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Effects Of Manual Resistance Training On Body Composition In Young Adults

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EFFECTS OF MANUAL RESISTANCE TRAINING ON BODY COMPOSITION IN YOUNG ADULTS

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ABSTRACT

Resistance training (RT) is a form of exercise that is important for strength development. Manual Resistance Training (MRT) is an alternative mode of RT that utilize an external resistance provided by a partner. MRT requires minimal equipment and is a convenient form of training for individuals who do not have access to traditional weight training equipment The purpose of this study was to investigate the effects of 8 weeks of MRT intervention on Fat Mass (FM), Lean Mass (LM) and Bone Mineral Density (BMD) and to compare the changes to the Weight Resistance Training (WRT) group. Thirty young adult (Females:18, males:12) were randomly assigned to either a MRT (n=10, mean±SD age: 23.08±3.09 years, height: 165.70±12.39 cm, body mass: 77.87±21.69 kg, and body fat: 32.00±10.86 %), WRT (n=10, mean±SD age: 22.08±1.74 years, height: 169.70±9.53 cm, body mass: 72.69±18.22 kg, and body fat: 31.34±2.08 %) or control (n=10, mean±SD age: 24.58±2.65 years, height: 162.30±8.59 cm, body mass: 70.30±21.80 kg, and body fat: 34.57±8.81%) group. The MRT and WRT groups engaged in a training done twice a week for one hour with 2 circuits that had 3 exercises per circuits while the control group were instructed to not engage in any form of exercise during 8 weeks. Body composition was measured using Dual-energy X-ray Absorptiometry (DXA) before and 24-48 hours after the intervention. Muscular Strength was measured with Isokinetic Knee Extension/Flexion, Isometric Bench Press, Isometric Mid-thigh Pull, One-Repetition Maximum (1RM) Bench Press (1RMBP) and 1RM Leg Press (1RMLP) before and immediately after the intervention. MRT group showed no change in FM ($p=0.77$), LM ($p=0.10$), BMD ($p=0.46$), and Total BMC ($p=0.74$) from pre to post testing. Similarly, no changes from pre to post testing in Total FM ($p=0.89$), Total LM ($p=0.24$), Total BMD ($p=0.62$), and Total BMC ($p=0.36$) were observed in WRT. However, an increase in Strength was seen in MRT through 1RMLP ($p<0.01$) and in WRT through 1RMBP ($p=0.01$) and 1RMLP ($p<0.01$) from pre to post testing.

No changes in the control group were observed ($p>0.05$). Therefore, an 8-week intervention increases muscle strength without the change of body composition.

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CHAPTER 1: INTRODUCTION

Resistance Training (RT) has been established as an effective method for developing musculoskeletal strength and has been prescribed for fitness or for rehabilitation purposes (Bird, Tarpenning & Marino, 2005; Cholewa et al., 2018; Feigenbaum & Pullock, 1999; Schoenfeld et al., 2015; Tokumaru et al., 2011). Coaches, personal trainers, physical therapist, and exercise physiologists are professionals that utilize RT to improve people's lifestyles. RT can be defined as a specialized method of physical conditioning that involves the use of different resistive load and a variety of modalities designed to enhance muscular fitness (Kluwer, 2017). RT should be distinguished from different competitive sports such as bodybuilding and powerlifting (Kluwer, 2017).

RT is a mode of exercise used to enhance muscular adaptations such as muscle hypertrophy, increase in CSA, specific tension, and muscular circumference. (Chestnut & Docherty, 1999; Hakkinen et al., 2003). The skeletal muscle is a highly plastic tissue that easily adapts when a load is constantly applied to the muscle (Bird, Tarpenning & Marino, 2005) . It has previously been stated that resistance training induces hypertrophy (Lasevicius et al., 2018; McCarthy, Pozniak & Agre, 2001). Increases in muscular strength occurs in the early stages (6-8 weeks) (Moritani & de Vries, 1979; Sale, 1988) through neural adaptations and late stages (12-16 weeks) (Carroll et al., 1979; Staron et al., 1994) through the increase in Cross Sectional Area (CSA). The muscle size increases due to the increase in CSA; this increase in CSA is caused by the increase in size of the different fiber types in humans which are Type I, IIa, and IIx. Type IIa are the fiber types that grow the most, followed by type IIx, with type I exhibiting the least amount of growth (Campos et al., 2002; Shoepe et al., 2003). A study conducted by Lasevicius et al., (2018) concluded that intensities ranging from 20-80% 1RM are effective for increasing muscle strength and hypertrophy in untrained men, however, those doing 20% 1RM would need to increase the intensity as the time progresses, in order for strength gains to be seen if that is the primary goal (Lasevicius et al., 2018).

Benefits of Resistance Training

RT has been associated with health improvements that have a significant impact on the quality of life and functional capacity in all individuals. RT has been recommended in the management of obesity and other metabolic disorders (Stasser & Schoberg, 2011). Obesity is a metabolic disorder that can lead to other major diseases such as cardiovascular disease and type II diabetes. People with excessive BF%, especially around the waist (adipose tissue), have been associated with risk factors such as elevated plasma cholesterol, plasma glucose, resting blood pressure (Strasser & Schobersberg, 2011; Wilson et al., 2002). Hurley et al. (2011) stated that RT may possibly reduce insulin resistance or improves insulin action, however, reductions are visceral fat are unclear if the RT are independent of dietary influences (Hurley et al., 2011). A proper diet and aerobic exercise have mainly been advised to reduce body weight and body fat (Kraemer, Ratamess, & French, 2002). In addition, recent research has shown that RT is beneficial to body fat reduction and increase in lean body mass (Mann et al., 2018).

Osteoporosis is another major concern in the older populations that is characterized by low bone mass and low bone mineral density. Weight bearing physical activity has been suggested as the main source of improving bone health. People may have less of a risk for developing fractures when performing RT to increase or maintain BMD (Carter, Kannus & Khan, 2001; Stevens et al., 1997). There is evidence that suggest that BMD increases the most with RT than with other types of exercises depending on the type of exercise utilized, the intensity of the resistance, the number of sets, rate of loading, direction of forces, and frequency of training (Westcott et al., 2012). A study conducted by Fujimura, et al. (1997), showed that after 4 months of RT, there was a significant increase of bone formation markers after the first month of RT and elevated levels throughout the training period. Although there was an indication of bone formation, there was no significant changes in bone density. This indicates that adaptive changes of bone metabolism occur before changes in BMD.

Manual Resistance Training

There are different modes RT that utilize specialized equipment; equipment comes in form of: resistance bands, medicine balls, hydraulic resistance, free weights, and machines as external resistance to improve strength (Adamovich & Seidman, 1987; Chulvi-Medrano et al., 2017; Dorgo et al., 2009). MRT is an alternative form of RT that only requires external resistance of another individual. The MRT can be performed in any type of setting since it requires limited equipment that includes benches, chairs, tables, step boxes, PVC pipes, and straps (Dorgo et al., 2009; Dorgo, King & Rice, 2009). In MRT, the person applying the resistance is considered the spotter and the person performing the exercises is called the lifter. This form of training allows for the lifter to use maximal effort and muscular contraction throughout the full range of motion when performing an exercise therefore it can potentially improve muscular strength (Bohannon & Jones, 1986; Dorgo, King, & Rice, 2009). The spotter must have the mechanical advantage to enhance muscular contraction and add resistance. Some advantages of using MRT include working the muscles to a high intensity when placing an emphasis on proper technique, form and technique can be controlled more closely, almost any exercise can be simulated, and both the lifter and the spotter receive a training effect simultaneously (Hendrick, 1999).

MRT has been shown to have similar improvements in muscular strength as other modes of RT (Behringer et al., 2015; Chulvi-Medrano et al., 2017; Dorgo, King, & Rice, 2009).

Previous studies have compared MRT to RT: Dorgo, King, & Rice (2009) compared MRT versus weight training (WT), similarly, Behringer et al. (2015) compared MRT versus Free-Weight training and Chulvi-Medrano et al. (2017) compared MRT versus Conventional Resistance Training (free-weights and machine based). These studies were conducted to compare the effects of MRT on muscular strength. Most MRT studies have shown improvements in muscular strength young adults (Behringer et al., 2015; Dorgo, King, & Rice, 2009; Vetter & Dorgo, 2009), teenagers (Dorgo et al., 2009), individuals Manifesting Carrier of Duchenne Muscular Dystrophy (Bohannon & Jones, 1986), and the elderly (Tokumaru et al., 2010). On the contrary, one study concluded that there were no significant changes in muscular strength in young adults (Chulvi-Medrano et al., 2017).

Body Composition

Body composition can be classified as FM and FFM where FFM can be further separated into Lean Tissue Mass and Bone Mineral Content (Toomey et al., 2015). Alterations of Fat Mass and Fat Free Mass (FFM), more specifically the location of changes in body fat, may have important health consequences (Despres et al., 1990; Steer, 1988). Resistance Training has shown to have changes in body composition (Chilibeck et al., 1998; Hurley et al., 1984; Schoitz et al., 1998; Wilmore, 1974). There are RT studies that found a decrease in body fat percentage (%BF) (Golber, Elliot & Kuehl, 1994; Schoitz et al., 1998; Van Etten et al., 1997) while others showed an increase in FFM (Brown & Wilmore, 1974; Golber, Elliot & Kuehl, 1994; Hunter, 1985). Other studies have shown no significant changes in FM or FFM after a RT intervention (Marcinik et al., 1991; Yang et al., 2018). There is currently limited research in the effects of MRT on body composition where no MRT studies have viewed the effects MRT on body composition. Although RT has shown changes in body composition, the MRT studies conducted by Dorgo et al. (2009) and Vetter & Dorgo (2009) have shown no increase in FM or decrease in FFM.

Bone mineral density can be described as the quantity of mineral deposited in a given area of bone (Baechle & Earle, 2008). It has been inferred that when muscles become stronger so do the bones; therefore, there is a potential increase in BMD can occur (Baechle & Earle, 2008; Manske et al., 2009). Interestingly, when a muscle becomes inactive or immobilized there is the opposite effect where there is a loss of bone mass and BMD (Baechle Earle, 2008). There is no current research done on the effects of MRT on bone mineral density (BMD) levels. However, there are RT studies that have shown changes in BMD or Bone Mineral Content (BMC) (Tsuzuku et al., 2001; Yang et al., 2018).

Purpose

The purpose of this study is to investigate the effects of MRT on strength and body composition. The main objective is to view the differences in FM, LM, BMD, and muscular strength after an 8-week intervention. The intervention will involve a MRT group that will be trained and compared to a WRT group as well as compared to a Control group that will not engage in any form of training.

CHAPTER 2: LITERATURE REVIEW

Resistance training is one of the most commonly prescribed forms of exercise (Almstedt et al., 2011). The American College of Sports Medicine (ACSM) recommends adults to be involved in muscular strengthening activities for more than two days a week that are of moderate or high intensity and that involve major muscle groups (Riebe et al., 2018). RT interventions have shown significant increases in muscular strength (Rhea et al., 2002; Schoenfeld et al., 2015), body fat and lean mass (Cholewa et al., 2017; Cullen & Caldwell, 1998; Van Etten et al., 1997), and bone mineral density (Mosti et al., 2014; Yang et al., 2018). Therefore, the primary purpose of this chapter is to review the literature on MRT and its effects on body composition and muscular strength.

Muscular Strength

Muscular strength is one of the main components of physical fitness; strength is defined as the maximum force that a muscle exerts against a resistance in a single effort**.** Reduced muscular strength can be a predictor of mortality in older adults (Cholewa et al., 2018; Ruiz et al., 2008). It has been inversely associated with risk of death from all causes and cancer in men of all ages who have high muscular strength compared to unfit men (Ruiz et al., 2008). To observe changes in muscular strength, the skeletal muscles need to receive appropriate levels of stress, which is most commonly achieved though external resistance (Dorgo, King, & Rice, 2009).

