EFFECTS OF RESISTANCE TRAINING INTENSITY TO MOMENTARY CONCENTRIC FAILURE ON MUSCULAR STRENGTH, BODY COMPOSITION, AND AFFECTIVE RESPONSES IN UNTRAINED FEMALES

by

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An Abstract of a thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the Department of Nutrition and Kinesiology University of Central Missouri

May, 2017
The purpose of this study was to examine strength, body composition, and affective responses from resistance training to failure at 30% 1-RM (30-fail) or 80% 1-RM (80-fail) in previously untrained females. Fourteen subjects completed this study. Subjects completed 10 weeks of RT to failure on four exercise machines. Strength and lean body mass were assessed at baseline and post-intervention. Strength increased significantly in the 30-fail and 80-fail groups (39.15 ± 22.00 kg and 35.15 ± 11.66 kg, respectively). Lean body mass increased significantly in the 30-fail group (1.45 ± 1.70 kg). The 30-fail group reported significantly increase in pleasure immediately post to 60 minutes post exercise (0.25 ± 1.98 to 2.13 ± 1.36, respectively). The 30-fail group reported lower perceived exertion than the 80-fail group (17.88 ± 1.36 and 18.67 ± 1.51, respectively). Training to momentary concentric failure can result in significant increases strength, LBM, and affective responses in untrained females.
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ACKNOWLEDGEMENTS

I would like to thank my faculty mentors Dr. Burns, Dr. Garver, and Dr. Docheff for the endless time and effort they put into helping me make this thesis what it is. Your willingness to provide insights and suggestions throughout the entire process is greatly appreciated. I would like to extend a thank you to Alex Rickard and William Miller, who devoted their time and energy for help with 12 weeks of data collection. Finally, I would like to thank my family and boyfriend for the love, support, and encouragement they have always provided.
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CHAPTER ONE
NATURE AND SCOPE

Resistance training (RT) is a recommended and integral component of any appropriate exercise routine (Haff & Triplett, 2016). It is the training modality most readily recognized to maintain and/or enhance levels of musculoskeletal health. When RT is employed, individuals may experience increased muscular strength and changes in body composition (increased lean body mass, increased muscular hypertrophy, decreased fat mass, and increased bone mineral density (BMD)) (Haff & Triplett, 2016). Traditional program guidelines from the American College of Sports Medicine (ACSM) and National Strength and Conditioning Association (NSCA) that promote muscular strength and hypertrophy generally recommend an individual to engage in RT two to four days per week, completing two to six sets of eight to twelve repetitions (reps) of 70-80% of a one-repetition max (1-RM) for each major muscle group (ACSM, 2014; Haff & Triplett, 2016).

As of 2006, only 17.5% of females in the United States engage in the recommended minimum amount of RT per week (CDC, 2006). Additionally, when females transition from supervised to unsupervised programs, exercise adherence declined (Arikawa, O’Dougherty, & Schmitz, 2011). Case in point, adherence to a RT program held at 95.4% when training sessions were in a supervised phase, but this number dropped to 64.5% after females transitioned to an unsupervised phase (Arikawa et al., 2011). Arikawa et al. (2011) noted that a lack of social support and motivation could have led to the attrition. One barrier for exercise adherence in this population is potential fear of the prescribed intensity, or the resulting muscular adaptations, recommended by the ACSM and NSCA. Fear of becoming too bulky, or sustaining injury due to
a high intensity, may cause attrition and lack of adherence/compliance in females who engage in RT.

A recent study by Cotter, Garver, Dinyer, Fairman, & Focht (2016), demonstrated that recreationally trained females who chose their own resistance during a RT session, chose a weight that corresponded to 57% of their 1-RM (Cotter et al, accepted and in press, Journal of Strength and Conditioning Research). Untrained females may have a propensity for self-selecting similar intensity for RT, as Focht showed this demographic chose a resistance corresponding to 56% of their 1-RM (Focht, 2007). Thus, both trained and untrained females chose weights during self-selected RT protocols that were well below an intensity range typically recommended by respected governing bodies (ACSM, 2014; Haff & Triplett, 2016). Resistance training at a lower intensity than recommended, particularly when conducted for two to three sets of eight to twelve reps, could undermine the likelihood for the typical adaptations expected in response to RT. This lack of demonstrable changes could feasibly lead to decreased adherence.

Since the 1990s, the ACSM and NSCA have recommended a conventional RT protocol at a minimum of 70% 1-RM, for two to six sets of eight to twelve reps, to generate muscular strength and hypertrophy. Recently, however, data has arisen which challenges these recognized and recommended protocols, specifically challenging the necessity of training at 70% 1-RM when training to momentary concentric failure is employed (Morton et al., 2016; Schoenfeld, Peterson, Ogborn, Contreas, & Sonmez, 2015; Mitchell et al., 2012). It is commonly believed that muscular strength and hypertrophy are achieved most effectively through use of a higher intensity (higher percent of 1-RM) RT load because volume (reps x sets) is increased due to increased weight (Schoenfeld, 2010). However, training to failure, regardless of intensity, has
the potential to elicit improvements in muscular strength and hypertrophy through increased volume.

There is limited, but encouraging evidence that training to momentary concentric failure can improve muscular strength and hypertrophy. Studies performed on trained male subjects have shown both low (30-50% 1-RM) and high (70-80% 1-RM) intensity RT protocols result in significant increases in muscular strength in the back squat (8.8% and 19.6%, respectively) and significant increases in hypertrophy in the elbow flexors (8.6% and 5.3%, respectively), elbow extensors (5.2% and 6.0%, respectively), and quadriceps femoris (9.5% and 9.3%, respectively) (Schoenfeld et al., 2015). Also, it has been shown that training to momentary concentric failure can increase quadriceps muscle size after just 10 weeks in males who have no formal experience in lifting. With use of low (30% 1-RM) and high (80% 1-RM) RT to momentary concentric failure, baseline quadriceps size increased from 1,581 (± 242) cm³ to 1,676 (± 198) cm³ and 1,529 (± 207) cm³ to 1,633 (± 198) cm³, respectively (Mitchell et al., 2012). Despite this evidence, at this time, location of any studies which examined these, or other effects, when prescribing RT to momentary concentric failure at a low and/or high intensity in untrained, young adult females was unable to be found.

