, and quick reaction time (Hara, 2006). The exact training regimen was developed by the strength and conditioning coach. It included resistance and fitness training specifically designed for the unique needs of the sport of softball (Table 3.2). The regular resistance program was implemented during the 12-week study, consisting of 3-4 resistance training workouts each week. Subjects were asked to refrain from eating and drinking anything except water 2-hours prior to training. Immediately following the last resistance exercise, subjects were asked to consume 200kcal or 260kcal of their assigned treatment (500mL of CM or 2 CHO packets with 8oz of water), within 60 minutes. Treatment was administered one time following resistance training, three times a week for the 12-week duration of the study.

Statistical Analysis

All data was analyzed using SPSS 21.0 software for Windows. Results are expressed as mean ± SE, and differences were considered significant at $P<0.05$. Independent T-tests were used to compare the means for height, weight, and age between the two groups. A two-way analysis of variance (ANOVA) with repeated measures design with time as the within-subjects factor and group as the between-subjects factor was used to analyze all body composition variables, power, speed, and agility changes, and dietary variables.

Table 3.2: Example of a 1-Week Workout Schedule for Female Softball Players

	Activation	Movement Prep	Speed Dynamic Warm-up	Linear Acceleration	Strength Training	Mobility/Soft Tissue Work
Monday	Barefoot Walks, Quadruped Hip Complex	Dynamic Flex Series, Hurdle Series	Skip Series	Run Rocket, 20 yard dash, Different Starts, Standing Dynamic Starts, Linear Bounds	Hang Clean, Split Squat, Bent Over Row, RDL	Ankle, Hip, T-Spine
Tuesday	Mini-Band Monster Walks (Lateral and Backwards)	Dynamic Flex Series, Lunge Series	Lateral + Multi-Direction Movement	Competitive Game (Ultimate Frisbee, Trashcan Basketball, Football, Capture the Flag, etc.) Footwork, Open Agility w/Banded Resistance or Weighted Vest, 60 Yard Shuttle	Goblet Squat, Double KB Squat, Seated Box Jump, GHR, Lateral Slide-Board + Ropes, Cable Column, Farmer's Carries, Weighted Abs	Ankle, Hip, T-Spine
Wednesday	Barefoot Walks, Quadruped Hip Complex	Dynamic Flex Series, Hurdle Series	Skip Series	Run Rocket, Sled/Bands, Flying 40's, In-Outs, Hurdle Hops, Competitive Sprints	Pull-Up, Rear-Delt Variation, Push-Up, Horizontal Pull, Plank Series	Ankle, Hip, T-Spine
Thursday	Mini-Band Monster Walk (Lateral and Backwards)	Dynamic Flex Series		Conditioning: Sled Pushes-Forward Walk, Backward Walk	Gauntlet, Tire Flips, Farmers Carries, Seated Rope Sled	Ankle, Hip, T-Spine

CHAPTER IV

RESULTS

A total of sixteen Division I female collegiate softball players participated in this study. Subjects were of similar age, weight, and height (Table 4.1). Independent t-tests indicated no significant differences in the mean age, weight and height. Subject compliance with treatment drinks, given three times per week for 12 weeks, was excellent with all subjects in both CM and CHO- consuming all of their treatments within the allotted time period, 94% ± 4.7% and 95% ± 3.5% respectively. Because of injury early in the study, two subjects in the CHO group and one subject in the CM group missed one or two treatments due to absence from training. However, no subjects were excluded from the study because they completed at least 75% of the treatment within the 12 weeks. The CM drink protocol was well tolerated with no major adverse side effects of increased dairy consumption.

The exercise protocol in the study was part of the team's regular off-season training program and consisted of both fitness and strength training sessions. Two subjects reported injuries early in the study, but still participated in some exercises with the consent of the athletic trainers, and consumed treatment drinks for the 12 weeks of the study. Since the subjects were allowed to participate in the exercises, under supervision, and completed treatment for the 12 weeks, they were not excluded from final analysis.

Dietary Measures

Dietary intake data for the CM and CHO groups, as estimated from 7-day food records pre-intervention, mid-intervention and post-intervention, are presented in Table 4.2.
The additional calories and nutrients consumed for each drink are included in the data. A two-way repeated measure ANOVA revealed no significant differences (p = .07, .11, .92, .12) between groups for total calories, carbohydrate, protein, or fat intake respectively, across the three time periods (Table 4.2).

Body Composition

The potential influence of chocolate milk versus carbohydrate drink treatment on the subjects' body composition was assessed using DEXA. Pre and post-intervention DEXA measurements were completed with all subjects participating in the study. A two-way repeated measure ANOVA was conducted to assess the impact of consuming CM and CHO three times a week for 12-weeks on total body mass, lean mass, fat mass and percent body fat (%). Data from this analysis are presented in Table 4.3.

Total Mass, Lean Mass, and % Body Fat

The interaction effect between the treatments (CM vs. CHO) and time in total body mass was not found to be statistically significant, Wilks' Lambda = .99, $F(1,14) = .12$, p =.74, partial eta squared = .01 (figure 4.1). No significance was found for the main effects comparing the two types of interventions (F (1,14) = .25, p = .63, partial eta squared = .02) and time ($F(1,14) = .02$, p = .90, partial eta squared = .02), suggesting no difference in the influence of the two drinks on changes in total body mass over the 12 week period. There was no significant interaction between CM and CHO interventions and time in lean mass, Wilks' Lambda = .97, $F(1,14) = .42$, p=.53, partial eta squared = .03 (figure 4.2). No significant differences were found in lean mass between the CM and CHO groups, $F(1,14) = .24$, p = .63, partial eta squared = .02, nor across the two time periods, Wilks' Lambda = .99, $F(1,14) = .09$, p = .77, partial eta squared = .01, thus suggesting no difference in the effectiveness of the two drinks on increases in lean mass.

An analysis assessing the impact of CM and CHO beverages on fat mass and % body fat across two time periods (pre-intervention and post-intervention) showed no significant interaction between the beverages and time, Wilks' Lambda = .97 and .69, p = .55 and p = .71, respectively. There was no significant difference for main effect of time for fat mass, $F(1,14)$, p = .29, partial eta squared = .08, however, there was a significant main effect for time, $F(1,14)$, $p <0.05$, partial eta squared = .31, with % body fat in both groups, thus indicating an increase in % body fat across the two time periods (figure 4.3). The main effect comparing the two types of beverages on fat mass $F(1,14)$, p = .55, partial eta squared = .03, and % body fat, $F(1,14)$, p = .71, partial eta squared = .01, were not found to be significant.

Performance Measures

The emphasis of most strength and conditioning programs is to improve strength, power, speed, and change of direction ability in athletes (Nimphius, McGuigan, & Newton 2010). As part of the regular training program, subjects underwent a variety of testing both at baseline and at the end of the training protocol. The intake of CM or CHO three times per week for twelve weeks was the only change in what would otherwise be normal off-season training.