It has previously been observed that RT increases muscular strength in healthy men. A study was conducted on recreationally experienced weight trained male young adults who were assigned to a 1 set (S-1) group or 3 set (S-3) group (Rhea et al., 2002). The groups trained 3 days per week for 12 weeks where they performed in a periodized protocol: first day was 8-10 RM, second day was 6-8 RM, and third day was 4-6 RM (Rhea et al., 2002). The results showed that both the S-1 and S-3 groups significantly improved strength after the training program, however, performing 3 sets elicited more strength gains than 1 set (Rhea et al., 2002). Changes in muscular strength were also observed when comparing a low vs. high load RT. Schoenfeld et al. (2015) conducted a study on 18 well trained men who were assigned to a low-load RT group (LL) where 25-35 reps were performed per set per exercise or a high-load (HL) RT where 8-12 repetitions were performed per set per exercise (Schoenfeld et al., 2015). The training protocol consisted of 3 sets of 7 different exercises performed 3 times per week on nonconsecutive days for a total of 8 weeks (Schoenfeld et al., 2015). The authors concluded that both the HL and LL training can elicit significant increases in strength among well-trained men with HL training being superior in maximizing strength adaptations (Schoenfeld et al., 2015).

Manual resistance training has been shown to be effective as effective as RT in increasing strength in untrained populations and healthy recreationally trained subjects (Behringer et al., 2015; Chulvi-Medrano et al., 2017; Kramer et al., 2000). A study conducted by Dorgo, King, & Rice, (2009), used Weight Resistance training (WRT) as the form of training that was compared to MRT. They used identical training programs by targeting the same muscle groups to have consistency. The major finding of the study was that there were similar improvements in muscular strength and endurance after a 14-week training in MRT as WRT (Dorgo, King, & Rice, 2009). A different study compared Self Powered Rope Trainer Duo (Sports Duo), a form of MRT, to resistance training conducted with free weights on healthy recreationally trained men and concluded that manual resistance training guided by SPORTS Duo is equally effective at improving muscle performance as free weights (Behringer et al., 2015).

Although there were improvements seen in previous studies on muscular strength, a study conducted by Chulvi-Medrano et al., (2017) saw no changes in muscular strength on recreationally trained men but only a small nonsignificant improvement. This is in contrary to the results demonstrated by Dorgo et al. (2009), a study conducted on a group of high school students where there were significant improvements in muscular strength (Dorgo et al., 2009). The main discrepancies indicated by the author are mainly attributed to two different parameters, the training status of the selected subjects and the duration of the study (Chulvi-Medrano et al., 2017). This study had trained individuals and only did an 8-week intervention compared to the study conducted by Dorgo et al. (2009) that had young sedentary subjects and an 18-week intervention. It appeared that the MRT may be effective in subjects only through a higher training frequency and longer duration intervention.

Improvements in strength have also been observed in special populations, elderly and youth when going through manual resistance training (Bohannon & Jones, 1986; Dorgo et al., 2009; Tokumaru et al., 2011; Vetter & Dorgo, 2009). Vetter & Dorgo (2009) modified MRT and used Partner's Improvisational Resistance training (PIRT), a form of training that following the same concepts of MRT, proposed a way to include muscular strength development within the dance class. They concluded that there was an increase in strength in those dancers that attended PIRT and dancing classes compared to those that only attended dancing classes (Vetter & Dorgo, 2009). The youth showed improvements in muscular strength when going through normal Physical Education (PE) classes with additional manual resistance training for 18 weeks (Dorgo et al., 2009).

Strength improvements were also found through therapy settings. A type of physical therapy setting that involved older adult's showed improvements in the lower extremities after training for 24 weeks and with physical therapist as spotters (Tokumaru et al., 2011). Muscular strength and the muscle-weight ratio significantly increased by 13.2% and 14.9% from baseline and there was a significant difference observed in muscle strength between the MRT and the control group (Tokumaru et al., 2011). In another setting, manifesting carriers of Duchenne muscular dystrophy showed an increase in strength and elimination of falls after completing a 12-week manual resistance program (Bohannon & Jones, 1986).

Body Composition

There are different aspects in body composition that can be measured such as body fat percentage, the amount and composition of lean mass, and the bone mass or bone mineral content. An excessive amount of Body Fat (BF%) has been associated with many risks of developing diseases. When observing the effects of strength training on total body weight, there is a correlation between strength and FFM (Donnelly et al., 2003; Schmit et al., 2007).

There is currently limited research on MRT and Body Composition, however, changes in body composition have been observed through several RT studies. Body composition changes have been observed in young sedentary (Cholewa et al., 2017; Marcinik et al., 1991; Van Etten et al., 1997), healthy (Butts & Price, 1994; Pipes, 1978; Wilmore, 1974), and trained adults (Brown & Wilmore, 1974; Schoitz et al., 1998). Healthy males and females have shown to increase FFM and decrease BF% after conducting a RT intervention. A study conducted by Willmore (1974) was done on 26 men and 47 women with an average age of 20 years old to compare the training response to a strength training program simultaneously in males and females. The subjects had to perform a weight training program for 10 weeks that required to perform two sets of 7-9 repetitions (reps) for 10 exercises. The male and female participants showed similar alterations in body composition where there was no change in body weight, however, there was a substantial increase in lean body weight and a significant decrease in both relative and total body fat. Similar studies have been conducted individually where only one type of gender is studied. One study was conducted in 36 healthy young men where they completed a 10-week intervention (Pipes, 1978) and another study was conducted in 30 young healthy females for 20-weeks (Calder et al., 1994). Both studies conducted an exercise intervention where the subjects were divided into different training groups. The conclusion that was derived from both studies was that whole BF% decreased and whole-body lean tissue mass increased regardless of the type of resistance training (Calder et al., 1994; Pipes, 1978).

Similar to healthy populations, changes in body composition have been shown in trained men and women (Brown & Wilmore, 1974; Schoitz et al., 1998). A study conducted in trained ROTC cadets, consisted of 22 trained college age men who were separated into the periodized group (PER) or constant-intensity group (CI) (Schoitz et al., 1998). The intervention lasted 10 weeks where the subjects trained on both Olympic free weights and Universal Power circuit exercises machines and the Per and CI groups had their sets and reps established to match the total training volume (Schoitz et al., 1998). The authors concluded concerning the anthropometric measures, the body mass and FFM of both groups remained unchanged, however, BF% did decrease in the PER group (Schoitz et al., 1998). These changes could have occurred between the groups due to the PER group initiating training volumes in the hypertrophy phase. Similar to men, changes in BF% were observed in trained women. Brown & Wilmore (1974) conducted a six-month study on 7 young females where changes in body composition were observed. The women performed upper and lower body exercises with dumbbells or machines three days a week on alternate days. The authors concluded that changes in adipose tissue were greater than lean tissue gains in all of the subjects and although there were increases in strength, average lean body weight did not increase in the subjects.

Not only are there changes in body composition in healthy and trained individuals, there have been studies that indicate RT can change body composition in sedentary individuals. Cholewa et al. (2017) conducted a study Toomey et al., 2015 on the effects of moderate (ML) versus high-load (HL) RT on body composition in untrained collegiate women. The HL performed the training within 5-7 repetition maximum zone and ML performed 10-14 repetitions over 8 weeks with subjects performing 4-6 exercises per session. The authors concluded that both groups had similar increases in FFM, lean dry mass, and thigh cross-sectional area (CSA) and there was a decrease in %BF. This indicates that the HL and ML training is effective in improving body composition and strength in untrained young women. A similar study was conducted by Van Etten et al. (1997) on 26 healthy sedentary men ages 23-41 for 18-weeks. The study consisted of an exercise group and a control group; the exercise group trained two times per week on nonconsecutive days where they performed 3 sets of 15 reps for 10 exercises. The authors concluded that FFM increased and FM decreased only in the Exercise group with no change in body mass in either group.

Although studies have shown changes in body composition between 6-20 weeks, a 12-week intervention conducted by Marcinik et al. (1991) showed no changes in FFM, body weight, or BF% in sedentary young males. This is contrary to a 12-week study conducted by Cullinen & Caldwell (1994) where there was an increase in FFM and a decrease in %BF in untrained undergraduate women. Marcinik et al., (1991) indicated that the lack of changes in body composition could have been attributed to Human error since there was a problem with the data collection for the training group. Although this explanation was provided by the author, another conclusion could be that the untrained females performed six different type of weight lifting exercises while the men performed 10 exercises in machines (Cullinen & Caldwell, 1994; Marcinik et al., 1991). The gender could have had an impact on the differences as well as the frequency, load, and volume of the training being performed by the subjects in each of the studies.

Dual-energy x-ray absorptiometry (DXA) has been identified as one of the most popular methods for quantifying fat, lean, and bone tissues (Duren et al., 2008). Studies have used this measurement technique to achieve accurate measurements of body composition and have shown significant changes. There are currently no studies that have observed the effects of MRT on BMD. Different RT studies have been conducted to view differences in BMD, a study was conducted on young women for 20 weeks with minimal strength training experience (Chilibeck et al., 1998). This study used the measurement technique DXA and had the subjects perform upper and lower body exercises twice a week where upper body exercises were five sets of 6-10 repetitions and lower body exercises were five sets of 10-12 repetitions (Chilibeck et al., 1998). The authors concluded that during the first 10 weeks, there was a significant increase in lean mass in both the upper and lower body (Chilibeck et al., 1998). This may be due to adaptation of the nervous system that account for increase in strength during the first few weeks of RT as observed with the increase in lean mass. Similar to this study, Yang et al. (2018) conducted a study in young healthy and recreationally active males for 12 weeks. The RT protocol consisted of the subjects performing three sets of 10 reps for six exercises for 2-3 days per week depending of the experimental group they were assigned (Consecutive vs Non-Consecutive). The study concluded that training increased strength for all exercises as well as Lean Mass and BMD.

Bone Mineral Density

Bone Mineral Density refers to the bone's ability to resist compressive, shear and tensile forces and is important for preventing osteopenia, osteoporosis, and fractures. Mechanical loading, as generated during physical activity and exercise, can have an effect on bone homeostasis (Manske et al., 2009). This can promote an increase in peak bone mass that is effective in stimulating bone formation (Ahles et al., 2012). The bone has a way to protect itself, it has a threshold stimulus that initiates new bone formation referred to as minimal essential strain (MES) (Baechle & Earle, 2008). The threshold can be exceeded with weight bearing exercises or high intensity exercises which cause strain to the bone. The bone will then create bone cells that will attach to areas of the bone that experience bone stress which will cause the diameter of the bone to increase and therefore decreasing the amount of mechanical stress (Baechle & Earle, 2008).

A positive correlation between BMD and muscular strength when performing RT has been observed. This is due to the idea that an increase in muscular strength will stimulate bone growth. A study compared high versus low intensity resistance training on 18 to 25-year-old males where the BMD of powerlifters (high resistance), recreational trainees (low resistance), and control were compared (Tsuzuku et al., 2001). The subjects were separated into different groups where the weight lifters were considered the high intensity resistance training (HI-INT) group that participated in a continuous exercise program for an average of 8 hours per week for at least 30 months (5 sets of 4-8 reps at 80-90% 1RM) prior to the study and the recreational trainees were defined as the low-intensity resistance (LOW-INT) group that engages in RT 3 hours per week for at least 18 months (30RM) prior to the study. The authors concluded that BMD was higher in the lumbar spine, femoral neck, and Ward's triangle of the high intensity group compared to the control. There was no difference between the low intensity and control group, therefore low intensity RT is not effective for increasing BMD while high intensity RT is (Tsuzuku et al., 2001). A similar study was conducted by Pettersson, Nordstrom, & Lorentzon (1997) on young males with the average age of 25. The subjects were separated into a high activity group where ice hockey players who performed high impact exercises were recruited and compared to physically active subjects that exercised with high impact exercises an average of 1.5 hours per week (Pettersson, Nordstrom, & Lorentzon, 1997). When comparing both groups, the authors concluded that the high activity group had high BMD in total body, humerus, spine, pelvis, spine, femoral neck, femur, and tibia compared to the low activity group (Pettersson, Nordstrom, & Lorentzon, 1997). This provides evidence that BMD is significantly higher in athletes than in more inactive individuals and weight bearing activities seem to be more effective than non-weight bearing activities to enhance BMD (Pettersson, Nordstrom, & Lorentzon, 1997).