Concurrent with changes in muscular strength and lean body mass is a concomitant, hormonally-mediated, enhancement of BMD (Haff & Triplett, 2016). As resistance is placed on the body, muscles adapt in both size and strength, and the pull on the bone leads to increased musculoskeletal connectivity and enhanced structural support (Haff & Triplett, 2016). However, the length of time and extent of changes is likely less obvious than those that occur with muscular strength and hypertrophy. A recent meta-analysis conducted by Kelley, Kelley, and Kohrt (2013) indicated small, statistically significant changes in BMD (<1% increase) in the
femoral neck and lumbar spine in premenopausal women who engaged in a variable frequency of RT (two to seven days per week) for a minimum of 24 consecutive weeks. There is some speculation that 24 weeks is the potential timeframe necessary to realize changes in BMD in response to RT; a consequence of the intensive nature of bone repair, remodeling, and reinforcement (Manolagas, 2000). However, Mosti et al. (2014) found that BMD increased by 2.2% in the lumbar spine and by 1.0% in both the intertrochanteric hip and total hip, after only 12 weeks of maximal RT in previously untrained females, where intensities ranged from 85-90% of 1-RM. Thus, there is no consensus of the dose-response and response-time course for how RT impacts bone mineral content (BMC) or BMD.

It is well established that affect (pleasure and displeasure), self-efficacy to continue training, and rating of perceived exertion (RPE) can influence exercise engagement and future intention towards exercise bouts (Rhodes & Kates, 2015). These variables have been investigated during acute bouts of RT at self-selected and imposed intensities in trained and untrained females (Focht et al., 2015; Focht, 2007). In trained females, RPE increased as a function of increasing intensity: 40% 1-RM = RPE of 11.26, self-selected intensity (57% 1-RM) = RPE of 13.94 and 70% 1-RM = RPE of 15.52 (Focht et al., 2015). That RPE increased with increased intensity is not surprising, but it is important to note that trained females showed greater pleasure throughout the RT session when lower intensities (40% or self-selected 57% 1-RM) and not higher intensities (70% 1-RM) were utilized. This is particularly true when considering that 70% 1-RM is in line with current recommendations (ACSM, 2014; Haff & Triplett, 2016). Moreover, there was greater self-efficacy to engage in 40% 1-RM vs. 70% 1-RM. At this time, there is no evidence regarding these variables when employing RT to momentary concentric failure in untrained, young adult females. Clearly, there is a need to
establish expected outcomes and the timeframe of adaptations with this RT strategy in this population.

**Significance**

There is convincing evidence that chronic RT at or greater than 70% 1-RM results in increases in muscular strength and positive changes in body composition (Haff & Triplett, 2016). However, there is considerable concern about a lack of participation overall, and specifically among females, to engage at this intensity during self-selected training sessions (Focht, 2007; Focht et al., 2015; Cotter et al., 2016). Self-efficacy is a strong correlate of exercise engagement and evidence indicates that females are more likely to engage in RT at lower intensities than are currently recommended (Focht, 2007; Focht et al., 2015). Thus, manipulation of a RT protocol to a lower intensity than is currently prescribed may increase adoption and long-term adherence. The result is feasibly greater adherence to the prescribed frequency of RT. Also, if training to momentary concentric failure is an effective RT strategy for females, as it is males (Morton et al., 2016; Schoenfeld et al., 2015; Mitchell et al., 2012), there is the potential to utilize this training to attract this target audience. The results of this study could provide insight on adaptations that result from training to momentary concentric failure RT in females, and there is sound rationale for the need for this investigation.

**Purpose and Aims**

The purpose of this study was to examine muscular strength, body composition (lean body mass, muscular hypertrophy, fat mass, and BMD), affective (pleasure-displeasure) and psychological (self-efficacy to continue training and RPE) responses to a RT to momentary concentric failure training protocol in untrained, young adult females. The primary aim was to provide information regarding changes in muscular strength, lean body mass, muscular hypertrophy, fat mass, and BMD in this population when employing RT to momentary
concentric failure at a low (30% 1-RM) or high (80% 1-RM) intensity. The secondary aim was to examine the pleasure-displeasure, self-efficacy to continue training, and RPE responses arising from RT to momentary concentric failure at these intensities.

**Delimitations**

The study was delimited to:

1. Females between the ages of 18 and 30 years of age who had not engaged in any formal, structured RT program (≥2 days per week for > 4 weeks) within the past two years;
2. Two training groups: a 30% 1-RM group (30-fail) and an 80% 1-RM group (80-fail);
3. A 12-week block of time; the 10 weeks of RT being fitted within one-week pre- and post-test windows for measurement of study variables;
4. Two RT sessions per week, each lasting one-hour;
5. Research variables of muscular strength and body composition (lean body mass, muscular hypertrophy, fat mass, and bone mineral density);
6. One-repetition maximum lifts to gauge muscular strength adaptations;
7. A standard tape measure used to gauge muscular hypertrophy adaptations;
8. Dual x-ray absorptiometry measuring lean body mass, fat mass, and bone density; and
9. Self-reported data for collection of affective (pleasure and displeasure), and psychological (self-efficacy to continue training and RPE) responses.

**Limitations**

The study was limited to:

1. A training period of a single academic semester: thus, the 10-week training period is on the low end of the range for seeing changes being investigated;
2. Subject diet: subjects were asked to maintain a food log and eat similar foods prior to each training day and 1-RM testing day; and

3. Subject compliance: subjects were asked to refrain from additional RT, but to maintain their current activity level; deviation from these requests could skew study variables measured.

Assumptions

It was assumed that:

1. All subjects maintained their current levels of physical activity and refrained from adding additional RT outside of the study;

2. All subjects maintained a consistent diet log prior to training days and 1-RM testing days;

3. All subjects achieved adequate sleep prior to training;

4. All subjects gave maximum effort on each one-repetition maximum test at pre-test and post-test;

5. All subjects completed reps of each resistance exercise until momentary concentric failure was achieved during each training session; and

6. All subjects completed the RT protocol during the unsupervised week.

Hypotheses

$H_1$: The 30-fail and 80-fail groups will result in significant increases from pre- to post-testing in overall strength as measured by the sum of 1-RM results in the leg extension, seated military press, leg curl, and latissimus pull down, but there will not be a difference between the two groups.
H2: The 30-fail and 80-fail groups will result in significant increases from pre- to post-testing in lean body mass, and there will be a greater change in the 80-fail group.

H3: The 30-fail and 80-fail groups will result in significant increases from immediate post- to 60 minute post-exercise for affective state, as measured by the feeling scale, and there will not be a significant difference between the two groups.

H4: The 30-fail group will result in lower perceived exertion (measured on the RPE scale) for the RT session when compared to the 80-fail group at week 10.