Vertical Jump and Broad Jump

A two-way analysis of variance was conducted to assess the impact of two treatment interventions (CM and CHO) on explosive leg power using the vertical jump test. Results of the vertical jump for both groups showed no significant interaction between inches jumped and time, Wilks' Lambda = .97, $F(1,8) = .22$, p = .66, partial eta squared = .03. There was a significant main effect for time, Wilks' Lambda = .54, $F(1,8) = 6.90$, $p<0.05$, partial eta squared = .46, with both groups demonstrating an increase in jump height across the two time periods (figure 4.4).

The main effect comparing the two types of drinks, CM and CHO, was not significant, $F(1,8) = .15$, $p = .71$, partial eta squared = .02, thus suggesting no difference in the effectiveness of the two drinks.

The standing broad jump, another easy to administer test of explosive leg power, was the second test used in this experiment. Results from analysis indicated no significant interaction between the two groups and time, Wilks' Lambda = .91, $F(1,8) = .82$, $p = .39$, partial eta squared = .09. There was trend toward significance in the main effect for time, Wilks' Lambda = .64, $F(1,8)$, $p = .07$, partial eta squared = .36, however, no significance found for the main effect comparing CM and CHO, $F(1,8) = .24$, $p = .64$, partial eta squared .03 (figure 4.5). These results also suggest no difference in the effectiveness between CM and CHO on explosive leg power.

Speed and Pro-agility

Analysis of the 20 yard dash revealed no significant interaction between the two treatment groups and time, Wilks' Lambda = .70, $F(1,6) = 2.54$, $p = .16$, partial eta squared = .27. A significant main effect for time was observed, Wilks' Lambda = .42, $F(1,6) = 8.29$, $p<.05$, partial eta squared = .58, indicating that both groups grew faster over the two time points (figure 4.6). The main effect comparing the two types of drinks was not significant, $F(1,6) = .19$, $p = .68$, partial eta squared = .03, suggesting that the increase in speed over time was similar for both treatment groups.

Results from the pro-agility t-test also showed no significant interaction between the two treatment groups and time, Wilks' Lambda = .92, $F(1,7) = .63$, $p = .45$, partial eta squared = .08. A strong significant main effect for time was observed, Wilks' Lambda = .23, $F(1,7) = 22.29$, $p<0.05$, partial eta squared = .76, suggesting that both groups increased in quickness over the two time points (figure 4.7). There was no significance discovered for the main effect comparing the two drinks, $F(1,7) = 1.76$, $p = .23$, partial eta squared = .20, thus suggesting no difference between the groups on the pro-agility performance test.

Table 4.1 - Descriptive Characteristics of Female Softball Players[a].

Variable	Chocolate Milk (CM) (n=8)	Carbohydrate (CHO) (n=8)	P-Value
Age (years)	20±1.98	20±1.41	.89
Height (in)	65.40±1.97	65.98±2.05	.58
Weight (kg)	72.97±10.79	76.56±17.64	.63

[a]Data is presented as mean ± SD for each group (n=16).

Table 4.2 - Estimated energy intakes before (pre), during (mid), and after (post 12 wks.) exercise training and treatment[a].

	CM (n=8)			CHO (n=8)			P-value
Variable	Pre	Mid	Post	Pre	Mid	Post	
Energy ($kcal\cdot d^{-1}$)	2030.06± 741.63	1886.40± 551.98	1607.97± 250.89	1685.55± 285.96	1834.70± 466.69	2021.38± 454.74	.07
CHO($g\cdot d^{-1}$)	252.90± 136.89	239.99± 76.07	188.81± 42.83	219.99± 43.86	247.77± 60.37	269.82± 68.93	.11
Fat($g\cdot d^{-1}$)	81.12± 30.30	73.36± 29.56	66.47± 12.55	60.89± 13.78	65.15± 23.46	75.19± 23.39	.12
PRO($g\cdot d^{-1}$)	66.06± 25.04	77.32± 24.00	72.23± 10.62	68.89± 20.67	77.49± 11.09	75.37± 10.95	.92

[a]Data is presented as mean ± SD for each group (n=16).

Table 4.3 – Body composition of the softball players from pre- to post-intervention[a].

Variable	CM (n=8)		CHO (n=8)		P-value
	Pre	Post	Pre	Post	
Total Body Mass (kg)	72.86±10.70	73.02±11.05	76.59±17.57	76.23±15.09	.74
Lean Mass (kg)	50.23±5.76	49.49±5.81	51.48±8.28	51.76±8.83	.53
Fat Mass (kg)	19.96±5.03	20.86±5.43	22.36±9.13	22.61±6.93	.55
Body Fat (%)*	27.00±3.51	28.14±3.81	28.36±4.42	29.20±2.96	.71

[a]Data is presented as mean ± SD for each group (n=16).

*Main effect for time ($p<.05$)

Figure 4.1: Total Mass (kg) before and 12 weeks post-intervention in CM (n=8) and CHO (n=8)

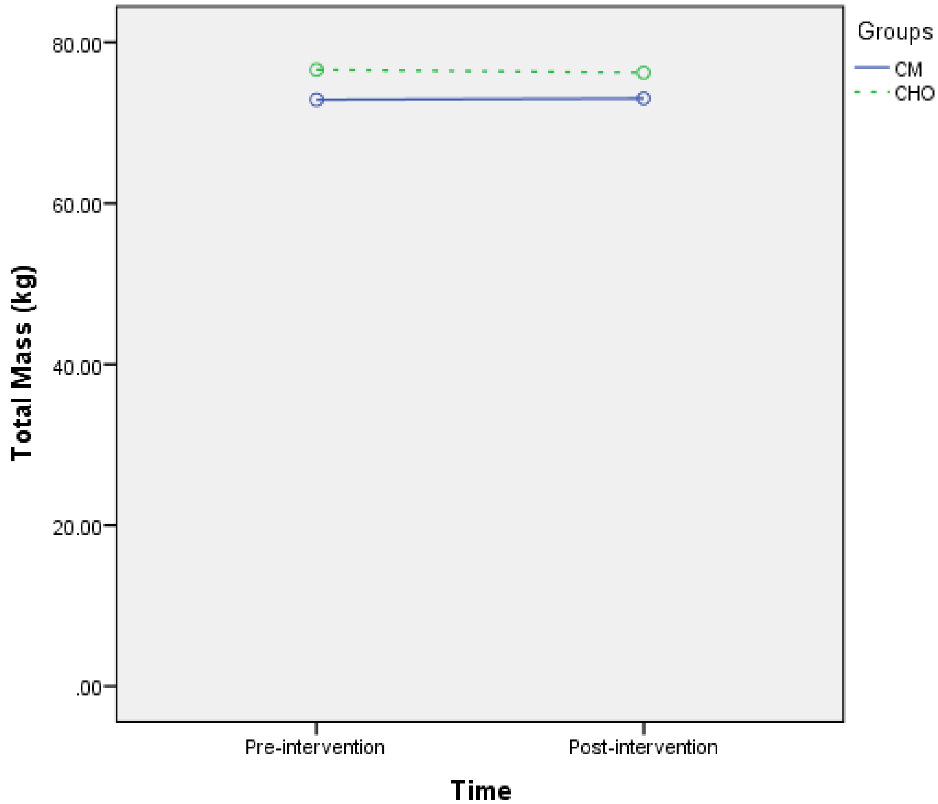


Figure 4.2: Lean Mass (kg) before and after 12 weeks in CM (n=8) and CHO (n=8)