Although there are currently no studies on MRT and BMD, RT studies have been conducted to observe changes in BMD. Inconsistent findings in longitudinal RT studies have been observed. Almstead et al., (2011) conducted a 24-week resistance training intervention in healthy 18-23-year-olds. The intervention consisted of exercising 3 nonconsecutive days, where day one focused on lower body, day two on upper body, and day three on combined exercise; the intensities of the exercises varied from 67 to 95% of 1RM. The authors concluded that there was a favorable bone response in males and females, males had an increase in BMD between 2.7 and 7.7% whereas the percent change in women ranged from -0.9 to 1.5% (Almsteadt et al., 2011). They stated that a possible explanation is that perhaps the men recruited had greater relative strength at baseline and were able to create greater strain on the bone which induces an increase in BMD (Almstedt et al., 2011). On the contrary, Chilibeck et al. (1996) conducted a 20-week study on 20 healthy young women with an average age of 20 years. The study consisted of completing a RT in weight machines where upper body exercises were performed for 5 sets of 6-10 reps and lower body exercises were performed for 5 sets of 10-12 reps, twice a week. The results of the study indicated that there was an increase in strength and lean mass but there was no change in BMD. The authors concluded that the reason there may have not be a change was due to normal young healthy individuals having already high BMD, therefore, a very extensive and intense training may require to produce effects.

Women have shown to have similar changes as men when going through a RT intervention. Mosti et al. (2014) conducted a study on 83 young women who were assigned to either a training group (TG) or control group. The TG completed a 12-week intervention that consisted of squat maximal strength training (MST) at 85-90% of 1RM, where they emphasized progressive loading and high acceleration in the concentric phase. The results showed that the TG increased the lumbar spine and total hip BMD by 2.2 and 1.0% which indicates that squat MST may serve as a simple strategy to optimize peak bone mass in early adulthood. Similar results in men were observed in the study conducted by Yang et al (2018) where he conducted a RT training for 12 weeks and BMD increased.

Body Composition Assessment

Body composition can be assessed at the atomic, molecular, cellular, and tissue level (Duren et al., 2008). For research purposes in the effects of exercise on body composition, the assessment is done at the tissue level where the distribution of adipose, skeletal, and muscle tissues are viewed. According to Toomey et al. (2015), the accuracy of a method used to assess body composition depends on the number of components it measures. They indicate there are a 2-component (2-C) model that divide the body into Body Fat Mass (BFM) and Fat-Free Mass (FFM); a 3-component (3-C) model that divides the body into Lean Tissue Mass (LTM), Bone

Mineral Content (BMC), and BFM; and a 4-component (4-C) model views BFM, protein, Total Body Water (TBW) and BMC (Toomey et al., 2015). Some examples of the 2-C model include hydrodensitometry or air displacement plethysmography, of a 3-C model is DXA, and of a 4-C model is combining several measurement techniques to divide body in to fat (hydrodensitometry), mineral (DXA), water (isotope dilution), and protein (residual) (Toomey et al., 2015).

There are direct and indirect methods of assessing body composition. Direct methods involve cadaver analysis and indirect methods are based on assumptions that have been derived from previous research in healthy individuals (Toomey et al., 2015; Wells & Fewtrell, 2006). Therefore, all techniques might suffer from methodological error when collecting data and error in the assumptions by which raw data are converted to final values (Wells & Fewtrell, 2006). Anthropometric methods such as skinfold, body fat index (BMI), Waist Circumference (WC), and Waist to Hip Ratio (WHR) are mainly used to estimate percentage body fat (BF%) (Roche, 1996; Toomey et al., 2015; Wells & Fewtrell, 2006). These are the simplest methods of measuring changes in body fat and can be used when measuring very large populations.

DXA is currently included in the ongoing National Health and Nutrition Examination Survey (NHANES) due to being a convenient method of measuring body composition in 8-59 year olds (Chumlea et al., 2002). According to Toomey et al. (2015), DXA has not been claimed to be as accurate as a 4-C model, however, it has become a widely-accepted criterion method for the measurement of body composition due to its excellent precision. Although the method is highly accurate, there are some limitations which include: estimates of body composition that vary by differences among manufacturers (Kohrt, 1995; Roubenoff et al., 1993) a body mass limit, and a height and width restrictions (Toomey et al., 2015; Wells & Fewtrell, 2006).

Bone Mineral Density Assessment

There are different protocols that are used to assess BMD. Some of the protocols include the use of absorptiometry, Computed Tomography (CT), Magnetic Resonance (MR), and Ultrasound (Hans et al., 1997; Njeh et al., 1999). The Ultrasound modality consist of Quantitative Ultrasound (QUS). This type of measurement assesses skeletal health and are not only influenced by BMD but also by bone's structure and composition (Hans et al., 1997). The CT modality consists of Quantitative computed tomography (QCT) and it is the only method that determines in three dimensions the true volumetric density of trabecular or cortical bone (Njeh et al., 1998). The MR modality consists of the application of high magnetic fields, transmission of radiofrequency (RF) waves and detection of RF signals from excited hydrogen protons; this form of modality measures the magnetic properties of trabecular bone and bone marrow (Hans et al., 1997).

The DXA technique has been established as the gold-standard technique for estimating BMD due to their reproducibility, large normative data, non-invasive nature, little time required for procedure, and minimal radiation exposure (Blake & Fogelman, 2007). Most of the modalities that assess BMD are used to diagnose osteoporosis, a systematic disease characterized by low bone mass and microarchitectural deterioration of bone tissue (Hans et al., 1997) or for identifying people with low bone mass at risk of fractures (Overman, Farley, & Deal, 2015). For research purposes, BMD will be assessed using the absorptiometry modality DXA. DXA was approved by the Food and Drug Administration (FDA) in 1988 for the purpose of measuring BMD (Krugh & Langaker, 2018).

There are currently limited studies that have analyzed the effects of MRT on body composition and strength. It is hypothesized that when comparing MRT to a similar weight resistance training (WRT), there will be an increase in strength. There will be a decrease in %BF and an increase in FFM and BMD on the MRT and WRT groups compared to the control group but no significant difference between the MRT and WRT groups.

CHAPTER 3: METHODS

Experimental Approach to the Problem

A randomized control design was employed to assess the changes in body composition and muscular strength across two RT programs. Thirty subjects were randomly assigned to one of three groups (MRT, WRT, or control) with the training program lasting eight weeks. Variables of interest, such as muscular strength and body composition, were obtained at baseline and after the training program period. Changes in variables of interest were then compared across groups.

Subjects

Thirty young adults were recruited for this study, 18 were female and 12 were male. All subjects completed a health history and training background questionnaire (Appendix 2) to assess health, physical limitations, physical activity habits, and resistance training experiences. After the subjects went through the pretraining assessment of muscular strength, the subjects were randomly assigned to the MRT (n=10), WRT (n=10) or a control (n=10) groups. Each group contained six females and four males. All subjects self-reported as being healthy and were able to participate in the resistance training program. The project was approved by the institutional review board (Appendix 3) and each subject provided a signed informed consent form (Appendix 4) in order to participate.

Assessments

Clinical and field base assessments were selected to measure Body Composition and Muscular Strength. The Dual-energy X-ray absorptiometry (DXA) scan provided body composition variables targeted such as LM, FM, and BMD. The DXA scan also provided regional data that separates the information in segments such as left and right arms, legs, trunk, and totals. Isometric, Isokinetic, and one repetition maximum (1RM) tests were conducted to provide information on changes in muscular strength. Isometric bench press and isometric mid-thigh pull viewed the upper and lower body changes in force, the 1RM tests viewed the upper and lower changes in maximal strength, and isokinetic knee flexion and extension viewed angular force. The same tests were done for pre-testing and post-testing, with the inclusion of a familiarization session before pretesting. The familiarization session was only for the isometric mid-thigh pull, isometric bench press, 1RM bench press, and 1RM leg press. The tests were conducted in two different days where the first day consisted of DXA scan, Isometric Mid-thigh pull, Isometric bench press, 1RM leg press, and 1RM bench press. The second day consisted of isokinetic knee flexion/extension. It was necessary to add a second day of testing due to the Stanley E. Fulton Biomechanics and Motor Behavior Laboratory not being available during the subjects scheduled day 1 testing times.

Dual-Energy X-ray absorptiometry (DXA) Scan

Dual-energy X-ray absorptiometry (DXA) was used to obtain the body composition of total body and body segment data. Subjects were informed that they had to complete the DXA scan before any other test. For this process the subjects were fully clothed and laid down on their back with their knees and ankles lightly wrapped. The scanning arm slowly went over the body from head to toe while emitting low energy x-rays. The radiation dose was approximately 0.3 millirem and the process took approximately 7-15 minutes for normal healthy adults, for larger adults it took longer to scan.

Muscular Strength through Isometric Tests

Isometric mid-thigh pull and isometric unilateral (right) bench press were used to assess muscular strength. All subjects conducted a familiarization session for the isometric and isokinetic tests before the baseline measurements. After 24 hours, the subjects returned for pre-testing measurements. Isometric tests were conducted by utilizing a force sensor (Chronojump) that measured the force applied to each isometric contraction. The data were recorded on an application that could then be exported to Microsoft Excel. Subjects did a warm-up by walking/jogging in the treadmill for 5-10 minutes. Before the isometric mid-thigh pull test was conducted, the measurements of the mid-thigh were taken by using a measuring tape starting at the iliac crest to the knee cap, then a masking tape was placed on the location of the mid-thigh. They were then informed to maintain a mini squat posture, where the knee angel would be at 140 degrees and the hip angle was at 160 degrees (measured with a goniometer). With that posture, the bar was placed on the mid-thigh tape and the chains were adjusted. The subjects were informed to pull up on the bar in constant motion without jerking with all their strength for 5 seconds when they hear the word go. The strength test was done two times with a one-minute rest in between.

Isometric unilateral (right arm) bench press was conducted after the Mid-thigh pull test. Before beginning the test, the subjects had to lie down flat on the bench and position their right arm in a horizontal 90-degree angle. When in that position, they had to grab the handle to adjust the chain. The subjects were strapped by the waist and rib cage so that they are unable to move, and they were informed to place their left hand on the hip. They were then informed to push onto the handle for 5 seconds with a constant motion at maximum force when they heard the word go. The test was done two times with a one-minute rest in between.

Muscular Strength through 1 Repetition Maximum (1RM) tests

All groups were assessed for muscular strength through 1RM testing of the upper- and lower body. Upper body was assessed through 1RM bench press and Lower body was assessed through 1RM unilateral (left) leg press. All groups conducted a familiarization session of the

1RM protocol during week 0, before the baseline measurements. After 24 hours of rest, they performed the pre-testing session. Before the 1RM testing, the subjects followed a standard warm-up routine composed of one set of 10 repetitions with 50% of the anticipated 1RM load. Later, they did three to five repetitions with 75% of the 1RM. After the warm-up, the subjects performed their first 1RM attempt with a load that was lighter than their maximum anticipated weight. There was a minimum of five minutes of rest in between the 1RM attempts. The maximum weight was achieved between the third and fourth attempts. The 1RM bench press was performed before the 1RM leg press. The 1RM leg press was conducted on the left leg only in order for the testers to spot the subjects appropriately and avoid injuries. Trained individuals assisted the subjects and supervised the testing.

Muscular Strength through Isokinetic test

The Biodex system (System 4 Pro™) dynamometer was used for isokinetic muscular strength testing. Before the isokinetic unilateral (right) knee flexion/extension, the subjects completed a warmup by walking in the treadmill at their own pace for three to five minutes. The subjects were then seated and strapped to the chair enough to isolate the leg performing the test. The subjects were informed to extend and flex their knee with as much strength as they could four times each for two trials. The speed of the test was 60 degrees/second. With the first trial being a practice and the second trial being the real test. Subjects performed the tests two times with 30 seconds of rest in between.