**Definition of Terms**

1. Affect: Psychological feelings experienced during and/or after a RT protocol (i.e.; pleasure-displeasure, intent for future engagement, and self-efficacy).
2. Intensity: Percent prescription for training weight based on an individual’s 1-RM.
3. Momentary Concentric Failure: The inability of a subject to complete the concentric portion of a lift with proper form (Schoenfeld, Peterson, Ogborn, Contreras, & Sonmez, 2015).
4. Muscular Endurance: Ability of a muscle to complete resistance training exercises at weights 30-50% of an individual’s 1-RM for 15-20 repetitions per set while avoiding muscular fatigue.
5. Muscular Hypertrophy: An increase in the size of the muscle by increasing the number of myofibrils, typically acquired via resistance training.
6. Muscular Strength: Maximum amount of external force generated by a specific muscle or group of muscles (ACSM, 2014).
7. One-repetition Maximum: The maximum amount of weight lifted for one repetition through the movement’s full range of motion.
8. Repetition: Single completion of a lift in its full range of motion.


11. Self-Efficacy: An individual’s belief in one’s own ability to succeed in or accomplish a certain task.

12. Set: A group of repetitions performed continuously until a desired amount of repetitions is reached.

13. Volume: Total amount lifted during training sessions (weight in pounds multiplied by number of repetitions completed).
CHAPTER TWO
REVIEW OF LITERATURE

The purpose of the current study was to expand on recent findings examining increased muscular strength and changes in body composition after RT to failure at low intensity and high intensity prescriptions in female subjects. While findings in current research demonstrate strength and hypertrophy can be increased after RT to failure with low intensity and high intensity loads, there is a lack of research examining the effect of RT to failure on untrained females in regards to muscular strength and body composition adaptations, and affective and psychological responses. This literature review highlights conventional RT guidelines, low intensity vs. high intensity RT to failure, affective responses to RT, and adherence to RT protocols.

Resistance Training in Females

Resistance training overloads the body by subjecting muscles and joints to a load stimulus, eliciting muscular contractions to overcome the load placed on the body. With increased overload from resistance exercises (RE), changes in the myofibrils of skeletal muscle occur, leading to increased contractile muscle proteins (Schoenfeld, 2010). Consequently, an increase in the cross-sectional area (CSA) of muscle fibers occurs, which leads to increased strength and size, or hypertrophy, within working muscle (Schoenfeld, 2010). Various RT protocols exist that, by nature of the exercise routine, cause changes within skeletal muscle. These changes take place when fundamentals of RT are altered based on the goal of the individual engaging in RT. Such variables that can be manipulated include type of contraction (eccentric, concentric, or both), exercise selection and order, muscle groups trained, rest time between sets, and volume, where load/intensity and repetition (rep) scheme are altered (Kraemer
& Ratamess, 2004). Depending on the training adaptation desired (e.g., muscular strength, hypertrophy, power, or endurance), variables may be manipulated in different ways. In general, total-body workouts implementing moderate to heavy intensity with higher rep schemes and multiple sets completed lead primarily to increases in muscular hypertrophy and also strength (Kraemer & Ratamess, 2004).

In females, RT has been shown to positively impact health and performance (Haff & Triplett, 2016). With the many physiological adaptations RT can improve, it seems intuitive that this exercise modality should be incorporated into physical activity regimens. In regards to body composition, females consistently report lower muscle mass, lower BMD, and increased body fat when compared to males (Haff & Triplett, 2016). Strength and hypertrophy in females is comparable to that of males when expressed in relative terms, but strength is lower in the upper body when females are compared to males (Haff & Triplett, 2016). The combination of increased body fat, decreased muscle mass, and decreased BMD highlights the importance of adding the training modality into weekly exercise programs. Females should respond to and gain physiological adaptations that help both their health and performance.

**Muscular Strength and Body Composition**

Chilibeck, Calder, Sale, and Webber (1997) used both single-joint (arm curl) and multi-joint (bench press and leg press) RE to determine changes in muscular strength (measured by 1-RM) and muscular hypertrophy (measured by DEXA scan and expressed as lean body mass) in females with limited strength training experience. Upper body RE (bench press, arm curl, lat pull down, and tricep extension) were completed for five sets of six to ten reps, while lower body exercises (leg press, leg curl, and leg extension) were completed for five sets of ten to twelve reps (Chilibeck et al., 1997). Authors stated intensity for both upper and lower body exercises
ranged from 75-90% 1-RM (Chilibeck et al., 1997), which is consistent with recommendations from recognized governing bodies for eliciting increased muscular strength and muscular hypertrophy (ACSM, 2014; Haff & Triplett, 2016). After 20 weeks of RT, significant increases in both muscular strength (in bench press, leg press, and arm curl) and muscular hypertrophy (measured separately at the arm, leg, and trunk regions) occurred (Chilibeck et al., 1997). Increases in muscular strength were seen from pre-testing to mid-testing (10 weeks) and from 10 weeks to post-testing (20 weeks); hypertrophy increases in the arm were seen throughout the full 20-week protocol, while hypertrophy increases of the leg and trunk were seen only in the last ten weeks (Chilibeck et al., 1997). This is indicative of disconnect between changes in strength and hypertrophy; strength increases are recognized to occur more quickly than hypertrophy in multi-joint movements (bench press and leg press), potentially due to neuromuscular adaptations (Chilibeck et al., 1997). Although muscular strength and muscular hypertrophy occurred at different time points for inexperienced resistance-trained females, adaptations did occur for both variables, which could lead to increased health and performance for female participants.

Changes in body composition, muscular strength, and muscular hypertrophy were also examined in untrained females participating in four different periodized RT protocols (total body, low rep; total body, high rep; upper body, low rep; and upper body, high rep) (Kraemer et al., 2004). Periodized RT programs change the intensity (percent of 1-RM lifted) and volume of the program throughout its entirety to ensure overload of the musculature is occurring at each time point throughout the RT protocol. Body composition, measured by a seven-site skinfold assessment, revealed a significant increase in fat-free mass after the six-month training period for all groups except for the upper body low rep RT group (Kraemer et al., 2004). Neither percent body fat nor fat mass was altered in any of the four groups (Kraemer et al., 2004). Kraemer et al.
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(2004) assessed hypertrophy by measuring the CSA of the arm and thigh via magnetic resonance imaging. The total body training groups both showed significant increases in arm and thigh CSA at week 12 and at week 24 (Kraemer et al., 2004). The upper body training groups showed significant increases in arm CSA at weeks 12 and 24, but not in thigh CSA at either time point (Kraemer et al., 2004), possibly due to specificity of training. In regards to maximal strength, total body low and total body high RT groups significantly increased maximal squat at week 12 and at week 24 (Kraemer et al., 2004). All training groups significantly increased 1-RM bench press at week 12 and at week 24 (Kraemer et al., 2004). Results of the study by Kraemer et al. (2004) indicate previously untrained females have the potential to produce positive changes in body composition, muscular strength, and muscular hypertrophy. However, the total body groups showed significant increases across the six-month period in all variables, unlike the upper body only groups. Since total body RT led to increased physiological adaptations common in RT programs, it is plausible females can improve health and fitness measures from RT and should add RT to an exercise program.