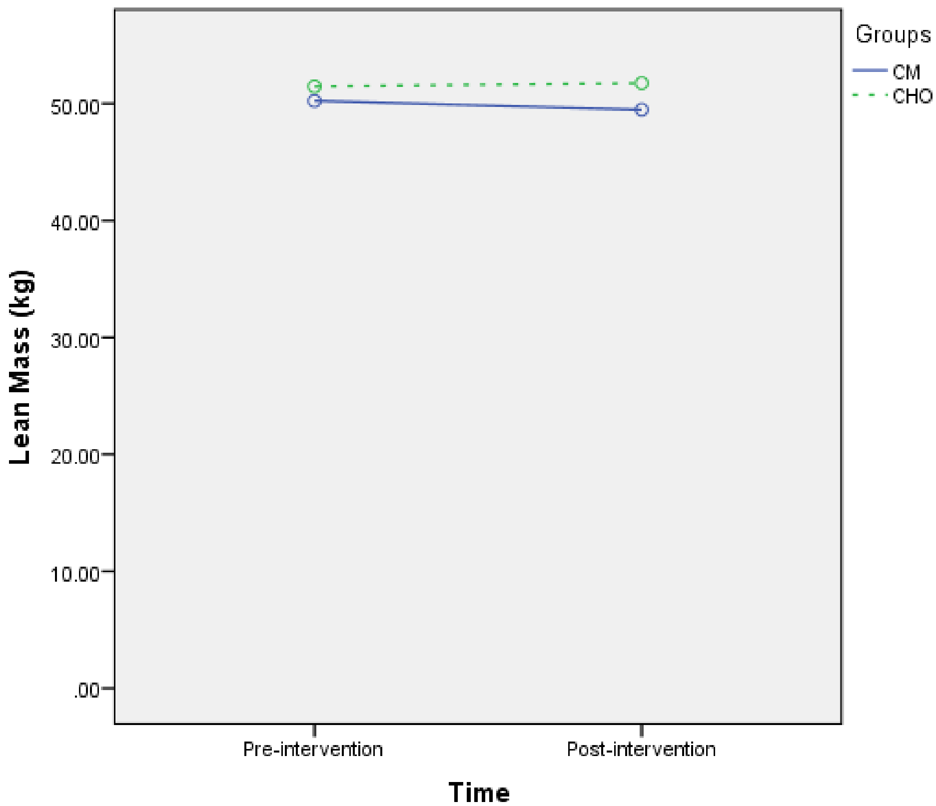


Figure 4.3: Percent Body Fat (%) before and after 12 weeks in CM (n=8) and CHO (n=8)

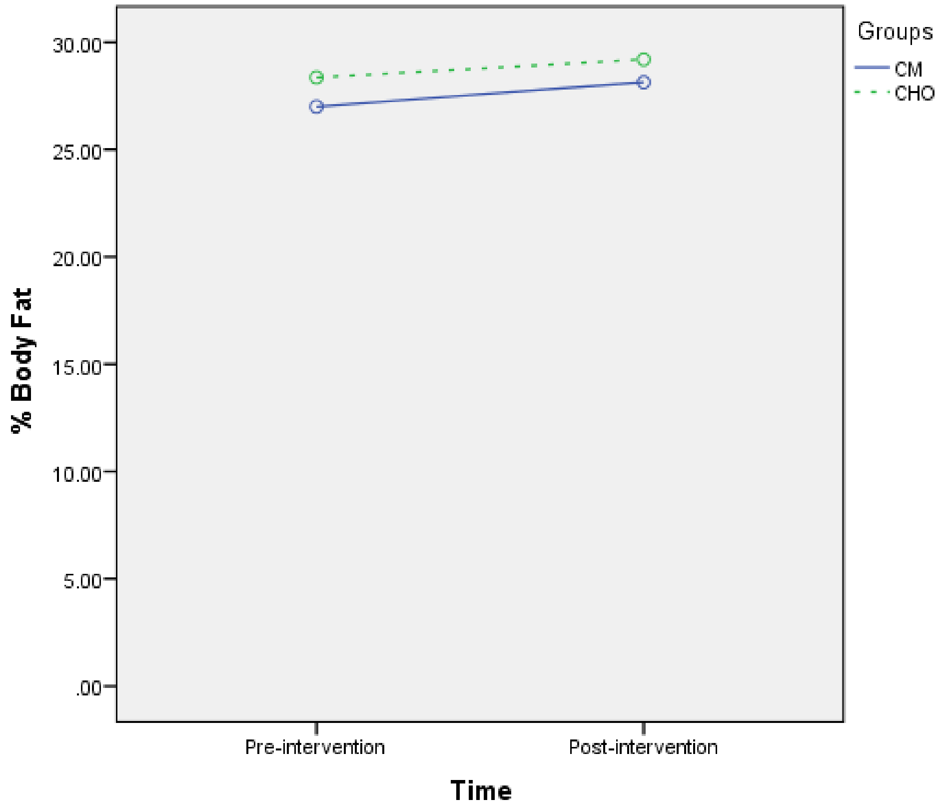


Table 4.4 – Performance measures of the softball players pre- and post-intervention[a].

Variable	CM		CHO		P-value
	Pre	Post	Pre	Post	
Vertical Jump (in)*	19.67±1.72	20.92±1.32	19.38±2.84	20.25±2.40	.66
Broad Jump (in)	74.00±4.29	76.17±4.31	73.00±6.16	73.88±7.40	.39
Pro-agility(s)*	5.04±.11	4.84±.07	5.20±.36	5.05±.24	.45
20 y dash(s)*	3.16±.12	2.99±.18	3.15±.22	3.10±.18	.16

[a]Data is presented as mean ± SD for each group.

*Main effect for time ($p<.05$)

Figure 4.4: Vertical jump (in) before and 12 weeks after in CM (n=6) and CHO (n=4)