Training Protocol

The MRT and WRT groups performed the same workout routine during the 8-week intervention with two 1-hour sessions every week. The control group was informed not to engage in any form of exercise or dietary plan for 8 weeks. The sessions of the MRT and WRT groups were organized in a mini circuit format (three exercises per circuit) with a 20-30 second rest interval in between each exercise. Every two weeks, the volume and intensity of the training sessions were adjusted based on the training plan. Week 1 & 2 consisted of the subjects completing circuit 1 (3 exercises) with 3 sets of 12 repetitions at 67% of 1RM while circuit 2 (3 exercises) was done with 2 sets of 12 repetitions at 67% of 1RM. Week 3 & 4 consisted of completing circuit 1 & 2 with 3 sets of 10 repetitions at 75% of 1RM. Week 5 & 6 consisted of completing circuits 1 (3 exercises) with 4 sets of 10 repetitions at 75% of 1RM while circuit 2 (3 exercises) was done with 3 sets of 10 repetitions at 75% of 1RM. Week 7 & 8 consisted of completing circuit 1 & 2 with 4 sets of 8 repetitions at 80% of 1RM. During each session, the subject performed six to nine large muscle group exercises such as Back Squats, bench press, split squats, push-ups. Every subject recorded their load used for each exercise so they could track their progress throughout the intervention. There was a resting period of at least 24 hours between each training session to avoid fatigue and injury.

The intensity of the training was within the 8-12RM for the entire training program. All subjects in the MRT group were encouraged to reach exhaustion in each set. The spotters in the MRT group provided maximum resistance for the lifters to reach exhaustion at the prescribed number of repetitions with resistance applied through the full range of motion in each repetition. The MRT and WRT programs were as identical as possible. Both groups performed the same number of sets and repetitions. Although the resistance of the MRT was not quantified, the way we ensured that the MRT group used maximal effort was through a 60 beats per minute metronome. The subjects were asked to perform the concentric phase for 3 beats and the eccentric phase for 3 beats, so the movements were done through the full range of motion. The spotter was also observing the MRT subject at all times to ensure they were providing maximal resistance during the exercise repetition. The WRT program mainly focused on multi-joint movements with the inclusion of some single-joint exercises. For example, every circuit included a multi-joint movement that targeted multiple muscle groups such as stationary split squats, different variations of bench press, Romanian deadlifts or shoulder press, bent-over rows, backsquats, along with single joint exercises that target isolate muscle groups such as leg curls, leg extensions, front raises, or lateral raises. The same exercises were performed for Day 1 or Day2 for two weeks and then they would change but still targeted the same muscle groups. All days worked out full body by including two multi-joint upper body, two lower body, and two single joint assisted exercises. The MRT program mimicked these same movements or activated the same muscle groups (Appendix 5). All subjects returned after the 8th week for post measurements.

Data Selection

Body composition data were collected from the DXA scans. For body composition data, the variables include FM, LM, and BMD. Full body and body segment data values were analyzed with the DXA protocol. Isometric midthigh and unilateral (right) bench press, isokinetic unilateral (right) knee flexion/extension, and 1RM bench press and unilateral (left) leg press were tests done to collect muscular strength data. For isometric midthigh and bench press, the data selected was the highest peak force out of the two five-second attempts for pre-testing and the highest peak force out of the two five-second attempts for post-testing. The data selected for 1RM was the highest load recorded for each individual subject that was confirmed as their 1RM attempt for pre-and post-testing. For isokinetic knee flexion/extension, the highest peak torque for flexion and extension out of the two attempts was the selected data.

Statistical and Data Analysis

Data were collected and compiled in Excel 2010. IBM SPSS (Version 26) was used to analyze the data. A normality test was used to determine the appropriateness of the parametric or non-parametric tests. A Shapiro-Wilk test was used to assess data normality. Data were normally distributed, therefore a two-way ANOVA (group x time) was used to compare pre-to-post changes between the groups and across time. Bonferroni post-hoc tests were used to assess changes in FM, LM, BMD, and muscular strength. All tests were completed with an alpha level of 0.05.

CHAPTER 4: RESULTS

Descriptive characteristics such as age, height, body mass, and body fat, for the MRT, WRT, and Control groups are shown in Table 1.1. All subjects had a height 165.90±10.40 cm, body mass 73.53±20.19 kg, 23.25±2.68 years, body fat percentage (BF%) 32.64±8.72 %. One-way ANOVA showed comparisons between MRT, WRT, and Control groups and revealed no significant difference for Age (years) ($p=0.09$), height ($p=0.37$), body mass (kg) ($p=0.62$), and Body fat (%) ($p=0.92$).

Body composition analysis showed that from pre to post testing the MRT group did not display any change in Total FM ($p=0.77$), Total LM ($p=0.10$), Total BMD ($p=0.46$), and Total BMC ($p=0.74$) (Table 2.1). Similarly, WRT group showed no differences in Total FM ($p=0.89$), Total LM ($p=0.24$), Total BMD ($p=0.62$), and Total BMC ($p=0.36$) from pre to post-testing (Table 2.1). No changes in Total FM ($p=0.17$), Total LM ($p=0.34$), Total BMD ($p=0.84$), and Total BMC ($p=0.86$) were also shown in the control group from pre to post-testing (Table 2.1). Furthermore, Table 2.1 shows the effect for time found on total BMC, total BF%, total tissue (Body Mass), total FM and total LM for the MRT, WRT, and Control group (Cohen's $d <0.2$), as well as for BMD (Cohen's $d =0.38$).

No significant differences in FM were observed from pre to post testing in the MRT group for left and right arms ($p=0.09$, $p=0.78$), legs ($p=0.10$, $p=0.44$), trunk ($p=0.73$, $p=0.97$) total ($p=0.99$, $p=0.34$), total arms ($p=0.42$), total legs ($p=0.21$), and total trunk ($p=0.84$) (Table 3.1). In addition, WRT showed no FM differences for left and right arms ($p=0.53$, $p=0.37$), legs ($p=0.74$, $p=0.57$), trunk ($p=0.56$, $p=0.82$) total ($p=0.98$, $p=0.79$), total arms ($p=0.86$) total legs ($p=0.64$), and total trunk ($p=0.64$) from pre to post testing (Table 3.1). The control group also showed no difference in FM from pre to post testing for left and right arms ($p=0.61$, $p=0.98$), legs (p=0.36, p=0.15), trunk (p=0.23, p=0.12) total (p=0.26, p=0.10), total arms (p=0.70), total legs (p=0.19), and total trunk (p=0.16) as similarity displayed by the MRT and WRT groups (Table 3.1). Furthermore, a low main effect for time (Cohen's d] <0.2) was found on FM for left arm, left leg, let trunk, left total, right leg, right arm, right trunk, right total, arms, leg, trunk for the MRT, WRT, and control groups with the exception of moderate effect for time (Cohen's d = 0.42) for right total in MRT group (Table 3.1).

No significant differences in LM were observed from pre to post testing in the MRT group for left and right arms (p=0.09, p=0.29), legs (p=0.38, p=0.19), trunk (p=0.46, p=0.22) total (p=0.10, p=0.20), total arms (p=0.17), total legs (p=0.78), and total trunk (p=0.35) (Table 4.1). In addition, WRT showed no LM differences for left and right arms (p=0.61, p=0.07), legs (p=0.17, p=0.35), trunk (p=0.88, p=0.80) total (p=0.57, p=0.10), total arms (p=0.26) total legs (p=0.19), and total trunk (p=0.93) from pre to post testing (Table 4.1). The control group also showed no difference in LM for left and right arms (p=0.08, p=0.49), legs (p=0.25, p=0.47), trunk (p=0.41, p=0.23) total (p=0.07, p=0.61), total arms (p=0.34), total legs (p=0.30), and total trunk (p=0.06) from pre to post testing (Table 4.1). Furthermore, a low main effect for time (Cohen's d <0.2) was found on LM for left arm, left leg, let trunk, left total, right leg, right arm, right trunk, right total, arms, leg, trunk for the MRT, WRT, and control groups with the exception of high effect for time (Cohen's d = 1.42) for left trunk in Control group (Table 4.1).

WRT group increase for Isokinetic Flexion (18.04%Δ, 95% CI [-32.6, -0.23]; p=0.04), an increase for 1RMBP (10.34%Δ, 95% CI [-23.2, -3.81]; p=0.01) and an increase 1RMLP (21.16%Δ, 95% CI -67.8, -23.2]; p<0.01) in muscular strength from pre to post testing (Table 5.1). 1RMBP changes from pre-to-post-test showed significant improvement in strength for the WRT group (Figure 1). However, WRT did not show any changes in Isokinetic Extension

($p=0.14$), Isometric BP ($p=0.23$), and Isometric MTP ($p=0.26$). Similar to WRT, MRT showed an increase in strength from pre to post testing for 1RMLP (21.46%Δ, 95% CI [-67.5, -23.5]; $p<0.01$) (Table 5.1). 1RMLP changes from pre-to-post-test showed significant improvement in strength for the MRT and WRT groups (Figure 2). Despite that improvement in strength shown in MRT through 1RMLP, no differences in Isokinetic Extension ($p=0.96$), Isokinetic Flexion ($p=0.20$), Isometric BP ($p=0.06$), Isometric MTP ($p=0.37$), and 1RMBP ($p=0.07$) (Table 5.1). No differences in strength were observed in the control group from pre to post testing for Isokinetic Extension ($p=0.94$), Isokinetic Flexion ($p=0.56$), Isometric BP ($p=0.11$), Isometric MTP ($p=0.80$), 1RMBP ($p=0.73$), and 1RMLP ($p=0.16$) (Table 5.1). Furthermore, a moderate main effect for time ($p<0.05$; [Cohen d] = 0.41), a moderate effect for time ($p<0.05$; Cohen's d = 0.38), and a low effect for time ($p<0.05$; Cohen's d = 0.01 was found for 1RMLP (kg) for the MRT, WRT, and Control group (Table 5.1). Similarly, a moderate-low main effect for time ($p<0.05$; Cohen's d = 0.24), a moderate-low effect for time ($p<0.05$; Cohen's d = 0.20), and a low effect for time ($p<0.05$; Cohen's d = 0.09 was found for 1RMBP (kg) for the MRT, WRT, and Control group (Table 5.1).

Table 6.1 states important questions asked before pretesting on a questionnaire to all subjects. For the question, "Do you exercise regularly?," for the MRT group, 6 subjects answered yes and 4 said no, for the WRT group, 7 subject answered yes and 3 answered no, and for the control group, 2 subjects said yes and 8 subjects said no (Table 6.1). For the question, "Have you exercised regularly the last 2 months?," for the MRT group, 7 subjects answered yes and 3 said no, for the WRT group, 8 subject answered yes and 2 answered no, and for the control group, 2 subjects said yes and 8 subjects said no (Table 6.1). For the question, "Are you currently in a Diet Program?," for the MRT group, 1 subjects answered yes and 9 said no, for the

WRT group, 2 subject answered yes and 8 answered no, and for the control group, 1 subjects said yes and 9 subjects said no (Table 6.1). For the question, “Were you in a diet program within the last 3 months?,” for the MRT group, 1 subjects answered yes and 9 said no, for the WRT group, 2 subjects answered yes and 8 answered no, and for the control group, 1 subjects said yes and 9 subjects said no (Table 6.1). For the question, “Have you had a weight change of more than 4lbs in the past 3 months?,” for the MRT group, 6 subjects answered yes and 4 said no, for the WRT group, 4 subject answered yes and 6 answered no, and for the control group, 2 subjects said yes and 8 subjects said no (Table 6.1).

CHAPTER 5: DISCUSSION

This study aimed to determine the effects of Body Composition on MRT in comparison to the WRT program and a Control group. We hypothesized that strength would increase in MRT and WRT groups and that FM would decrease and LM, BMD would decrease in MRT and WRT groups compared to a control group with no differences between the groups. Our first hypothesis was supported, there was an increase in muscular strength in the MRT and WRT groups. However, our second hypothesis was not supported, there were no differences in FM, LM, and BMD observed in MRT, WRT, and Control groups. To our knowledge, the present study is the first to investigate the changes in FM, LM, and BMD in young adults with MRT, WRT, and a control group. Therefore, we hoped that the methodology of the study would allow us to explore the differences in body composition and muscular strength in young adults between an MRT and WRT or Non-Exercising (control) group. The main result of this study was that an 8-week MRT and WRT improve muscular strength while no differences observed in body composition. When comparing the MRT, WRT, and Control groups, there were no differences between the groups.