Schmitz et al. (2007) examined the efficacy of a two times per week RT program on decreasing intra-abdominal fat in premenopausal females during a two-year study. After two years, the training group showed a significant decrease in percent body fat (-3.5%) and intra-abdominal fat (-14.3%) in year two compared to year one of the two-year program (Schmitz et al., 2007). Additionally, total fat mass and subcutaneous abdominal fat showed small, but significant decreases in year two of the program (Schmitz et al., 2007). In regards to maximal strength, the training group saw increases in both the bench press (9.4% increase) and leg press (9.7% increase) (Schmitz et al., 2007). These results indicated that two RT sessions per week
can positively influence health (decreased percent body fat and intra-abdominal fat) and performance (increased maximal strength).

In untrained males, findings similar to long-term RT programs were reported after only 12 weeks of RT (Widrick, Stelzer, Shoepe, & Garner, 2002). Resistance training followed a 12-week, nonlinear periodized training program of the following cycles: during weeks one and two subjects completed three sets of twelve reps; during weeks three through twelve, subjects completed three sets of ten reps on day one, three sets of eight reps on day two, and three sets of six reps on day three (Widrick et al., 2002). Following 12 weeks of RT, lean body mass increased by 4%, leg press six RM increased by 62% (relative to total body mass), and CSA of type I, IIa, and IIx fibers increased (about 30% increase for all three fiber types) (Widrick et al., 2002). The findings of the study by Widrick et al. (2002) are encouraging for body composition and muscular adaptations within a short time-frame (12 weeks); however, the intervention used only males, preventing generalization of results to females.

Recently, Mosti et al. (2014) implemented a maximal RT program in untrained females. After only 12 weeks of maximal RT (one exercise repeated three times per week at 85-90% 1-RM for three sets of three to five reps), lower body lean body mass increased by 0.42 kg. Body fat mass, however, did increase by 0.75 kg whole body and 0.35 kg in the lower extremity (Mosti et al., 2014). In regards to strength, 1-RM in the hack squat increased by 97.7% in the training group versus the control group after 12 weeks of RT (Mosti et al., 2014).

**Bone Mineral Density**

When loading is applied to the body via RE, osteoblasts are brought to the surface of bones and bone modeling begins (Haff & Triplett, 2016). An increase in osteoblasts to the bone surface initiates protein secretion, bone matrix formation on the outer bone surface, and a
subsequent increase in diameter and strength of bones (Haff & Triplett, 2016). Consequently, increases in muscular strength and/or hypertrophy lead to increases in BMD (amount of mineral within an area of bone) (Haff & Triplett, 2016). It has been suggested that it takes 24-weeks for adaptations, or increases, in BMD to be noticed as the regrowth and remodeling process for bone is extensive (Manolagas, 2000). As peak bone mass is said to be reached by 30 years of age, there is an age-related and hormonally-related decrease in BMD (Kohrt, Bloomfield, Little, Nelson, & Yingling, 2004), indicating the importance of increasing or maintaining BMD in premenopausal females.

The 2004 ACSM Position Stand on Physical Activity and Bone Health advocates that adults should engage in moderate to high intensity bone loading activities such as plyometrics, gymnastics, weight-bearing endurance activities, or RT for BMD improvement or maintenance (Kohrt et al., 2004). Multiple RT interventions lasting at least 16 weeks in females older than 18 years of age were examined to determine the efficacy of RT for improving BMD (Kelley, Kelley, & Tran, 2001). Both premenopausal and postmenopausal females saw small, but statistically significant increases in BMD of the lumbar spine after RT protocols. Although this review included study designs that were less than the suggested 24-week BMD adaptation timeline (Manolagas, 2000), statistically significant increases of BMD were seen for premenopausal females in the lumbar spine, indicating RT can have a positive effect on BMD increases. In contrast, a review of only premenopausal females and increases in BMD of the lumbar spine and femur after RT showed no statistically significant improvements (Kelley & Kelley, 2004). As mentioned by these authors, use of machine weights in most studies could have caused insignificant findings as free weight exercises have been stated as the superior modality for improved BMD (Kelley & Kelley, 2004).
In a more recent review, Kelley, Kelley, and Kohrt (2012) examined the effects of exercise interventions including ground or joint reactions lasting anywhere from 24 to 104 weeks, with training on two to seven days per week on BMD in the femoral neck and lumbar spine in premenopausal females. Exercise led to a statistically significant increase in BMD of the femoral neck (0.4% increase in exercise vs. -0.7% decrease in control) and in the lumbar spine region when results were collapsed (Kelley et al., 2012). This indicates an exercise protocol that elicits loading of the joints can lead to small increases of BMD in the femoral neck and lumbar spine of premenopausal females.

On a much shorter time scale, Mosti et al. (2014) found increases in BMD of the lumbar spine and total hip in young females after only 12 weeks of RT. Females aged 18 to 27 years engaged in 12 weeks of a single-exercise RT program: the hack-squat exercise was performed for three sets of three to five reps at 85-90% 1-RM, three times per week (Mosti et al., 2014). Despite the relatively short time frame in regards to BMD increases and the single-exercise protocol, subjects in the training group showed a 2.2% increase in BMD of the lumbar spine and a 1.0% increase in BMD of the total and intertrochanteric hip (Mosti et al., 2014). A control group consisted of subjects who were recommended to engage in the ACSM resistance training guidelines, but saw no increases in BMD of either the lumbar spine or total hip after the 12-week period (Mosti et al., 2014). Whole-body BMD did not increase in either of the two groups (Mosti et al., 2014). The results by Mosti et al. (2014) indicated BMD increases within a short time frame are possible, if the muscles, joints, and bones are stressed to near maximal levels (i.e., 85-90% of 1-RM was used).
Affective and Psychological Responses

While results of the previously discussed studies on RT and physiological adaptations among young females are encouraging for both health and performance measures, the studies lacked information regarding affect (pleasure and displeasure), self-efficacy, and intent for future engagement. These variables are vital and recognized to relate to exercise adoption and adherence (Ekkekakis, Hall, & Petruzzello, 2008; Rhodes & Kates, 2015). For this reason, it is important to examine related literature assessing the affective and psychological responses to RT at various intensity prescriptions.