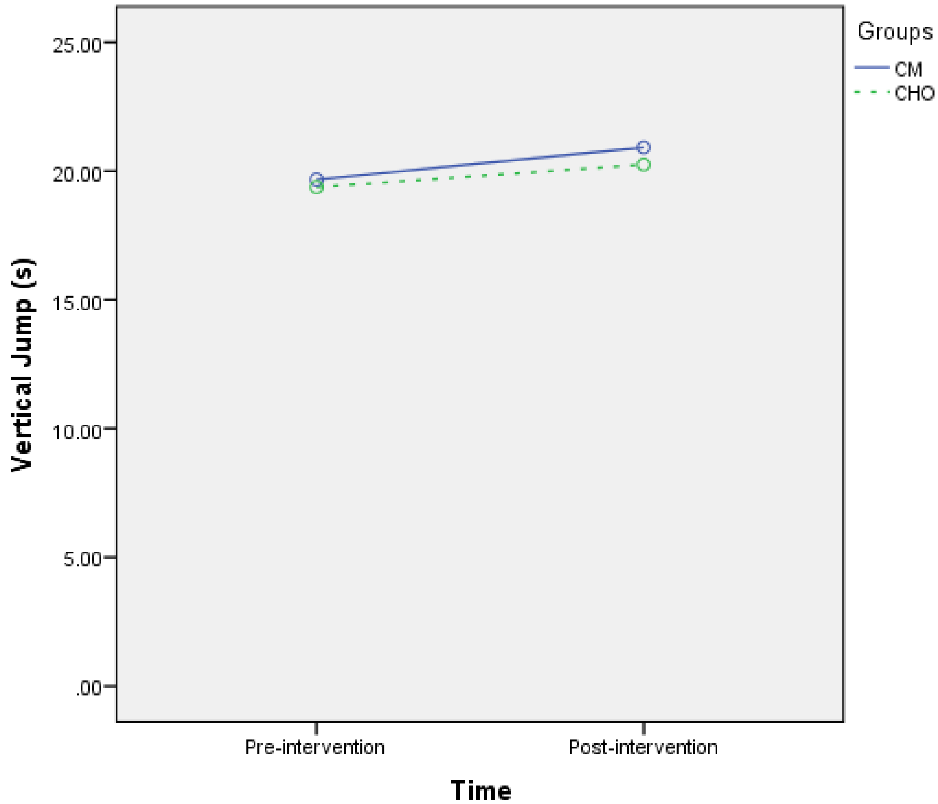


Figure 4.5: Broad jump (in) before and 12 weeks after in CM (n=6) and CHO (n=4)

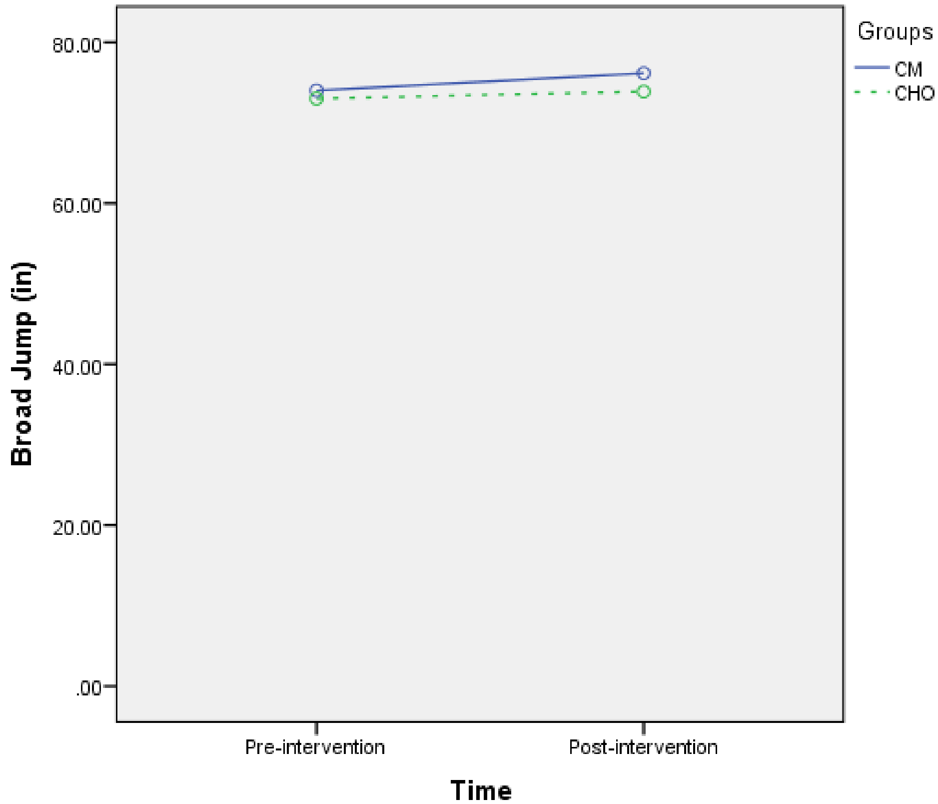


Figure 4.6: Speed 20 yard dash (s) before and after in CM (n=5) and CHO (n=3)

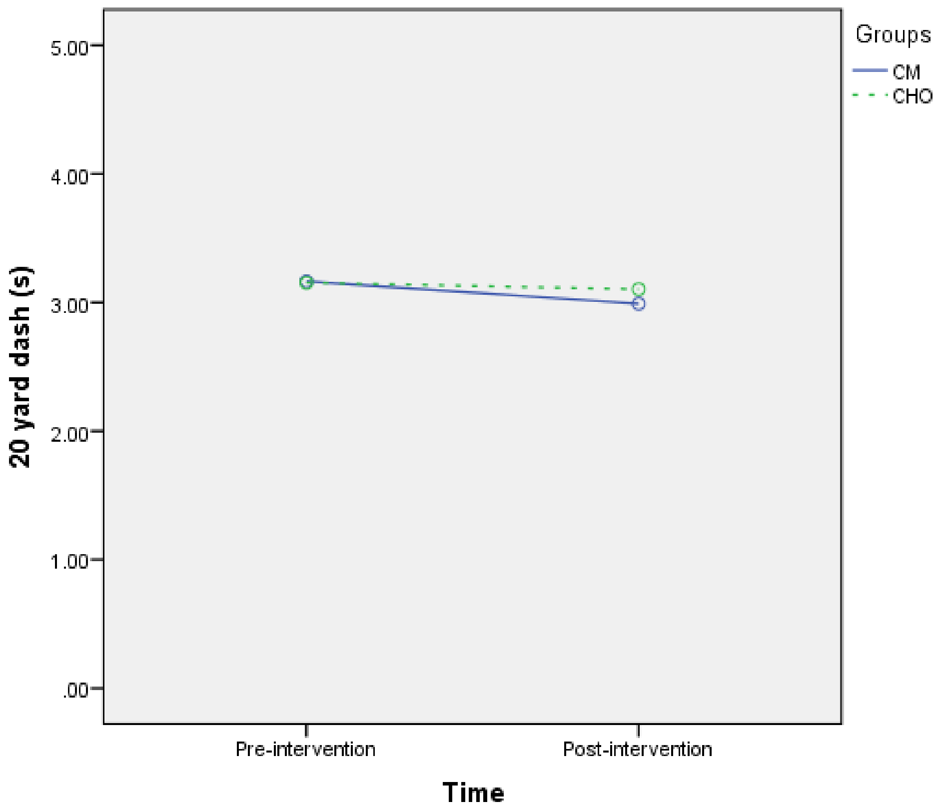
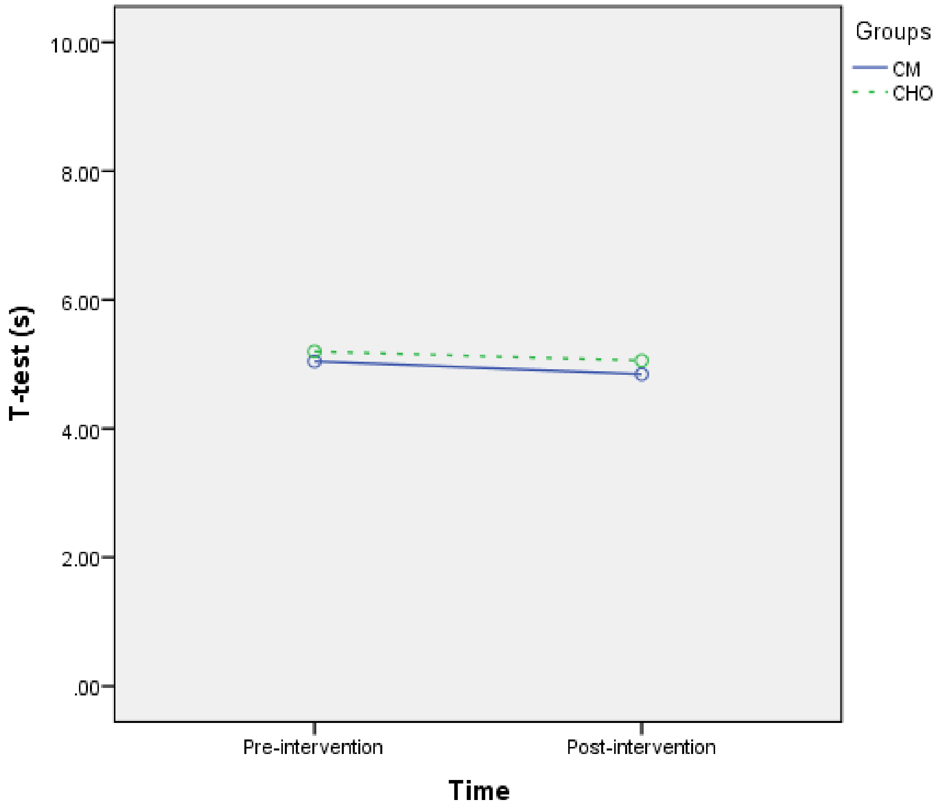