It is crucial that we first view the differences between the MRT and WRT training modalities. MRT and WRT use different forms of resistance, MRT utilizes accommodating resistance, a form of resistance that adjusts to the strength added to each repetition, in comparison to WRT that uses constant resistance, the resistance that is the same amount throughout all repetitions. Constant or accommodating resistance both cause muscle fatigue due to the constant muscle contraction. The only difference is that MRT adds maximal strength throughout all repetitions which fatigues the muscle throughout all repetitions while WRT starts with less strength in the muscle and progresses in difficulty the last few repetitions where the muscle fatigues by those repetitions. MRT also focuses on the muscle contraction loading of the eccentric phase as well as the concentric phase whereas RT focuses on the contraction of the concentric phase.

The main finding of the study observed strength improvements in both MRT and WRT from pre to post-testing. The MRT group had an increase in 1RMLP while the WRT group had an increase in both 1RMBP and 1RMLP (Table 5.1). This finding indicates that both MRT and WRT increased lower body strength while WRT increasing strength in the upper body. Differences found in MRT and WRT in the upper body can be attributed to the MRT group adjusting to the different modality or the spotter was not providing enough resistance. The effect size of both the MRT and WRT groups in 1RMBP were both small to medium indicating that MRT group was also in the way of having statistical differences in upper body strength if the study had a longer duration, on the contrary, the control group had a small effect size (Table 5.1). Different studies have shown changes in MRT vs RT in muscular strength, one study resulted in an increase in upper and lower body strength for both MRT and WRT groups after a 14-week intervention (Dorgo, King, & Rice, 2009), while a different study displayed similar findings to our study where no upper body differences were observed in both the MRT or conventional RT program after an 8-week intervention (Chulvi-Medrano et al., 2017). Our study was conducted for 8 weeks with circuit training containing six exercises done twice a week for an hour which was less time than the study conducted by Dorgo, King, & Rice (2009) that was a 14-week study with circuit training containing six exercises done three times a week for an hour. On the other hand, Chulvi-Medrano et al. (2017) conducted a study for 8 weeks with only two exercises done twice a week. It can be concluded from these studies described that conducting MRT studies with an 8-10 week intervention containing circuit training with six exercises done two-three times a week can lead to increases in muscular strength.

The purpose of measuring strength as an isometric, isokinetic, and 1RM tests was to view differences in different strength tests. The strength tests chosen imitated the type of exercises that were used during the intervention. For example, the isokinetic knee flexion/extension imitated the seated leg flexion and extension exercise conducted by both the MRT and WRT group. This exercise was slow and controlled which was imitated by the 60 degrees/second motion during the test. Neuromuscular adaptations can account for the differences observed in the MRT and WRT groups. Some of these adaptations include muscle hypertrophy due to the increase in cross-sectional area (CSA) that leads to improvements in muscular strength. The CSA increases due to the increase in muscle fiber size which can lead to an increase of force generated by the voluntary contraction of the muscle fibers. Although our study did not measure CSA of muscle, a study conducted by Hakkinen et al. (2003), found that after a 21-week intervention done twice a week, large gains in maximal strength were accompanied with significant enlargements in the CSA and in size of individual muscle fiber and in addition, an increase maximal voluntary neural activation of the trained muscle was observed (Hakkinen et al., 2003). A different study that was conducted for 10-week concluded increases in strength, CSA, specific tension and muscular circumference (Chestnut & Docherty, 1999). Both studies viewed CSA changes by using magnetic resonance imaging (MRI).

In the present study, although an increase in strength was observed, there were no differences observed in LM for any of the groups from pre to post-testing. LM is part of the body composition that consists of bones, ligaments, tendons, internal organs, and muscle (everything other than FM). This indicates that there was an increase in strength without a change in muscle mass. Several RT studies have shown a correlation between muscular strength and lean mass where there are increases in LM and strength in young adults (Alegre et al 2014; Gomes et al., 2019; Villanueva, Lane & Schroeder, 2015). The training load, frequency, and study duration of these studies were: 8-12 RM, 3-5 times a week, and 8-10 weeks. However, similar to our study, different studies have known that there were no significant differences in LM after an intervention (Fisher, Carlson & Steele, 2015; Schoitz et al., 1998). The training load, frequency, and study duration of these studies were: 6-12RM, 2-3 times a week, and 10-12 weeks. Yang et al. (2018), conducted a 12-week intervention to examined three consecutive or non-consecutive days of RT per week and concluded that both groups induced similar improvements in strength and LM. In comparison to our study, Yang et al., (2018) had five different exercises done for two to three times a week for 45 minutes at a 10RM for a longer duration than 8 weeks. The only difference that can be observed between studies is the duration of the studies. Therefore, changes in the training load, frequency, volume, and study duration may result in different findings.

No differences in total FM was shown in our study for any groups. Our results were similar to the ones reported by Alegre et al. (2014), a RT study that resulted in no differences in total FM for young adults after the participation of a 10-week study (Alegre et al., 2014). Lack of changes in FM in the present study can be attributed to not monitoring the caloric consumption and caloric expenditure during the study. This study did not have any restriction or recommendations for the nutritional intake. A review paper conducted by Blundell et al. (2015), concluded that there is evidence that exercise will influence the components in which influence the drive the urge to eat (Blundell et al., 2015). Multiple studies have shown that nutrition by itself can decrease FM to lose weight (Benito et al., 2017; Foster- Schubert et al., 2012; Josse et al., 2014). Other studies show that if a diet is incorporated into an exercise intervention then decreases in FM are observed (Garthe et al. 2011; Campbell et al., 2018). Regional FM was also analyzed in our study but no significant differences were observed compared to baseline. One

RT study reported no change in total and regional (arm, trunk, and leg) fat mass after a 12-week intervention that viewed differences between excising two or three times a week (Yang et al., 2018). On the other hand, Chilibeck et al. (1996), showed significant group times time interactions on the FM arms, trunk, and leg on their training group that exercised 20 weeks two times per week for 6-10 repetitions with 5 sets for each exercise (Chilibeck et al., 1996). Our study had a shorter intervention than the other two studies, however only the 20-week study showed difference in regional FM. Therefore, longer duration studies result in increases in regional FM than 8-12 week interventions with similar exercise volume.

No significant changes in BMD were observed in our study after the 8-week intervention for the MRT, WRT, and Control groups. The inclusion of BMD is important due to the availability of RT studies on BMD in young adults being limited. Lack of BMD changes can be attributed to the type of training in this study not having enough load to cause an impact on the bone. Previous studies have shown that mechanical loading on bone is effective for increasing and maintaining BMD (Lanyon, 1987; Whalen, Carter & Steel, 1988). Tsuzuku et al. (2001), compared mechanical loading of a powerlifter, recreational training, and a control group where they concluded high-intensity resistance training, such as a powerlifter, is effective in increasing BMD where a low-intensity resistance training does not (Tsuzuku et al., 2001). Long term BMD interventions seem to show greater changes in BMD and regional BMD compared to short term interventions. The present study is a short-term study where after 8 weeks total BMD showed no significant differences. In similarity, a different study showed improvements in the lumbar spine, intertrochanteric hip and total hip BMD although no changes were observed in Total BMD in the training group after a 12-week intervention (Mosti, et al., 2014). While a study with a 24-week intervention showed favorable bone responses in the lateral spine and femoral neck with males having a greater change than females (Almstead et al., 2011).

Limitations

There are several limitations to the study. Firstly, although there were no significant changes in FM for any of the groups, the control group showed a greater loss than the MRT and WRT groups. The questionnaire shows that the control group had fewer subjects that indicated they exercised regularly, were in an exercise plan for the last 2 months, were enrolled in a diet program, or had lost more than 4lbs the past 3 months. Future studies will need to provide a questionnaire at the end of the training to the control subjects to ensure they did not enroll in a new form of training or diet. This study was not able to control for diet and physical activity exterior to the study. Secondly, MRT subjects could not measure the external resistance load as the WRT group. MRT group had to put maximal effort in the concentric and eccentric phase of the exercise by following a three-second metronome as a guide to change between phases and completing a repetition (Dorgo, King & Rice, 2009). MRT subjects had to learn how to perform the exercises and had to understand to use the metronome. Lastly, MRT depended on the experience and strength of their partner providing external resistance. In similarity to the study conducted by Dorgo, King, & Rice (2009), spotters were trained in the MRT group and were instructed to provide maximal resistance for their partners as well as always having the mechanical advantage during an exercise (Dorgo, King & Rice, 2009). Lacking experience or strength as the MRT partner might have not properly challenged the MRT subject and therefore the effects of MRT might have been minimized.

Conclusion

This study aimed to examine the effects of body composition in young adults across different groups. Our first hypothesis was supported; however, our second hypothesis was not supported since there were only improvements observed in muscular strength without any significant difference in body composition measurements for any of the groups. The reason behind these results could be the load, frequency, and duration of the study was not enough to induce any type of body composition changes. Although no changes in body composition were found, an increase in strength was shown for the MRT and WRT group. Changes in strength have been previously observed in studies that have been published using the MRT modality. Future MRT studies with longer periods of intervention that explore changes in body composition with the inclusion of a control group is recommended. Furthermore, alterations in load, and frequency that may capture changes in body composition not observed in the present study.

Practical Applications

MRT can be as effective as a WRT in improving in muscular strength on young adults without changing body composition in 8 weeks. Health professionals could advocate for MRT in the strength and conditional field. Since WRT is dependent on equipment, this may prevent many individuals from engaging in RT. Thus, MRT presents the advantage of minimal need for equipment; schools, public recreation centers, or low budget programs could utilize this RT modality if a weight facility is not available.

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APPENDIX

Appendix 1: Tables and Figures

Appendix 2: Health Status

Appendix 3: IRB Approval

Appendix 4: Informed Consent Form

Appendix 5: Exercise Training

Appendix 1

Table 1.1. Mean ± SD pre-training descriptive characteristics of the weight resistance training (WRT) group, the manual resistance training (MRT), and control group study subjects.

Group	n	Age (y)	Height (cm)	Body Mass (kg)	Body Fat (%)
MRT	10, (f=6, m=4)	23.08±3.09	165.70±12.39	77.87±21.69	32.00±10.86
WRT	10, (f=6, m=4)	22.08±1.74	169.70±9.53	72.69±18.22	31.34±2.08
Control	10, (f=6, m=4)	24.58±2.65	162.30±8.59	70.30±21.80	34.57±8.81

Table 2.1. Mean ± SD, percent change (% change), P value, 95% Confidence Interval (CI) and effect size, of body composition changes from pre- to post-test for the Weight Resistance Training (WRT), Manual Resistance Training (MRT), and control groups.

Group	Body Composition Measurement	Pre-Testing (Mean ± SD)	Post-Testing (Mean ± SD)	% Change.	P value	95% CI	Effect size
MRT	Total BMD	1.26±0.11	1.26±0.11	0.33	0.46	-0.17-0.01	0.38
	Total BMC (kg)	2.84±0.62	2.84±0.62	-0.11	0.74	-0.02-0.02	0.00
	Total %Fat	32.00±10.86	32.06±10.16	0.19	0.91	-1.24-1.12	0.01
	Total Tissue (kg)	74.87±20.98	75.74±20.86	1.15	0.23	-2.39-0.66	0.04
	Total Fat (kg)	24.23±12.44	24.39±11.58	0.65	0.77	-1.35-1.04	0.01
	Total lean (kg)	50.64±15.23	51.35±15.73	1.39	0.10	-1.59-0.17	0.05
WRT	Total BMD	1.22±0.16	1.22±0.159	0.16	0.62	-0.01-0.01	0.01
	Total BMC (kg)	2.81±.0.69	2.82±0.70	0.28	0.36	-0.03-0.01	0.01
	Total %Fat	31.34±6.57	31.04±6.80	-0.97	0.56	-0.81-1.41	0.04
	Total Tissue (kg)	69.63±17.36	70.19±15.66	0.80	0.39	-1.96-0.84	0.03
	Total Fat (kg)	21.96±8.05	22.02±8.43	0.27	0.89	-1.06-0.94	0.01
	Total lean (kg)	47.67±12.38	48.17±13.18	1.05	0.24	-1.41-0.40	0.04
Cont.	Total BMD	1.16±0.16	1.16±0.16	0.13	0.84	-0.02-0.02	0.01
	Total BMC (kg)	2.50±0.58	2.50±0.58	-0.04	0.86	-0.01-0.02	0.00
	Total %Fat	34.57±8.81	33.69±9.01	-2.55	0.08	-0.11-1.87	0.10
	Total Tissue (kg)	67.26±21.12	66.66±20.44	-0.90	0.32	-0.71-1.92	0.03
	Total Fat (kg)	23.75±10.01	22.98±9.68	-3.23	0.17	-0.39-1.92	0.08
	Total lean (kg)	43.51±12.99	43.67±12.81	0.37	0.34	-0.52-0.19	0.01

Table 3.1. Mean ± SD, percent change (% change), P value, 95% Confidence Interval (CI) and effect size, of regional FM changes from pre- to post-test for the Weight Resistance Training (WRT), Manual Resistance Training (MRT), and control groups.