Affective Responses. In trained and untrained individuals, a multitude of RT protocols with differing variables have been found to increase muscular strength and body composition in females (Kraemer & Ratamess, 2004; Chilibeck et al., 1997; Kraemer et al., 2004; Schmitz et al., 2007; Kelley et al., 2001; Kelley & Kelley, 2004; Mosti et al., 2014), indicating many RT protocols could be used to enhance muscular and skeletal adaptations in untrained females for improved health. However, these studies lacked the inclusion of resultant affective and psychological responses of the females engaged in the RT protocols (Kraemer & Ratamess, 2004; Chilibeck et al., 1997; Kraemer et al., 2004; Schmitz et al., 2007; Kelley et al., 2001; Kelley & Kelley, 2004; Mosti et al., 2014). It has been suggested that affective responses to RT can predict future engagement in exercise (Rhodes & Kates, 2015). In regards to RT, affective responses refer to the pleasure or displeasure (i.e., positive or negative affect) an individual may feel after an acute exercise bout. Arent, Landers, Matt, and Etnier (2005) found a linear relationship between exercise intensities and positive and negative measures of affect. Male and female subjects with no RT background performed three sets of ten upper body RT exercises at low (40% 10-RM), moderate (70% 10-RM), and high (100% 10-RM) intensities (Arent et al.,
Performing RE at the moderate intensity showed the only increase in positive affect and largest decrease in negative affect after training (Arent et al., 2005). Additionally, the low and high intensities corresponded with the largest total decrease in positive affect after training and the only increase in negative affect throughout the RT session and after training, respectively (Arent et al., 2005). The affective responses of subjects in the aforementioned study correspond with recommended intensity by ACSM and NSCA for improving or maintaining muscular strength and hypertrophy (ACSM, 2014; Haff & Triplett, 2016). This indicated recommended intensities for increased strength and hypertrophy may show higher feelings of pleasure than either lower or higher intensities.

Similar findings by Arent et al. (2005) were found in a study that examined trained females RT at low (40% 1-RM), high (70% 1-RM) and self-selected (corresponding to 57% 1-RM) intensities for three sets of ten reps of four upper and lower body exercises (Focht et al., 2015). Trained females showed increases in feelings of pleasure during and immediately following RT at the low and self-selected intensities, decreases in pleasure during RT at the high intensity, and increases in pleasure immediately following RT at the high intensity (Focht et al., 2015). These findings demonstrated positive affect was evident both during and after the acute RT bout in both low and self-selected intensities, showing females prefer lighter loads for pleasure than currently recommended prescriptions of 70% 1-RM. This is encouraging as it showed females can find an intensity they enjoy while engaging in RT. Participants in the research performed by Focht et al. (2015) completed three sets of ten reps, consistent with governing bodies’ guidelines for muscular strength and hypertrophy (ACSM, 2014; Haff & Triplett, 2016). However, the self-selected intensity by trained females was not enough to elicit said adaptations at the imposed set and rep range.
In contrast, Bibeau, Moore, Mitchell, Vargas-Tonsing, and Bartholomew (2010) found males and females showed the largest increases in positive affect in a low intensity bout (50-55% 1-RM) versus high intensity bout (80-85% 1-RM) of RT. Resistance exercises for the low intensity groups were carried out for three sets of ten to eleven reps (Bibeau et al., 2010). While this is below current recommendations in regards to intensity and reps for strength and hypertrophy (ACSM, 2014; Haff & Triplett, 2016), both sexes found more pleasure at lower intensities. The way an individual feels post-RT session could affect the efficacy of the training program and, potentially, the intent to continue a program for weeks to come for beginning exercisers (Bibeau et al., 2010).

Finally, in a review of literature on affective responses and exercise, Rhodes and Kates (2015) found a significant and positive relationship between affective response during moderate intensity exercise and future engagement in exercise; however, affective responses after an exercise bout showed no relationship to future exercise engagement. In short, this implied that an individual’s feelings of pleasure and/or displeasure have a positive relationship with future exercise engagement (i.e., positive affect is predictive of higher exercise engagement), while negative affect does not show an increased future exercise engagement. Additionally, affective response from vigorous intensity exercise had no relationship with future exercise engagement (Rhodes and Kates, 2015).

**Self-Efficacy.** Self-efficacy is an individual’s belief in his or her own ability to succeed in or accomplish a specific task or situation (Bandura, 1997). In relation to exercise, self-efficacy has been found to be a main contributor to exercise adherence and compliance across multiple populations (McAuley & Blissmer, 2000). In other words, when an individual’s self-efficacy is high, one is more likely to continue exercising in the long-term. In females, it has
been stated that self-efficacy is negatively affected with increasing age; however, if exercising, self-efficacy in females is significantly higher than their non-exercising counterparts (McAuley & Blissmer, 2000). This is promising as low adherence to unsupervised exercise programs is high in females (CDC, 2006), but when exercising, self-efficacy increases which could potentially increase adherence (McAuley & Blissmer, 2000). Prevalence of attrition to RT in females is high, and reviewing self-efficacy during a RT protocol may provide insight into engagement of various programs.

Focht et al. (2015) has examined self-efficacy in trained females engaging in low (40% 1-RM), high (70% 1-RM), and self-selected (57% 1-RM) intensities after an acute bout of RT (four exercises completed at specified intensities for three sets of ten reps). Self-efficacy to engage in RT at the prescribed intensity was highest in the self-selected intensity; low intensity also showed greater self-efficacy than the high intensity load (Focht et al., 2015). This indicated that intensity prescriptions of 70%, which are congruent with recommended intensities (ACSM, 2014; Haff & Triplett, 2016), may not improve self-efficacy; this does not bode well for adherence. As self-efficacy has been previously reported as an indicator of adherence and compliance to exercise (McAuley & Blissmer, 2000), prescribing high intensities in females may not be the best recommendation for improving RT participation rates among this population.

Rhodes and Kates (2015) also reviewed self-efficacy during and after exercise. In regards to affect and self-efficacy during exercise, studies reported both positive and no relationship between the two variables when moderate intensity exercise was performed (Rhodes and Kates, 2015). Similar to moderate intensity exercise, vigorous intensity exercise showed equivocal results between positive and no relationship of affect and self-efficacy (Rhodes and Kates, 2015). This review indicated further research was needed in regards to exercise intensity,
affective response, and self-efficacy during exercise. Furthermore, Rhodes and Kates (2015) utilized aerobic exercise instead of RT, increasing the need for further research on the area.