Figure 4.7: Pro-agility t-test before and 12 weeks after in CM (n=5) and CHO (n=4)



CHAPTER V

DISCUSSION

The main purpose of this study was to examine the potential effects of skim chocolate milk supplementation on power, speed, agility, and body composition, after a 12-week off-season training program among NCAA collegiate softball players. In this exploratory study, consuming 16oz of chocolate milk three times per week for 12-weeks did not increase lean tissue and/or decrease percent body fat, nor did it improve performance measures compared to consumption of 16oz of an isocaloric carbohydrate drink, matched with chocolate milk for carbohydrate content. Although both groups showed improvements in power, speed, and agility, over time, the effect was attributed to time (over the 12 week period) rather than type of post-training treatment.

Body Composition

In the current study, no significant differences in body composition, specifically in lean mass or body fat mass were observed between softball players consuming 16oz of skim chocolate milk or 16oz of the commercially available carbohydrate sports beverage. A study conducted by Rankin et al. (2004) showed similar results in that no differences in body composition were observed between untrained males consuming a one-time dose of either low-fat chocolate milk or an isoenergetic carbohydrate-electrolyte beverage three times per week following resistance exercise. It was reported, however, that a statistical trend in differences existed and that they favored the subjects who consumed the fat-free chocolate milk in terms of body weight and fat-free mass (Rankin et al., 2004). The treatments given to each group were matched for calories based on body weight (5kcal/kg), but differed in volume and macronutrient content. A study conducted by White, Bauer, Hartz, & Baldridge (2009) examined if yogurt, containing 5g of protein and 19g of carbohydrate, had an effect on body composition compared to a protein:carbohydrate supplement and a carbohydrate only supplement, in untrained women. After three weight-training sessions per week for 8 weeks, no significant differences in body composition were observed between the three groups; however, a significant main effect of time was observed in all participants in terms of increased fat-free mass and decreased % body fat.

The results of these studies are similar to the current study, but contrast those found by Josse et al. (2010), who reported a greater significant increase in lean mass and a significant decrease in fat mass in women consuming 500 mL of skim white milk twice per session, 5 days per week for 12 weeks following resistance training compared to those given an isoenergetic carbohydrate drink. Given the fact that neither the current study nor the studies conducted by Rankin et al. (2004) and White et al., (2009), showed significant difference in body composition between groups, one possible explanation for these results was the fact that the subjects only received one dose of each drink or one 6 oz. container of yogurt immediately following resistance exercise three times per week, unlike those supplemented by Josse et al. (2010). Given the practical nature of this study, it was determined that a lower amount of each drink would be feasible, well tolerated, and provide the same effects as a larger amount of supplementation (Cockburn et al. 2012). It is possible that a larger amount of skim chocolate milk, given more frequently, would have contributed to greater changes in body composition in our sample; however feasibility of such treatment in practical settings is questionable.

Lean Muscle Mass

Unlike the studies conducted by Rankin et al. (2004) and White et al., (2009), no statistical trends were observed in gains in lean mass over time in the current study. Muscle protein synthesis is stimulated in the recovery period following resistance exercise and nutrient intake is necessary to achieve positive net muscle protein balance (Borsheim et al., 2002). A positive energy balance is needed to ensure optimal metabolic recovery, while a negative energy balance is associated with a protein catabolism, i.e. muscle protein breakdown exceeds muscle protein synthesis, which may compromise the mechanisms for muscle protein synthesis (Hausswirth et al., 2011; Tipton et al., 2004). It is possible that the subjects in this study were consuming enough macronutrients to maintain lean body mass throughout the study, but not enough calories to promote a positive muscle protein balance needed for muscle growth. Studies have demonstrated that the response of muscle protein metabolism to an acute resistance exercise bout lasts up to 48 hours, thus any meals consumed during this time will determine the impact of the diet on muscle hypertrophy (Phillips, Tipton, Aarsland, Wolf, & Wolfe, 1997; Tipton et al., 2001). In the absence of food intake, muscle protein synthesis and breakdown are increased in response to resistance exercise, however the rate of breakdown exceeds synthesis so that net protein balance remains negative (Biolo et al., 1999; Phillips et al., 1997 & 1999; Tipton et al., 2001).

Timing of the drinks may have also had an effect on the results. The timing of supplement ingestion may be crucial as to whether muscle protein metabolism will be enhanced compared to one's regular diet (Tipton & Wolfe, 2001). Each subject in this study received their respective drink within 60 minutes of completing resistance exercise. Studies conducted by Rasmussen et al. (2000) and Tipton et al. (2001) observed a greater anabolic response, in terms of muscle protein synthesis, when an amino acid-carbohydrate supplement was consumed before exercise. According to these two studies, the muscle protein synthesis that occurred was due to greater delivery of amino acids to the muscle, caused by an increase in arterial blood flow, which, in turn, is increased during an exercise bout (Rasmussen et al., 2000; Tipton et al., 2001). Since blood flow following exercise is not as high, delivery of post-exercise consumption of amino acids to the muscle is less in comparison to delivery of amino acids pre-exercise (Tipton & Wolfe, 2001); therefore it is possible that giving the subjects their drinks after exercise decreased the potential of muscle protein synthesis. Another possible explanation no significant changes were observed in the present study could be the duration of the study not being long enough. According to Tipton (2001), it would take approximately 1 year before any effect of a dietary supplement plus resistance training could be distinguished from the training alone. A study of this extent would require control of the subjects' diet, exercise, and other lifestyle variables and would not be realistic for collegiate athletes to participate in.