Group	Body Composition Measurement (kg)	Pre-Testing (Mean±SD)	Post-Testing (Mean±SD)	% Change	P value	95% CI	Effect size
MRT	Left Arm Fat	1.22±0.53	1.31±0.52	6.87	0.09	-0.20-0.02	0.17
	Left Leg Fat	3.85±1.30	3.94±1.31	2.34	0.10	-0.19-0.02	0.07
	Left Trunk Fat	6.55±4.66	6.46±4.09	-1.37	0.73	-0.48-0.66	0.02
	Left Total Fat	12.10±6.24	12.22±5.71	0.99	0.67	-0.77-0.52	0.02
	Right Arm Fat	1.22±0.56	1.25±0.48	2.46	0.78	-0.25-0.19	0.06
	Right Leg Fat	3.91±1.32	3.96±1.29	1.28	0.44	-0.21-0.10	0.04
	Right Trunk Fat	6.56±4.49	6.55±4.19	-0.15	0.97	-0.57-0.59	0.00
	Right Total Fat	15.89±11.83	12.17±5.89	-23.41	0.34	-4.67-12.1	0.42
	Arms Fat	2.45±1.09	2.57±0.98	4.90	0.42	-0.43-0.20	0.12
	Legs Fat	7.76±2.61	7.90±2.60	1.80	0.21	-0.38-0.09	0.05
	Trunk Fat	13.11±9.14	13.00±8.25	-0.84	0.84	-1.01-1.21	0.01
WRT	Left Arm Fat	1.14±0.43	1.12±0.46	-1.75	0.53	-0.05-0.89	0.04
	Left Leg Fat	3.86±1.36	3.83±1.33	-0.78	0.74	-0.17-0.23	0.02
	Left Trunk Fat	5.53±2.32	5.63±2.53	1.81	0.56	-0.48-0.27	0.04
	Left Total Fat	11.1±3.97	11.02±4.17	-0.72	0.98	-0.57-0.55	0.02
	Right Arm Fat	1.13±0.46	1.16±0.50	2.65	0.37	-0.10-0.04	0.06
	Right Leg Fat	3.95±1.35	3.90±1.33	-1.27	0.57	-0.12-0.21	0.04
	Right Trunk Fat	5.50±2.36	5.53±2.54	0.55	0.82	-0.29-0.24	0.01
	Right Total Fat	10.95±4.08	11.00±4.26	0.46	0.79	-0.51-0.39	0.01
	Arms Fat	2.27±0.89	2.28±0.96	0.44	0.86	-0.14-0.12	0.01
	Legs Fat	7.81±2.70	7.74±2.65	-0.90	0.64	-0.27-0.41	0.03
	Trunk Fat	11.03±4.68	11.15±5.06	1.09	0.64	-0.72-0.47	0.02
Cont.	Left Arm Fat	1.23±0.42	1.21±0.48	-1.63	0.61	-0.07-0.11	0.04
	Left Leg Fat	3.93±1.43	3.86±1.46	-1.78	0.36	-0.10-0.25	0.05
	Left Trunk Fat	6.29±3.39	6.04±3.17	-3.97	0.23	-0.19-0.70	0.08
	Left Total Fat	11.85±4.90	11.54±4.86	-2.62	0.26	-0.30-0.92	0.06
	Right Arm Fat	1.26±0.51	1.26±0.51	0.00	0.98	-0.06-0.06	0.00
	Right Leg Fat	4.10±1.51	3.97±1.45	-3.17	0.15	-0.06-0.32	0.09
	Right Trunk Fat	6.08±3.28	5.78±3.06	-4.93	0.12	-0.09-0.68	0.09
	Right Total Fat	11.90±5.11	11.44±4.82	-3.87	0.10	-0.11-1.03	0.09
	Arms Fat	2.49±0.93	2.47±0.99	-0.80	0.70	-0.10-0.14	0.02
	Legs Fat	8.03±2.93	7.82±2.91	-2.62	0.19	-0.12-0.54	0.07
	Trunk Fat	12.37±6.66	11.82±6.22	-4.45	0.16	-0.26-1.35	0.09

Table 4.1. Mean ± SD, percent change (% change), P value, 95% Confidence Interval (CI) and effect size, of regional LM changes from pre- to post-test for the Weight Resistance Training (WRT) and Manual Resistance Training (MRT) groups.

Group	Body Composition Measurement (kg)	Pre-Testing (Mean±SD)	Post-Testing (Mean±SD)	% Change	P value	95% CI	Effect size
MRT	Left Arm Lean	2.73±1.23	2.89±1.32	5.86	0.09	-0.34-0.29	0.13
	Left Leg Lean	9.12±2.91	9.03±2.91	-0.99	0.38	-0.13-0.30	0.03
	Left Trunk Lean	11.93±3.57	12.06±3.41	1.09	0.46	-0.50-0.24	0.04
	Left Total Lean	25.43±7.85	25.85±7.78	1.65	0.10	-0.94-0.10	0.05
	Right Arm Lean	2.87±1.20	3.01±1.35	4.88	0.29	-0.44-0.15	0.11
	Right Leg Lean	9.07±3.05	9.21±3.23	1.54	0.19	-0.34-0.08	0.04
	Right Trunk Lean	11.55±3.30	11.84±3.37	2.51	0.22	-0.78-0.21	0.09
	Right Total Lean	25.13±7.49	25.50±7.97	1.47	0.20	-0.98-0.23	0.05
	Arms Lean	5.60±2.42	5.90±2.66	5.36	0.17	-0.76-0.16	0.12
	Legs Lean	18.19±5.96	18.24±6.14	0.27	0.78	-0.39-0.30	0.01
	Trunk Lean	23.51±6.85	23.89±6.77	1.62	0.34	-1.25-0.48	0.06
WRT	Left Arm Lean	2.73±1.28	2.77±1.23	1.47	0.61	-0.21-0.13	0.03
	Left Leg Lean	8.31±2.29	8.57±2.65	3.13	0.17	-0.66-0.14	0.11
	Left Trunk Lean	11.14±2.65	11.16±2.73	0.18	0.88	-0.29-0.25	0.01
	Left Total Lean	23.95±6.27	24.09±6.73	0.58	0.57	-0.69-0.40	0.02
	Right Arm Lean	2.82±1.27	2.90±1.31	2.84	0.07	-0.17-0.01	0.06
	Right Leg Lean	8.53±2.28	8.64±2.38	1.29	0.35	-0.38-0.15	0.05
	Right Trunk Lean	10.99±2.47	11.02±2.68	0.27	0.89	-0.54-0.47	0.01
	Right Total Lean	23.72±6.13	24.08±6.48	1.52	0.10	-0.80-0.08	0.06
	Arms Lean	5.55±2.54	5.67±2.54	2.16	0.26	-0.35-0.11	0.05
	Legs Lean	16.83±4.57	17.21±5.02	2.26	0.19	-0.98-0.23	0.08
	Trunk Lean	22.13±5.10	22.16±5.41	0.14	0.93	-0.64-0.59	0.01
Cont.	Left Arm Lean	2.32±1.09	2.41±1.16	3.88	0.08	-0.20-0.01	0.08
	Left Leg Lean	7.86±2.76	7.77±2.59	-1.15	0.25	-0.08-0.26	0.03
	Left Trunk Lean	10.20±2.70	6.04±3.17	-40.78	0.41	-1.06-2.36	1.42
	Left Total Lean	21.80±6.40	22.03±6.39	1.06	0.07	-0.49-0.02	0.04
	Right Arm Lean	2.59±1.13	2.67±1.13	3.09	0.49	-0.34-0.18	0.07
	Right Leg Lean	7.81±2.63	7.76±2.58	-0.64	0.47	-0.11-0.22	0.02
	Right Trunk Lean	9.66±2.59	9.80±2.52	1.45	0.23	-0.38-0.10	0.05
	Right Total Lean	21.715±6.60	21.65±6.43	-0.28	0.61	-0.23-0.37	0.01
	Arms Lean	4.91±2.22	4.98±2.30	1.43	0.34	-0.25-0.09	0.03
	Legs Lean	15.67±5.39	15.52±5.14	-0.96	0.30	-0.17-0.49	0.03
	Trunk Lean	19.86±5.29	20.09±5.19	1.16	0.06	-0.46-0.01	0.04

Table 5.1. Mean ± SD, percent change (% change), P value, 95% Confidence Interval (CI) and effect size, of strength changes from pre- to post-test for the Weight Resistance Training (WRT) and Manual Resistance Training (MRT) groups.

Group	Strength Measurement	Pre-Testing (Mean±SD)	Post-Testing (Mean±SD)	% Change	P value	95% CI	Effect size
MRT	Isokin. Ext.	193.0±53.09	178.2±54.31	-8.31	0.96	-3.22-32.8	0.28
	Isokin. Flex.	90.70±31.54	86.00±36.34	-5.47	0.20	-3.06-12.5	0.14
	Isomet. BP	243.2±67.65	258.9±83.36	6.07	0.06	-32.6-1.16	0.21
	Isomet. MTP	696.1±188.5	722.4±222.7	3.64	0.37	-89.4-36.7	0.13
	1RMBP	122.0±75.06	140.5±78.90	13.2	0.07	-39.2-2.22	0.24
	1RMLP	166.5±98.27	212.0±123.5	21.5	0.00*	-67.5--23.5	0.41
WRT	Isokin. Ext.	174.7±67.80	185.9±62.60	6.02	0.14	-26.7-4.31	0.17
	Isokin. Flex.	75.40±39.18	92.00±42.05	18.0	0.04*	-32.9--0.23	0.41
	Isomet. BP	248.6±82.99	235.6±78.14	-5.50	0.23	-9.97-35.9	0.16
	Isomet. MTP	710.0±237.1	756.2±287.1	6.11	0.26	-133-40.7	0.18
	1RMBP	117.0±64.73	130.5±73.46	10.3	0.01*	-23.2--3.81	0.20
	1RMLP	169.5±108.6	215.0±128.3	21.2	0.00*	-67.8--23.2	0.38
Cont.	Isokin. Ext.	163.7±71.58	164.6±73.52	0.55	0.94	-28.4-26.6	0.01
	Isokin. Flex.	69.70±32.54	74.80±32.57	7.32	0.56	-24.1-13.9	0.16
	Isomet. BP	242.5±100.9	234.4±93.62	-3.35	0.11	-2.14-18.4	0.08
	Isomet. MTP	731.4±268.9	741.9±281.6	1.44	0.80	-102-80.9	0.04
	1RMBP	114.0±67.32	115.0±68.76	0.88	0.73	-7.26-5.26	0.09
	1RMLP	141.5±92.77	156.0±101.7	10.3	0.16	-36.1-7.06	0.01

*Significantly different from pre-test.

Table 6.1. Questionnaire asked before pretesting to MRT, WRT, and Control Subjects.