**Intention.** Intention to continue RT after an acute RT bout in trained females was examined by Focht et al. (2015). Intent for RT within the next month was highest in a self-selected intensity (57% 1-RM) compared to low (40% 1-RM) and high (70% 1-RM) intensities (Focht et al., 2015). Interestingly, when the low and high intensity RT bouts were compared, females showed greater intent for continued RT at the high intensity compared to the low intensity (Focht et al., 2015). This is interesting, as the same study showed females reported greater pleasure during RT at the low intensity compared to the high intensity (Focht et al., 2015). This revealed a disconnect between pleasure and intention, and could be a reason for attrition among female RT participants. To expand, the study by Focht et al. (2015) had females complete only three sets of ten reps at each intensity, which could have led to a decrease in adherence at lower intensities due to potential boredom or lack of challenge, but also decreased pleasure at high intensity prescriptions due to the increased challenge from increased loading. It is necessary to examine RT at lower intensities and carrying reps to failure and their relation to intent for future RT engagement.

The relationship between affective response during and after moderate intensity and vigorous intensity exercise and intent for further exercise engagement was discussed in a systematic review (Rhodes & Kates, 2015). Rhodes and Kates (2015) stated affective responses during and after exercise have a potential relationship to intent in engagement; however, there were limitations in sample size and power that effected results. These results indicated a need for affective response from RT to failure and the relationship to intent for engagement in the same RT protocol. The seemingly positive relationship between affect and self-efficacy (Rhodes
& Kates, 2015) as well as self-efficacy and intensity by Focht et al. (2015) underlined an important concept that should be further applied when examining RT protocols in females, since this group was lacking in participation of RT (CDC, 2006).

Adherence to Resistance Training Protocols

As of 2006, only 17.5% of female adults in the United States engage in the recommended amount of RT per week, recognized by the Centers of Disease Control and Prevention as ≥ 2 days per week (CDC, 2006). While this may be attributed to boredom, fear, or lack of enjoyment, there are implications in regards to affective responses from training that could increase adherence. A two-year, two times weekly RT program for premenopausal females, ages 25 to 44, measured adherence to a RT program during supervised and unsupervised conditions (Schmitz et al., 2007). At the end of the first year of supervised training, adherence to twice weekly RT was 76%; at the end of the second year of unsupervised training, adherence to twice weekly RT decreased from 76% to 61% (Schmitz et al., 2007). While adherence was greater than the national average of 17.5% of females who reported RT engagement in 2006 (CDC, 2006), a decrease in adherence when supervision conditions changed was problematic. More recently, Arikawa et al. (2011) examined RT adherence to a twice weekly protocol and saw adherence decreased from 64.5% to 51.4% from year one to year two of unsupervised RT. When unsupervised, females seemed to lack the desire to meet minimum RT recommendation (at least two times per week). The affective state of premenopausal females during or after RT was unknown in the previous two studies. However, it has been shown that greater affective responses corresponded to increased exercise adherence (Williams et al., 2008). Because of this, affective responses to exercise, specifically RT at different intensities, is needed to understand an appropriate prescription for increased adherence.
Resistance Training to Failure

Although current RT guidelines suggest muscular strength and muscular hypertrophy occur with moderate to high intensity loading completing moderate to low reps, respectively, recent research has investigated adaptations employing low intensity workloads when reps are taken to failure. Hypertrophy occurs when muscle protein synthesis (MPS) exceeds muscle protein breakdown (MPB). It has been shown that MPS rate is increased and MPB breakdown rate is slightly decreased in mixed, mitochondrial, and myofibrillar regions after an acute bout of RT (Egan and Zierath, 2013). Protein synthesis is activated by the Akt (PBK)-mTOR signaling pathway, which is made up of various proteins necessary for protein synthesis, including p70S6K (Egan and Zierath, 2013). In regards to MPS, Burd et al. (2010) examined mixed, myofibrillar, and sarcoplasmic protein synthesis at rest, 4 hours post-exercise, and 24 hours post-exercise in three groups exercising at different intensities. Interestingly, RT at 30% of 1-RM until failure brought about significantly greater increases in myofibrillar MPS than 90% of 1-RM until failure at 24 hours post-RT workout (Burd et al., 2010). Greater MPS is indicative of hypertrophy, as protein makes up the contractile units of skeletal muscle. In addition, p70S6K, a downstream target for mTOR, was upregulated 4 hours post-exercise in the 30% to failure RT group only; both mTOR and p70S6K are critical for muscular growth adaptations to take place (Burd et al., 2010; Egan & Zierath, 2013). This research provides insight into the potential efficacy of the RT to failure strategy for realizing increases in MPS. Although the findings are encouraging, the aforementioned study used experienced male volunteers, thus limiting the generalization of results.

More recently, two eight-week studies focused on trained men carrying out RT to failure. One study focused on total volume between low and high intensities, and the second focused on
muscular strength, hypertrophy, and endurance between low and high intensity RT (Schoenfeld et al., 2016; Schoenfeld et al., 2015). When comparing low intensity and high intensity workloads (25-35 reps to failure and 8-12 reps to failure, respectively), the low intensity group showed a significantly greater total volume than the high intensity group (Schoenfeld, 2016). Training volume is a variable commonly manipulated within RT protocols to elicit various responses dependent on individual goals. Altering the weight lifted (intensity) and rep scheme of a RT program leads to changes in total volume. It has been postulated that greater hypertrophy gains are seen with volume and rep schemes of moderate to heavy (Kraemer & Ratamess, 2004). Typically, high intensity with moderate reps is prescribed in conventional RT protocols. This is consistent with guidelines set forth by both ACSM and NSCA, with recommendations of 67-85% 1-RM of 8-12 reps for strength and hypertrophy adaptations (ACSM, 2014; Haff & Triplett, 2016). However, Schoenfeld et al. (2016) found lower intensities, when performed to fatigue, revealed greater total volume over an 8-week time course. Although changes in muscular strength and muscular hypertrophy were not examined, lifting when fatigued (i.e., momentary concentric failure) does increase motor unit activation (Kraemer & Ratamess, 2004), potentially leading to increased strength and hypertrophy, even at lighter intensities.