Percent Body Fat

In the current study, % body fat did not change with either the consumption of low-fat chocolate milk or a carbohydrate-electrolyte drink following a bout of resistance exercise over the course of 12 weeks. This is in contrast to studies showing that resistance exercise can contribute to loss of body fat (Winett & Carpinelli, 2001), even more so when combined with consumption of milk (Josse et al., 2010). It has been suggested that dietary calcium plays a role in the regulation of energy metabolism, in that circulating vitamin D ($1,25(OH)_2D$) and parathyroid hormone (PTH) increase as a result of low calcium intake and low blood calcium concentrations, and as a consequence, calcium entry in the adipocytes is higher than normal, thus signaling lipogenesis (Gropper et al., 2009). Referencing this mechanism, Josse et al. (2010) suggested that the significant loss of fat mass in the subjects who consumed milk was possibly due to the observed reduction in PTH that may have decreased $1,25(OH)_2D$, thereby increasing lipolysis. In a study to determine the effects of dairy consumption on adiposity and body composition in obese African Americans, results showed that those consuming three servings of dairy per day were found to have significant reductions in total and central adiposity without weight loss or caloric restriction (Zemel, Richards, Milstead, & Campbell, 2005). Another key finding from the study by Zemel et al., 2005, was that when calories were restricted, dairy foods seemed to accelerate weight loss and total and central body fat. This theory is interesting to consider since none of the subjects in this study, in either group, had consumed insufficient amounts of calcium, according to the 7-day food records and, although advised to keep the same dietary habits throughout the study, overall caloric intake varied pre-, mid-, and post-intervention between both groups.

Before committing to this theory as a possible explanation for the lack of body fat loss in this study, a few thoughts should be mentioned. First, many of the studies that support this theory were observational studies that showed an inverse association between dietary calcium intake and body fat, and seem to suggest that calcium influences energy balance favorably in the growing groups of people with weight problems (Astrup, 2008). For example, in a 2-year exercise intervention study examining the effects of exercise on bone measures in women age 18-31yrs, conducted by Lin, Lyle, McCabe, McCabe, Weaver, & Teegarden (2000), a secondary analysis of the relationship of diet and body composition was also performed over the two years. Results from this analysis found that the ratio of dietary calcium to energy and the ratio of dairy calcium to energy were negative predictors of changes in both body weight and fat (Lin et al., 2000). Although interesting, results from the intervention showed no significant difference in body composition between the exercisers and non-exercisers and stated that individual subjects both gained and lost body weight, fat, and lean mass over the two years (Lin et al., 2000). Researchers did note the possibility of other components of dairy products, which were not analyzed in this study, could have been factors that influence body weight (Lin et al., 2000). Second, low dietary calcium intake does not necessarily mean plasma values will also be low or that increased calcium intake will result in increased lipid oxidation. Given the varying BMI recorded in this study and the fact that no participant showed a significant decrease in % body fat following treatment, more research is needed in this area before a definitive statement can be made regarding calcium and loss of body fat. Third, the study conducted by Josse et al. (2010) does not mention whether the subjects engaged in exercise activity, such as aerobic exercise, outside of the study. At the present time, significant changes in % body fat over time most likely could be attributed to dietary intake, not necessarily reported on the 7-day food records, and a lower intensity training protocol that was more focused on increasing fitness.

Treatment Effect on Performance Measures

In this study**,** consuming 16oz of chocolate milk three times per week for 12-weeks was not associated with improvements in performance measures compared to consumption of 16oz of an isocaloric carbohydrate drink, matched with chocolate milk for carbohydrate content. Most coaches prescribe programs to improve muscular strength and power in an effort to translate these improvements into decreases in speed and agility times (Nimphis et al., 2010). Chronic exercise produces many neuromuscular adaptations and the extent of these adaptations depends on the type of training program (Kenney et al., 2010). The emphasis of most strength and conditioning programs is to improve strength, power, speed, and agility in athletes however, most subjects in research utilizing strength training are untrained, i.e. have not participated in weight lifting (Kenney et al., 2010; Nimphius, McGuigan, & Newton 2010). Because the subjects in this study were trained athletes, it is possible that the training status of the subjects influenced the results in that the intensity of their training protocol was not enough to challenge the muscles in terms of observable changes in lean mass (Tipton et al., 2001). However, in a study conducted by Chilibeck, Calder, Sale, & Webber (1998) it was concluded that a more prolonged neural adaptation related to the more complex exercise movements such as bench press and leg press, and that this may have delayed hypertrophy in untrained women undergoing a 20 week resistance training protocol. It was also discovered that with simpler exercises, such as the arm curl, early gains in strength were observed along with muscle hypertrophy (Chilibeck et al., 1998). Since the training protocol for the participants in this study focused on whole-body complex exercises, this could possibly explain why there was a significant increase in performance measures over time in both groups without seeing an increase in lean muscle mass. In addition, adequate nutritional intake is important for optimizing sport and exercise performance and for optimizing adaptations to training (Roy, 2008).

Dietary Intake

A secondary nutrition-related outcome of the study was the estimated energy intake among the subjects in each group. Although not statistically significant, it is apparent that the caloric intake in the CM group decreased from pre-intervention to post-intervention, while the caloric intake in the CHO group increased. This finding had no significant effect on body weight, both within and between the groups, however a significant main effect over time was observed for % body fat. As previously mentioned, underreporting on the 7-day food records could possibly explain these results.

According to the Dietary Reference Intakes (DRI) for young females like the female college students in our study, the average intake should have been 2967.38±297.41 and 3015.88±286.07 for the CM and CHO groups, respectively. Conferring to the results, none of these daily averages were met pre-, mid-, or post-intervention for either group. According to Hornstrom, Friensen, Ellery, & Pike (2011), college athletes often turn to strength and conditioning staff, coaches, or other athletes for nutrition advice instead of dietetics professionals. The subjects in the current study were advised not to change their eating habits for the duration of the study. It is possible that the subjects received dietary recommendations outside this study that was not controlled by the PI, which could have possibly influenced the results.

Limitations of the Study

There are a few strengths as well as limitations associated with this study. One strength for this study is that it was feasible because treatments were only given once in a realistic amount that could be easily tolerated, within 60 minutes, immediately post-exercise. Other studies that used higher volumes of milk, given more frequently, reported favorable results in terms of body composition (Josse et al., 2010); however, this did not necessarily translate to increases in performance. Treatment volumes were based on the minimum amount shown to be beneficial in previous research and can be feasibly consumed by athletes. A second strength for this study was its practicality in that it was a field study in which the PI wanted to observe whether even this minimal amount may lead to significant impact on the outcome measures in female athletes. So far, little is known about these responses among women or athletes participating in various sports, or how they would respond in a practical setting.

A major limitation of this study was that there were a small number of participants and that the training protocol changed weekly (Table 3.2). The exercise the participants engaged in seemed to favor more fitness-type conditioning exercises that included low-intensity resistance training. Softball is classified as a low-endurance, precision skill sport that requires fine motor control, coordination, and quick reaction time (Hara, 2006), and as previously mentioned, the emphasis of most strength and conditioning programs is to improve strength, power, speed, and agility in athletes (Nimphius et al., 2010). The type of training the participants in this study engaged in could explain why the subjects significantly decreased their speed and agility over time.