Questions	MRT		WRT		Control	
	Yes	No	Yes	No	Yes	No
Do you Exercise Regularly?	6	4	7	3	2	8
Have you exercised regularly the last 2 months?	7	3	8	2	2	8
Are you currently in a Diet Program?	1	9	2	8	1	9
Were you in a diet program within the last 3 months?	1	9	2	8	1	9
Has your weight changed more than 4lbs in the past 3 months?	6	4	4	6	2	9

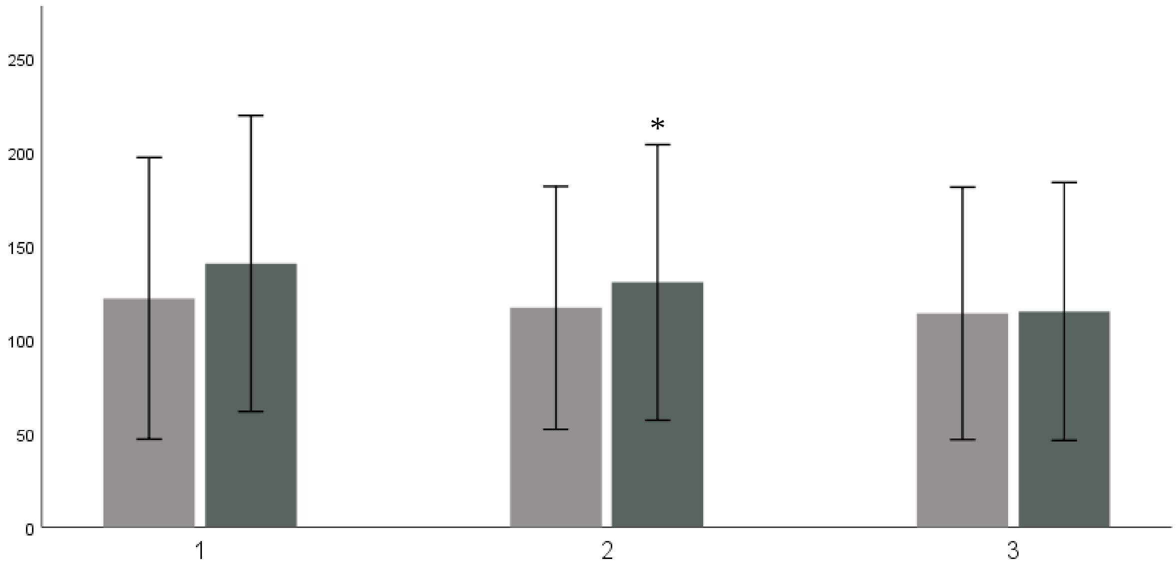

Figure 1. 1. Changes in One Repetition Maximum Bench Press (mean±SD) from pre-to-post testing in MRT, WRT, Control groups. 1=MRT, 2=WRT, 3=Control. *Significantly difference from pre-to-post-test.

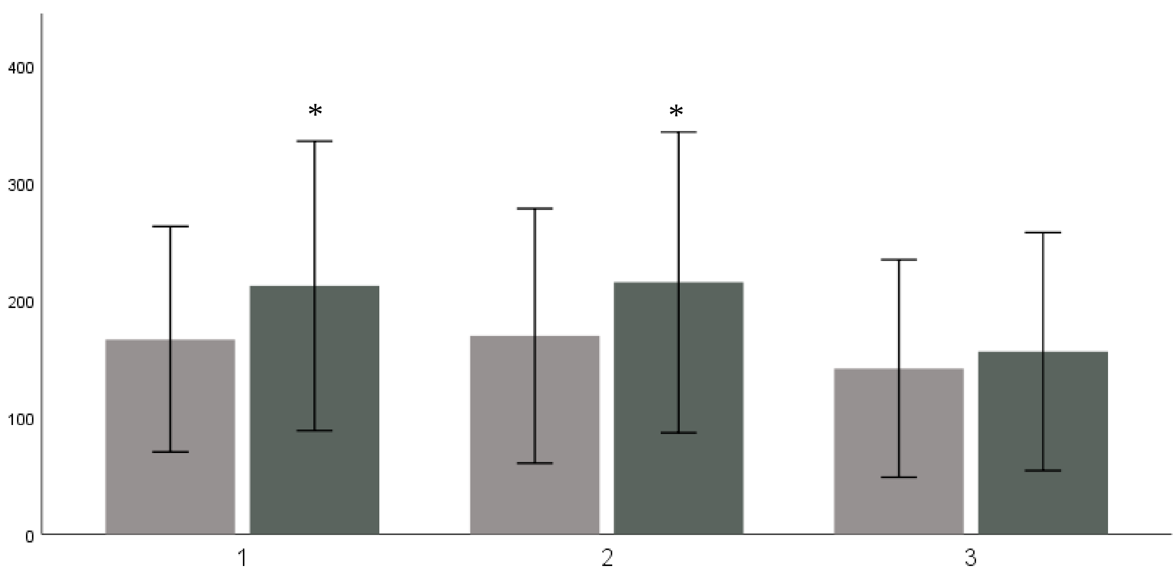

Figure 2. 1. Figure 2. Changes in One Repetition Maximum Leg Press (mean±SD) from pre-to-post testing in MRT, WRT, Control groups. 1=MRT, 2=WRT, 3=Control. *Significantly difference from pre-to-post-test.

Appendix 2

Attachment

Health Status and Exercise Background Questionnaire

Please complete the following questions as accurately as possible.

Date of Birth: ______/_____/______ Age:________yr.

Average number of hours worked per week:

☐ Less than 20 ☐ 20-40 ☐ 41-60 ☐ over 60

More than 25% of time spent at work/school is: (mark all that apply)

☐ Sitting at a desk ☐ Lifting or carrying loads ☐ Standing
☐ Walking ☐ Driving

Medical History

Are you pregnant or is there any chance that you may be pregnant? ☐ Yes ☐ No

Please mark all of the following for which you have been diagnosed or treated by a physician or health professional:

☐ Alcoholism	☐ Emphysema	☐ Kidney problems
☐ Anemia, sickle cell	☐ Epilepsy	☐ Liver disease
☐ Anemia, other	☐ Eye problems	☐ Lung disease
☐ Asthma	☐ Gout	☐ Mental illness
☐ AIDS	☐ Hearing loss	☐ *Spine deformities*
☐ Back Strain	☐ Heart problem	☐ Obesity
☐ Bleeding trait	☐ Heart murmur	☐ Phlebitis
☐ Bronchitis, chronic	☐ Hepatitis	☐ Rheumatoid arthritis
☐ Cancer	☐ High blood pressure	☐ Stroke
☐ Cirrhosis, liver	☐ Hypoglycemia	☐ Thyroid problem
☐ Concussion	☐ High Cholesterol	☐ *musculoskeletal disease*
☐ Congenital defect	☐ Infectious mononucleosis	☐ Other___________
☐ Diabetes	☐ Joint problems	

Please mark any of the following symptoms you have had recently:

☐ Abdominal pain	☐ Frequent urination
☐ Arm or shoulder pain	☐ Leg pain/numbness
☐ Breathless with slight exertion	☐ Low blood sugar
☐ Blurred vision	☐ Low-back pain
☐ Blood in urine	☐ Palpitation or fast heart beat
☐ Burning sensations	☐ Shortness of breath
☐ Chest pain	☐ Significant emotional problem
☐ Cough up blood	☐ Swollen joints

☐ Difficulty walking
☐ Dizziness
☐ Feel faint
☐ Unusual fatigue with normal activity
☐ Weakness in arms

Health and Exercise Related Behaviors

Do you smoke? ☐ Yes ☐ No

If yes, How much do you smoke per day?
Cigarettes: ☐ 40 or more ☐ 20-39 ☐ 10-19 ☐ 1-9
Cigar or pipe only: ☐ 5 or more or any inhale ☐ Less then 5, none inhaled

Have you been exercising regularly? ☐ Yes ☐ No

If yes, at what age did you start exercising? ___________________

Have you been exercising regularly in the past 2 months? ☐ Yes ☐ No

How long have you been participating in your current exercise program? _____________

What is your primary mode of exercise?_______________________

What is your secondary mode of exercise?_____________________

Any other modes of exercising? __________________________

What is the average length of your workouts? _____________________

How many days per week do you engage in your primary form of exercise?
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

What is the average length of your primary form of exercise sessions? ________________

How many days per week do you engage in your secondary form of exercise?
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

What is the average length of your secondary form of exercise sessions? ______________

What other forms of exercise do you participate in regularly? How many days per week?
_________________________ ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7
_________________________ ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7
_________________________ ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7
_________________________ ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7
_________________________ ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

What is the average length of your workouts? _____________________

How many days per week do you do cardiovascular training?
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

What type of cardiovascular training are you involved in? ___________________

What is your average weekly mileage? ___________________

What is your average weekly mileage during the last month? ___________________

How many days per week do you do resistance training?
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

What is the average length of your workouts? _____________________

What form of resistance training do you do? _____________________

How many exercises do you perform in an average resistance training session? ________

How many sets per exercise? _______________

What is the range of repetitions that you usually perform? ___________________

Do you perform resistance training sets to exhaustion? ☐ Yes ☐ No

What is the average rest time in between your sets? _____________________

Are you currently on a diet or program specifically designed to change your body weight?
☐ Yes ☐ No

During the past 3 months have you been on a diet or program specifically designed to change your body weight? ☐ Yes ☐ No

During the past 3 months has your body weight changed more than 4 pounds?
☐ Yes ☐ No

Appendix 3

Institutional Review Board

Office of the Vice President for Research and Sponsored Projects
The University of Texas at El Paso IRB
FWA No: 00001224
El Paso, Texas 79968-0587
P: 915-747-7693 E: irb.orsp@utep.edu

Date:	December 17, 2018
To:	Lizette Terrazas, BS
From:	University of Texas at El Paso IRB
Study Title:	[1353193-2] Effects of Manual Resistance Training on Young Adults
IRB Reference #:	College of Health Sciences
Submission Type:	New Project
Action:	APPROVED
Review Type:	Full Committee Review
Approval Date:	December 17, 2018
Expiration Date:	December 16, 2019

The University of Texas at El Paso IRB has approved your submission. This approval is based on the appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This study has received Full Committee Review based on the applicable federal regulation.

Based on the risks, this project requires Continuing Review by this office on an annual basis. Please use the appropriate renewal forms for this procedure. The renewal request application must be submitted, reviewed and approved, before the expiration date.

This approval does not replace any departmental or other approvals that may be required. Other institutional clearances and approvals may be required. Accordingly, the project should not begin until all required approvals have been obtained.

Please note that you must conduct your study exactly as it was approved by the IRB. Any revision to previously approved materials must be approved by this office prior to initiation, except when necessary to eliminate apparent immediate hazards to the subject.

All serious and unexpected adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

Please report all Non-Compliance issues or Complaints regarding this study to this office.

Remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Upon completion of the research study, a Closure Report must be submitted the IRB office.

You should retain a copy of this letter and any associated approved study documents for your records.

All research records must be retained for a minimum of three years after termination of the project. The IRB may review or audit your project at random or for cause. In accordance with federal regulation (45CFR46.113), the board may suspend or terminate your project if your project has not been conducted as approved or if other difficulties are detected.

If you have any questions, please contact the IRB Office at irb.orsp@utep.edu or Christina Ramirez at (915) 747-7693 or by email at cramirez22@utep.edu. Please include your study title and reference number in all correspondence with this office.

Sincerely,

Dr. Lorraine Torres, Ed.D, MT(ASCP)
IRB Chair

Appendix 4

University of Texas at El Paso (UTEP) Institutional Review Board

Informed Consent Form for Research Involving Human Subjects

Protocol Title: Effects of Manual Resistance Training in Young Adults
Principal Investigator: Lizette Terrazas
UTEP Kinesiology Department

Introduction

You are being asked to take part voluntarily in the research project described below. You are encouraged to take your time in making your decision. It is important that you read the information that describes the study. Please ask the study researcher or the study staff to explain any words or information that you do not clearly understand.

Why is this study being done?

There are different forms of resistance training (RT) that utilize resistance bands, medicine balls, hydraulic resistance, free weights, and machines as external resistance to improve strength. An alternative form of RT that only requires external resistance of another individual is manual resistance training (MRT). Manual resistance training allows for the lifter to use maximal effort and muscular contraction throughout the full range of motion when performing an exercise therefore it can potentially improve muscular strength. Therefore, the purpose of the study is to understand the effects of MRT in young adults. To achieve the goal of this study, changes in muscular strength, body composition, and bone mineral density in young adults will be analyzed.