The second eight-week study revealed muscular hypertrophy increased similarly in both low intensity (30-50% 1-RM, 25-35 reps to failure) and high intensity (70-80% 1-RM, 8-12 reps to failure) training groups, contradicting the current belief that RT protocols must use at least 67% of 1-RM to elicit hypertrophic gains (Schoenfeld et al., 2015; Haff & Triplett, 2016). Additionally, muscular strength increased from baseline levels in 1-RM bench press and 1-RM back squat for both groups (Schoenfeld, 2015). Current RT guidelines suggest intensities nearing 80% 1-RM are recommended for maximal strength increases to occur (Haff & Triplett,
2016). On the contrary, data provided by Schoenfeld (2015) revealed muscular strength was still improved when only 30-50% 1-RM was used, indicating muscular strength is plausible at lower intensities if reps are performed to failure.

In regards to adaptations in male subjects without a formal RT background, Mitchell et al. (2012) found significant increases in 1-RM strength, muscular hypertrophy of the quadriceps, and mTOR elevation in subjects performing 3 sets of 80% 1-RM to failure, 3 sets of 30% 1-RM to failure, and 1 set of 1 rep at 80% 1-RM. Although mTOR was elevated in all groups, its downstream target p70S6K was only elevated post-exercise in the two 80% groups (Mitchell et al., 2012). Although the target protein is important, an elevation of mTOR post-exercise allows an increase in MPS; additionally, hypertrophy of the quadriceps still occurred indicating MPS was taking place (Mitchell et al., 2012). Interestingly, hypertrophy of the two groups performing rep to failure doubled the average increase from the single set performed at 80% 1-RM (Mitchell et al., 2012). Although lower intensities are not typically indicative of hypertrophy occurrence and higher intensities are, reps to failure at 30% 1-RM showed greater increases compared to 1 rep at 80%. This may not be too surprising, however, since total volume plays a large role in motor unit activation and subsequent hypertrophy.

After 12 weeks of total body RT 4 days per week, trained men were able to show similar increases in lean body mass, muscle fiber CSA, strength, and hypertrophy at both low (30% 1-RM) and high (80% 1-RM) intensities (Morton et al., 2016). These findings are consistent with previous studies indicating that as long as reps are taken to volitional failure, strength and hypertrophy can occur after a RT protocol regardless of intensity used. Similar to findings by Mitchell et al. (2012), strength gains after 12 weeks of RT to failure were greater in subjects who used 80% 1-RM compared to those who used 30% 1-RM (Morton et al., 2016). Again, this is
consistent with current RT guidelines that suggest reps performed at near 85% 1-RM are necessary for muscular strength adaptations. If 1-RM strength is the main goal, higher intensities will elicit greater strength increases; however, 1-RM strength will increase above baseline measures if lower intensities are taken to failure.

The previously mentioned studies examined trained and untrained male subjects and their responses in terms of muscular strength and muscular hypertrophy during RT to failure. Females show similar adaptations in muscular strength and muscular hypertrophy, relatively speaking, and recruit the same muscle groups as males for various activities (Haff & Triplett, 2016), meaning program design should not differ between males and females. However, it is possible physiological adaptations to RT to failure could differ in male and female participants. It may be necessary to determine the efficacy of RT to failure at various intensities in female subjects to determine physiological adaptations (body composition, muscular strength, muscular hypertrophy, and BMD), affective responses, and psychological responses.
CHAPTER THREE
METHODS

Conventional RT programs with a goal towards increasing muscular strength and hypertrophy have individuals complete three sets of eight to twelve reps at 70% or greater of their 1-RM (Haff & Triplett, 2013). The purpose of this study is to expand on previous findings indicating that increases in muscular strength, muscular hypertrophy and bone mineral density can occur at loads typically indicative of muscular endurance training i.e. 30% 1-RM if sets are performed to momentary concentric failure (Mitchell et al., 2012; Schoenfeld et al., 2015; Morton et al., 2016). Affective and psychological responses were collected to determine the likelihood of continued exercise training until muscular failure at the given percent loads after study completion.

Subjects

Participants for the study consisted of a convenience sample of young adult (18-35 years) women within the Warrensburg, Missouri area. Subjects were included if they were free from any musculoskeletal injuries, not pregnant, currently not participating in weight training and have not participated in a structured (≥ 2 days per week > 4 weeks) RT program for the past two years, low risk for CV disease according to ACSM risk stratification, and demonstrate readiness for physical activity (PAR-Q). Subjects were asked to eat similar foods prior to each training day and 1-RM testing day, and maintain their current activity level (while refraining from any additional RT).

Resistance Training Protocol

Prior to the RT intervention, all subjects performed 1-RM testing on the chest press, leg extension, seated military press, leg curl, and lat pull down to provide a baseline strength
measure and to prescribe training load. Subjects were pair-matched based on their initial 1-RM
lifts and randomly assigned to one of two groups: a low-intensity group who performed RE at
30% 1-RM to momentary concentric failure (30-fail) or a high-intensity group who performed
RE at 80% 1-RM to failure momentary concentric failure (80-fail). Momentary concentric
failure has been defined as the point in which a subject could no longer complete the concentric
contraction of a lift with proper form (Schoenfeld et al., 2015). The 80-fail group was
designated as the traditional group as the intensity and reps completed until momentary
concentric failure would most closely align with recommendations by governing bodies (Haff &
Triplett, 2016). Exercises performed (chest press, leg extension, seated military press, leg curl,
and lat pull down), rest time (90 seconds), and repetition cadence (two second concentric
contractions, two second eccentric contraction) remained constant between the two groups.

The RT training protocol required subjects to perform two sets of six exercises during the
first four weeks of the study; a third set was introduced in week five and carried out through
week ten to mimic progressive overload seen within strength cycles (Haff & Triplett, 2016).
Exercises were performed in the following order: chest press, leg extension, seated military
press, leg curl, lat pull down, and abdominal crunches or back extensions (alternating days). All
exercises besides abdominal crunch and back extension were performed until momentary
concentric failure for all sets; abdominal and back extensions were completed as two sets of 20
reps and increased to three sets of 20 reps at week five. All exercises were completed at the
University of Central Missouri Student Recreation Center using machine weights (FreeMotion
Fitness, Logan, UT, USA). Machine weights were implemented to ensure safe execution of all
exercises as the subject pool consisted of inexperienced lifters. ACSM and NSCA recommend
all resistance training exercises be completed in a slow and controlled manor to employ the full
range of motion and proper form (ASCM, 2014; Haff & Triplett, 2016). Thus, cadence was controlled between subjects with a 2-second concentric contraction and a 2-second eccentric contraction. Subjects were given 90-seconds rest between all exercises (Haff & Triplett, 2016). Subjects completed two resistance training sessions per week and were given at least 48-hours rest between sessions.