A second limitation of this study was that because it was a field study and not controlled in a lab, subjects' exercise habits could not be controlled during the study. It is possible that the subjects participated in other types of training outside those provided by the strength and conditioning coach.

A third imitation of this study could be underreporting dietary intake. According to Goris, Meijer, & Westerterp (2001), it is known that underreporting can range from 0-50%, is observed in both obese and lean subjects, and might be due to under-eating or to under-recording. Subjects in this study were advised to maintain dietary habits throughout the study; however results showed a non-significant, decrease in caloric intake in the CM group and a non-significant increase in caloric intake in the CHO group. Because of practical and training reasons, exercise tests were conducted and measured by the strength and conditioning coaching staff. Testing days occurred on the same days as body composition assessments, and thus, could not be monitored by the PI as originally planned. Furthermore, due to recovery from previous injuries, scheduling conflicts, and other reasons not provided, some of the subjects did not complete either pre-testing or post-testing. This limitation decreased the number of subjects who completed all the study measurements and thus could have affected the final analysis of performance and body composition measures.

Future Recommendations

This study suggests that low fat chocolate milk, given as a one-time dose within 60 minutes following resistance training for 12 weeks, does not have an effect on body composition nor does it assist in enhancing performance outcomes such as speed, power and agility. The aim of training is to achieve optimum performance on the day of competition via three processes; training hard to create the required training stimulus, training smart to maximize adaptations to the training stimulus, and training specifically to fine-tune the behaviors needed for competition strategies (Maughan & Burke, 2011). Nutrition represents an important component of exercise performance as well as recovery from exercise. Recovery from strenuous exercise, whether resistance training, endurance training, or a combination of the two, is central to the ability of reaching performance potential after practice sessions or competitive events (Ferguson-Stegall et al., 2011). Majority of the studies that used milk or chocolate milk as a recovery beverage following training, have focused on endurance trained sports such as cycling or soccer (Gilson et al., 2010; Ivy et al., 2002; Spaccarotella & Andzel , 2011). Future studies should include utilization of CM for recovery in female collegiate athletes in a variety of sports and should be investigated further with a particular focus on practicality and feasibility of CM consumption related to training.

The macronutrient content in milk and chocolate milk has been implicated in many research studies to promote glycogen re-synthesis, stimulate muscle protein synthesis, and aid in rehydration. While this evidence is beneficial, many of studies are inconsistent with amount of macronutrients needed to promote these benefits, when these nutrients should be consumed, and how much the dosage should be. Therefore, further work is needed to better understand the physiological mechanisms by which milk exerts its actions following exercise and training (Roy 2008) and the amounts and timing needed to maximally promote these actions.

The theory that calcium plays a role in weight maintenance or weight reduction is controversial. None of the subjects in this study, whether consuming chocolate milk or a carbohydrate drink, showed a significant decrease in % body fat following treatment. Although there is good evidence to support the role of dietary calcium in weight regulation in general population, more research is needed in the area of fat loss among trained athletes.

Finally, many laboratory studies utilizing milk and chocolate milk have used fractional synthetic rate (FSR) to observe stimulation of muscle protein synthesis. While this method has shown to be extremely useful, few if any studies have shown that clinically significant increases in muscle protein synthesis relates to practical enhancement of athletic performance or if it helps the athlete recover faster from training induced muscle damage. Acute increases in protein synthesis could possibly lead to enhancements in the more chronic adaptations that occur with resistance training (Roy 2008), thus future research should focus not only on proving that chocolate milk can promote muscle protein synthesis, but also that these increases can possibly lead to actual enhanced performance.

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APPENDICES

APPENDIX A

Written Consent of Head Coach, Strength and Conditioning Coach, and Athletic Trainer

August 13, 2012

Stacy Campbell, Dr. Shriver, Dr. Betts
Department of Nutritional Sciences
301 Human Sciences
College of Human Sciences
Oklahoma State University
Stillwater, OK 740 78

Dear Ms. Campbell, Dr. Shriver and Dr. Betts,

This is to confirm that I have been informed about the research study titled "Effect of skim chocolate milk on strength, power, and body composition in NCAA Division I female softball players." I give permission for the research team to recruit potential volunteers for the study from the current members on the OSU Softball Team.

I understand the players' participation is completely voluntary. They have the right to stop participating in the study at any time and without any negative consequences.

Sincerely,

Rich Wieligman
Head Coach
OSU Softball Team

June 25, 2012

Oklahoma State University Institutional Review Board

RE: Nutrition-related Parameters, Dietary Intakes, and Food and Exercise-Related Attitudes among Division I College Softball Players

The Oklahoma State Athletic Department has reviewed this purposed research study by the Nutritional Sciences Department. This study will be a benefit to us and we look forward to putting it in.

Through this research we hope to learn better nutritional information to provide our athletes and coaches. The nutritional information should help out athletes and coaches to be more competitive in their athletic pursuits as well as help them to lead healthier lives when their athletic careers are over. Also, this information should help us to identify potential injury/illness risk factors and address these issues early before they become more serious problems.

We look forward to participating in this research project and hopefully others in the future.

Sincerely,

Callye Williams
Assistant Strength and Conditioning Coach
Oklahoma State University

OKLAHOMA STATE
Athletics Center • Home of Historic Gallagher-Iba Arena • Stillwater, OK 74078-5070

August 16, 2012

Stacy Campbell, Dr. Shriver, Dr. Betts
Department of Nutritional Sciences
301 Human Sciences
College of Human Sciences
Oklahoma State University
Stillwater, OK 740 78

Dear Ms. Campbell, Dr. Shriver and Dr. Betts,

This is to confirm that I have been informed about the research study titled "Effect of skim chocolate milk on strength, power, and body composition in NCAA Division I female softball players." I agree to assist the research team to recruit potential volunteers for the study from the current members on the OSU Softball Team.

I understand the players' participation is completely voluntary. They have the right to stop participating in the study at any time and without any negative consequences.

Sincerely,

ATC, LAT

Nathan Hoffmeier
Graduate Assistant Athletic Trainer
OSU Softball Team

APPENDIX B

Informed Consent Form

CONSENT TO PARTICIPATE IN A RESEARCH STUDY
OKLAHOMA STATE UNIVERSITY

PROJECT TITLE: Effects of skim chocolate milk and a carbohydrate beverage on strength, power, and body composition in NCAA Division I female softball players.

PROJECT LEADERS: Stacy Campbell; Lenka Shriver, PhD; Nancy Betts, PhD, RD; Department of Nutritional Sciences, Oklahoma State University

PURPOSE:
This study, which is a research project conducted for a dissertation, is being conducted through Oklahoma State University. The purpose of this study is to examine the effects of two different beverages on strength, power, and body composition in NCAA Division I female softball players. You have been selected as a possible participant because you are a member of the OSU softball team. The goal of this study is to examine effects of fat-free chocolate milk and a commercially available carbohydrate-electrolyte beverage on strength, power, and body composition. The results of this study will help us determine whether the two beverages produce significant changes in body composition and performance-related measures (strength and power) and whether one may be more beneficial than the other beverage. You must be 18 years or older to be able to participate in this study.

PROCEDURES:
You will be invited to make two visits to the Nutrition Assessment Lab in the Department of Nutritional Sciences during the off-season (the lab will be visited one time at the beginning and end of the off-season). Each visit will take approximately 1.5-2 hours.