Approximately, 30 people will be enrolling in this study at UTEP.

You are being asked to be in the study because you are a healthy individual that is within the ages *18 and 30. You do not qualify if you have any cardiovascular disease, musculoskeletal disease, spine deformities, and if you are a female who is pregnant.*

If you decide to enroll in this study, your involvement will last about 10 weeks. You will be required to attend a pretesting in week 1, exercise intervention for weeks 2-9, and post-testing week 10. In weeks 2-10, you will be engaged in either a Manual Resistance Training (MRT) group, Weight Resistance Training (WRT) group or a non-exercising (control) group.

What is involved in the study?

If you agree to take part in this study, the research team will: Collect your height and weight, body fat%, bone mineral density, muscle mass, and strength measurements for analysis. No audio will be recorded and no video analysis will be required for analysis. You will also be assigned to either a WRT, MRT, or control group and will participate in an 8-week intervention

You will: Participate an 8-week resistance training intervention. The first week will be for pretesting, second to ninth week will be the intervention and the tenth week will be for post-testing. The testing measurements will be collected in week 1 and week 10.

Pre- and post-testing Protocols:

First Protocol

Anthropometrics and Dual Energy X-ray Scan

We will obtain height and weight from a calibrated physicians scale. The Dual Energy X-ray Scan (DXA) will be done to obtain the body fat%, muscle mass and bone mineral density. During the DXA scan, you will be asked to lie down on you back on a table, the hands and knees will be lightly strapped. You will need to remain still until the scanning is done. The scanner will scan you from head to toes and the scanning should take around 10-15 minutes.

Second Protocol

Muscular Strength

We will obtain your maximal strength through the one repetition maximum (1RM) test, isometric and isokinetic strength tests. For the 1RM, there will be two different tests such as the bench press for strength of the upper body and leg press for the lower body strength. You will warm up for 5 minutes in the treadmill and then the testing protocol will begin. The testing protocol will begin with a warm up routine of one set of 10 repetitions at half of the maximum weight you can bench press or squat. Then another set of 3-5 repetitions will be done with a heavier load. When your warm up is done, you will attempt your maximum strength for 3-4 times until your maximum weight is reached. You will rest for 5 minutes between each set. There will be trained assistants that will supervise the testing and will help when necessary such as in failed attempts.

The Biodex system dynamometer will be used for isokinetic muscular strength testing. For the lower body, you will do a knee flexion and for the upper body, you will do an arm flexion. You will first take a seat where you will be strapped on the chair and either your leg or arm will be strapped as well depending on the protocol you will be doing. You will then be instructed to do as many arm or knee flexions as possible in 30 seconds. This protocol will be repeated three times with one-minute rests in between. You will be told when to begin and when to rest.

The mid-thigh pull and isometric bench press with the usage of Chronojump force sensor will be used for isometric muscular strength testing. The procedure for the mid-thigh pull starts by adjusting the bar at the correct height. You will then grab the bar by getting into the correct position. The chain will be adjusted so that the knees are bent, a position where the back will be bent slightly forward at the hips. Without bending the back, you will pull as hard as possible on the chain. The procedure will be done 3 times with 5-minute rest in between. The force sensor will be placed on the bar that will be connected to a laptop which will provide the data. The procedure for isometric bench press will begin by first setting up the safety bars to the appropriate level. You will lay down on the bench and grab the barbell with the thumbs being on outside of the closed fist, overhand grip, and with arm slightly wider than shoulder-width apart. You will then attempt to lift the barbell where there will be no movement since it will be stopped by the safety bars. You will repeat the attempt 3 times with 5-minute rests in between each attempt. The force sensor will be placed on the bar that will be connected to a laptop which will provide the data.

Intervention:

You will go through an 8-week training program with two 1 hour training sessions per week. You will attend a total of 10 weeks, 1st week for pretesting, 2nd-9th for the intervention, and 10th for post testing. There will be a health status and exercise background questionnaire that you will have to complete before pre-testing. During the pretesting and post-testing sessions, the anthropometric measures, DXA scan, and muscular strength testing will be done.

You will be informed if you are going to be joining a manual resistance training (MRT), weight resistance training (WRT), or non-exercising group. During this training period, you will be told not to engage in any other strength training activities. All sessions for the MRT and WRT groups will be organized in trisets or mini-circuits, where three exercises will be performed with 20-30 seconds of rest between each exercise. The training volume and intensity will be adjusted weekly and you will do 2-3 sets per exercise. The repetitions will be set at 8-12 repetitions and you will be required to rest for at least 24 hours between sessions. The training intensity will be kept in the hypertrophy zone (8-12RM) for the entire training program and the training programs for the two groups will be created so that both groups perform the same exercises and target the same muscle groups.

You will perform six to nine large muscle group exercises during each training session. The training program for the two groups will be as identical as possible where both groups will perform the same number of sets and repetitions. The WRT program will primarily be based on free weight large muscle group multi-joint exercises such as bench press, shoulder press, squat, lunge, etc., with single joint movements such as leg curls, arm curls, etc. For most of the exercises, the MRT exercises will mimic the WRT exercises by targeting the same muscle groups, requiring identical movements, and using similar exercise set ups. For instances where the exercises cannot be mimicked by the MRT, an exercise that targets the same muscle group and that has similar movement will be applied. The control group will not engage in any exercises.

What are the risks and discomforts of the study?

There are minimal potential risks associated with this study. The risks associated with this research are no greater than those involved in daily activities. There is a low probability of harm or discomfort during the DXA scan procedure. The radiation emitted by the DXA during one scan is equivalent to 0.2517µSv, which is smaller than the radiation emitted during medical examinations such as a dental x-ray that emits 5µSv, a chest X-ray that emits 100µSv, and a CT scan that emits 10µSv. The DXA scan will be operated by a certified enCORE™ Operator (ASRT Reference Number: WIZ0120003F); they will be able to answer any questions that you might have. If you wish to withdraw, you can do so at any time.

Aside from this potential risk, there are no other known risks but there might be minor discomfort such as soreness, fatigue, muscle cramps, or minor strains that may result from the 1RM testing *or the exercise sessions*. You will do a 5-minutes run/jog warm up at a comfortable pace in a treadmill to reduce the risk of muscular injury or discomfort. The testing will stop if there is a risk of injury, pain or if the researcher believes you should not continue. There will always be qualified personnel supervising the sessions.

What will happen if I am injured in this study?

The University of Texas at El Paso and its affiliates do not offer to pay for or cover the cost of medical treatment for research related illness or injury. No funds have been set aside to pay or reimburse you in the event of such injury or illness. You will not give up any of your legal rights by signing this consent form. You should report any such injury to Lizette Terrazas to the number 915-433-5741 and to the UTEP Institutional Review Board (IRB) at (915-747-7693) or irb.orsp@utep.edu.

Are there benefits to taking part in this study?

You are not likely to benefit by taking part in this study but you will be able to gain knowledge on your body composition, bone mineral density, and muscular strength levels. This research may help us to understand if manual resistance training will have the same effects as any other form of resistance training and what are the benefits of using this type of training.

What are my costs?

There are no direct costs.

Will I be paid to participate in this study?

You will be compensated for your participation in the form of a $20 gift card. The gift card will be provided at the end of the post-testing procedure.

What other options are there?

You have the option not to take part in this study. There will be no penalties involved if you choose not to take part in this study

What if I want to withdraw, or am asked to withdraw from this study?

Taking part in this study is voluntary. You have the right to choose not to take part in this study. If you do not take part in the study, there will be no penalty or loss of benefit. If you choose to take part, you have the right to skip any questions or stop at any time. However, we encourage you to talk to a member of the research group so that they know why you are leaving the study. If there are any new findings during the study that may affect whether you want to continue to take part, you will be told about them.
The researcher may decide to stop your participation without your permission, if he or she thinks that being in the study may cause harm.

Who do I call if I have questions or problems?

You may ask any questions you have now. If you have questions later, you may call Lizette Terrazas at 915-747-7327 or email laterrazas2@utep.edu.

If you have questions or concerns about your participation as a research subject, please contact the UTEP Institutional Review Board (IRB) at (915-747-7693) or irb.orsp@utep.edu.

What about confidentiality?

Your part in this study is confidential. The following procedures will be followed to keep your personal information confidential. Your information will be collected by the primary investigator, Lizette Terrazas. You will be assigned an identification number so you're your personal information is not exposed. When the data is collected, your information will be added to an excel sheet that will be encrypted with a password and saved in a computer. No one will have access to the information other than the primary investigator. The results of this research study may be presented at meetings or in publications; however, your name will not be disclosed in those presentations.
Every effort will be made to keep your information confidential. Your personal information may be disclosed if required by law.

Organizations that may inspect and/or copy your research records for quality assurance and data analysis include, but are not necessarily limited to:

- Office of Human Research Protections
- UTEP Institutional Review Board

Because of the need to release information to these parties, absolute confidentiality cannot be guaranteed.
All records will be stored in a computer that will be password secured. The computer will be kept in the Student Computer Research Lab at the College of Health Science Department Room 455. Only the primary investigator will have access to the files.

Mandatory reporting

If information is revealed about child abuse or neglect, or potentially dangerous future behavior to others, the law requires that this information be reported to the proper authorities.

Authorization Statement

I have read each page of this paper about the study (or it was read to me). I will be given a copy of the form to keep. I know I can stop being in this study without penalty. I know that being in this study is voluntary and I choose to be in this study.

____

Participant's Name (printed)

____ ____________

Participant's Signature Date

____ ____________

Signature of Person Obtaining Consent Date

Appendix 5

Weight Training:

Day 1

Circuit 1:
Barbell Bench Press
low row cable back extensions
Alternated dumbbell bench press

Circuit 2:
Lying Leg curl machine
Flat bench dumbbell flys
Stationary split squats with barbell

Day 2

Circuit 1:
Back Squats with barbell
Glute-ham rack hyperextensions w/plate
Leg extensions w/ dumbbell on plyo box

Circuit 2:
Barbell narrow grip bench press
Dumbbell lateral raises
Narrow grip seated cable rows

Manual Training:

Day 1

Circuit 1:
Resisted seated chest press with pipe & chains
Resisted seated back extensions (pair of chains with handles)
Resisted alternated one-arm bench press (hand on hand)

Circuit 2:
Resisted prone lying leg curls (hands on heels)
Resisted flat bench fly's (hands on wrists)
Resisted stationary split squats with short bar

Day 2

Circuit 2:
Two-partner resisted back squats with short bar
Resisted glute-ham rack hyperextensions (resisted on shoulder)
Resisted single-leg extensions on plyo box (hand on ankle)

Circuit 2
Narrow hand position bench press (resisted on bar)
Resisted lateral raises (hands on wrists)
Resisted seated rows (pair of chains with handles)

VITA

My name is Lizette Terrazas and I currently have a Bachelor of Science in Kinesiology Degree with a minor in Nutrition and a concentration in Exercises Science. My personal email is lizette_terrazas@yahoo.com and my school email is laterrazas2@miners.utep.edu. I was part of the Kinesiology Fitness Research laboratory where I assisted other research projects.

There is currently a publication in preparation with the title, “The Effects of Manual Resistance training on Body Composition in Young Adults after a 14-week Intervention," where I was the Co-PI and the targeted Journal is Journal of Strength and Conditioning Research with the intended submission by the end of Summer 2020. There are two Peer Reviewed Abstracts where I was PI that were accepted by the National Strength and Conditioning Association for 2020 Conference with the titles:” Changes in Body Composition Following an 8-week Manual Resistance vs. Weight Resistance Training Intervention,” and “The Effects of Manual Resistance Training on Muscular Strength.” There is another abstract where I was a Co-I accepted by the National Strength and Conditioning Association for the 2019 Conference with the title, “Differences in Modified Functional Screen Scores between Male and Female Active Older Adults.” I participated in the University of Texas at El Paso’s Graduate Expo Symposium as a poster presenter with the abstract title, “Differences in Body Composition After Participation in a Manual Resistance Training Program.” I was awarded the Dodson Grant at the University of Texas at El Paso in Fall 2018 with the amount of $900.