Your body composition and bone density will be measured using the Dual-Energy X-ray Absorptiometry (DEXA), which is located in 307 HS in the Nutritional Sciences Department. DEXA is currently the most accurate scan that measures body composition and bone density. You will be asked to dress comfortably (we will provide scrubs for you to change into) and remove any metal (including belly rings, nose rings, bracelets, ear piercings and rings). During the scan, you will lay on an examination table while a machine arm passes over your body. We expect you to feel minimal discomfort and the scan will take approximately 10-15 minutes including all of the preparation procedures. The x-ray exposure from DEXA is smaller than the exposure received from a chest x-ray (approximately 10 times less).

Your height and weight will be recorded, followed by the DEXA scan. You will also be asked to complete a pregnancy test (using an OTC pregnancy test kit). You may refuse to complete the test; however, you will not be allowed to have the DEXA scan. If you choose to not submit a pregnancy test and do not receive a DEXA scan, you may still participate in the other measurements if you so desire. You will then be asked to complete a 7-day food record at home, which will be explained to you in detail by a trained researcher. In general, to complete the 7-day food record, you will be asked to write down all foods and beverages you consume within a 7–day period following your visit. You will also be asked to complete another 7-day food record, at about 6 weeks of treatment, to control for dietary intake, and a third 7-day food record at the end of the study. The format will be the same as the first 7-day food record completed at the beginning if the study.

If you decide to participate, you will also be asked to come to the OSU weight room at a designated date and time. When you arrive, you will be briefed before the commencement of the exercise testing regarding all procedures. Exercise testing will consist of a fitness test, a strength test, and a power test. The strength test will consist of a three-repetition maximum (3RM) back squat. You will be allowed a warm up period followed by three testing attempts to product the highest test result possible. All testing will be monitored by trained personnel. The power test will consist of the vertical jump. You will be staff responsible for safeguarding the rights and wellbeing of people who participated in research. Confidentiality will be maintained except under specified conditions required by law.

The OSU Institutional Review Board has the authority to inspect consent records and data files to assure compliance with the approved procedures. The participation on the study is voluntary. If at any time you feel uncomfortable while reporting any information, you can choose to not answer any question, or to withdraw completely from the study. A decision to withdraw from the study will not result in any loss of benefits to which you are otherwise entitled.

CONTACTS:
You may contact any of the researchers at the following addresses and phone numbers, should you desire to discuss your participation in the study and/or request information about the results of the study: Stacy Campbell, MS, 310 HS, Dept. of Nutritional Sciences, Oklahoma State University, Stillwater, OK 74078, stacy.campbell@okstate.edu or Dr. Lenka Shriver, PhD, 311 HS, Dept. of Nutritional Sciences, Oklahoma State University, Stillwater, OK 74078, 405-744-8285, lenka.shriver@okstate.edu. If you have questions regarding your rights as a research volunteer, you may contact Dr. Sheila Kennison, IRB Chair, 219 Cordell North, Stillwater, OK 74078, 405-744-1676 or irb@okstate.edu.

CONSENT DOCUMATION:
I have been fully informed about the procedures listed here. I am aware of what I will be asked to do and the benefits of my participation. I also understand the following statements:

I affirm that I am 18 years of age or older.

I have read and fully understand this consent form. I sign it freely and voluntarily. A copy of this form will be given to me. I hearby give my permission for my participation in the study.

______________________________ ______________________________
Signature of Participant Date

I certify that I have personally explained this document before requesting that the participant sign it.

______________________________ ______________________________
Signature of Researcher Date

INFORMATION RELEASE FORM

Your signature certifies that the project leaders have your permission to send the results of your measurements (including the DEXA scan, body weight, body height, power and strength tests) to your team athletic trainer(s) who will then share the results with you. If the measurements collected during the study indicate that you may have any potential nutrition-related problems, the project leaders will make nutrition recommendations through your athletic trainer(s) and suggest a referral to your team physician.

I fully understand the information release form. I, __________________________ (print name), give permission to the project leaders to share the results of my measurements with my athletic trainer(s).

____ Date _______________

Signature

APPENDIX C

Oklahoma State Institutional Review Board

Oklahoma State University Institutional Review Board

Date:	Friday, August 24, 2012
IRB Application No	HE1246
Proposal Title:	Effect of Fat-Free (Skim) Chocolate Milk on Strength, Power, and Body Composition in NCAA Division I Female Softball Players
Reviewed and Processed as:	Full Board

Status Recommended by Reviewer(s): Approved   Protocol Expires: 8/14/2013

Principal Investigator(s):

Stacy Campbell	Nancy Betts	Lenka Humenikova Shriver
310 HS	301 HS	311 HS
Stillwater, OK 74078	Stillwater, OK 74078	Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval. Protocol modifications requiring approval may include changes to the title, PI, advisor, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Shelia M. Kennison

Shelia Kennison, Chair
Institutional Review Board

APPENDIX D

7-Day Food Records

Name:	**Date Taken:**
Physical Activity: sedentary lightly active moderately active very active ________ min or hrs per day	Takes Nutritional Supplements: ☐Yes ☐No If "yes" list type:
Pregnant: ☐yes ☐no	Nursing: ☐yes ☐no
I had _____ cups of **<u>water</u>** yesterday Male ☐ Female ☐ Circle One Age Group: 17-21 22-26 27-31 32-36 37+	Meal Type: Morning =1 Afternoon =4 Midmorning =2 Evening =5 Noon = 3 Late Evening =6

Conversion Table

1/16 = 0.06	1/3 = .033	3 tsp = 1 TBSP	16 TBSP = 1c	1 quart = 4 c
1/8 = 0.12	½ = 0.50	2 TBSP = 1 fl oz	½ pint = 1c	1 c (liquid) = 8 fl oz
1/6 = 0.16	2/3 = 0.66	4 TBSP = ¼ c	1 liter = 4 c	1 dash = 1/8 tsp
¼ = 0.25	¾ = 0.75		16 oz = 1 lb	30 drops = ½ tsp

Food Item (*List only one food item per line*)	Amount Eaten	Meal Type	G	V	F	D	P	O
TOTAL								

VITA

Stacy Jean Campbell

Candidate for the Degree of

PhD in Human Sciences

Dissertation: EFFECTS OF FAT-FREE SKIM CHOCOLATE MILK ON POWER SPEED, AGILITY, AND BODY COMPOSITION FEMALE SOFTBALL PLAYERS

Major Field: Nutritional Sciences

Biographical:

Education:

Completed the requirements for the PhD in Human Sciences at Oklahoma State University, Stillwater, Oklahoma in December 2015.

Completed the requirements for the Master of Science in Food and Nutritional Sciences at Tuskegee University, Tuskegee, Alabama in May 2003.

Completed the requirements for the Bachelor of Science in Food and Nutritional Sciences at Tuskegee University, Tuskegee, Alabama in May 2000

Experience:
Teaching Assistant; Oklahoma State University, 2009-2014
Research Assistant; Tuskegee University, 2000-2003

Professional Memberships:
American Dietetic Association
Oklahoma Dietetic Association
Sigma Xi Research Society