Assessments

Muscular strength was assessed by completion of 1-RM testing both pre- and post-intervention. Resistance exercises tested during 1-RM testing were consistent with the lifts performed during the training sessions. Subjects were asked to refrain from any exercise at least 48-hours prior to their individual 1-RM assessment. One-repetition maximum testing followed procedures set forth by the NSCA. Subjects received 3 minutes rest between each of the maximum attempts.

Lean body mass, fat mass, and BMD were used to determine changes in body composition measures. Lean body mass was used as an indirect measure of muscular hypertrophy, as increases in muscle mass are indicative of hypertrophy occurrence due to the increase of fiber size from muscle protein synthesis and satellite cell proliferation (Schoenfeld, 2010). To assess, a DEXA scan was performed pre-intervention, week 4 of the intervention, and post-intervention. Subjects were instructed to refrain from eating and drinking caffeine at least 4 hours prior to the scan and to maintain normal hydration levels on the day of testing. The DEXA scan taking place on week 4 of the intervention was completed prior to engagement in the RT protocol.

Affective and Psychological Measurement Protocol

Affective and psychological responses to exercise and self-efficacy in regards to
continued exercise were assessed. Affective measures were included to determine the pleasure/displeasure experienced from exercise, and the practicality of an individual completing the same exercise protocol after study completion. Measures of the affective response and self-efficacy give a better understanding of continued training as they provide insight on intrinsic motives of the exerciser.

Affective response was measured using a Feeling Scale (FS) and was used to determine the amount of pleasure or displeasure an individual experienced during the RT protocol. The FS used is a single rating assessing pleasure on a scale of -5 (very bad) to +5 (very good) (Hardy & Rejeski, 1989). It was measured before each lift, after the 2nd (weeks 1-4) or 3rd set (weeks 5-10) of each exercise, immediately following the RT session, and 15 minutes post-exercise. Previous research has found the FS to be both valid and reliable when used to assess affective response from exercise (Ekkekakis, Hall, & Petruzzello, 2008; Williams et al., 2008).

Self-efficacy was assessed to provide information on the subject’s confidence that he or she could continue to perform RT exercises at the given intensity during unsupervised conditions i.e. after study completion. Self-efficacy was measured by completing a 12-item questionnaire rated on a 100-point scale ranging from 0% (no confidence at all) to 100% (completely confident). Self-efficacy was assessed twice weekly (once at the end of each training session). Self-efficacy has been found to be valid and reliable in previous research studies (McAuley & Blissmer, 2000).

RPE was measured to provide information on perceived exertion from the RT protocol. RPE was measured on a two different scales: 1-10 and Borg’s RPE 6-20. RPE was assessed immediately following every set of each lift. RPE has been found to be a reliable measure of perceived exertion when using it during RT sessions.
Statistical Analysis

For H₁, separate paired t-tests were conducted to test differences in pre- to post-overall strength outcomes in the 30-fail and 80-fail groups. An independent t-test was conducted to test the differences in pre- to post-strength changes between the two groups.

For H₂, separate paired t-tests were conducted to test differences in pre-intervention and post-intervention lean body mass in the 30-fail and 80-fail groups. An independent t-test was conducted to test the differences in pre- to post-lean body mass changes between the two groups.

For H₃, separate paired t-tests were conducted to test differences in immediate post-exercise and 60 minute post-exercise affective state in the 30-fail and 80-fail groups. An independent t-test was conducted to test the differences in the change scores for immediate post-exercise and 60 minute post-exercise affective state between the two groups.

For H₄, an independent t-test was conducted to test the differences between perceived exertion at week 10 between the 30-fail and 80-fail groups.
The purpose of this study was to examine the effects of resistance training to failure in two intensity groups, 30-fail or 80-fail, in untrained females. Subjects’ 1-RM was defined as the maximal amount of weight a subject could move one time through a full range of motion. Statistical analyses were conducted to determine differences in strength, body composition, and affective responses between the two training groups. Dependent t-tests were completed to determine any statistical differences in pre- and post-intervention changes in overall strength and lean body composition, and FS value changes from immediate post-exercise to 60 minutes post-exercise within the two intensity groups. Independent t-tests were conducted to determine statistical differences in strength and lean body mass between the 30-fail and 80-fail groups at pre- and post-intervention, and FS value changes from immediate post-exercise to 60 minutes post-exercise between the two groups. The session RPE mean and standard deviation of both training groups was calculated and an independent t-test conducted to determine any differences between the 30-fail and 80-fail training groups.

Descriptive Statistics

A total of 19 untrained females entered the study. Prior to beginning training, one female withdrew due to the requirement to avoid additional resistance training. During week three, one subject was removed due to non-compliance. Also, two subjects withdrew due to injury. A total of 14 subjects completed the research study. The overall population had a mean ± standard deviation (SD) age, height, and weight of 20.7 ± 1.5 years (yrs), 166.5 ± 6.9 centimeters (cm), and 62.8 ± 6.3 kilograms (kg), respectively. Table 4.1 illustrates the same descriptive information by
group. Independent t-tests revealed no significant differences existed between the two groups at the start of the study.

Table 4.1

*Intensity Group Descriptive Statistics*

<table>
<thead>
<tr>
<th></th>
<th>30-fail Mean ±SD</th>
<th>80-fail Mean ±SD</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>20.88 ±1.73</td>
<td>20.50 ±1.22</td>
<td>0.660</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>165.31 ±8.21</td>
<td>168.18 ±5.05</td>
<td>0.466</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>64.58 ±7.25</td>
<td>59.96 ±3.50</td>
<td>0.215</td>
</tr>
</tbody>
</table>

Yrs = years; cm = centimeters; kg = kilograms

**Statistical Evaluation of Overall Strength**

The overall strength score was determined by computing the total sum of the 1-RM scores of leg extension, seated military press, leg curl, and latissimus pull down. It was hypothesized that both the 30-fail and 80-fail groups would result in significant increases in overall strength from pre- to post-testing, and that there would not be a difference between the two groups. As determined by dependent t-tests, both 30-fail and 80-fail groups experienced significant increases in overall strength over the course of the 10 week training period. Data for changes in strength are shown in Table 4.2. There were no significant differences between the two groups ($t(12) = 0.402$, $p = 0.695$) for overall change in strength. Based on these results, the first hypothesis was accepted.
Table 4.2

*Changes in Strength (kg)* pre-post testing for the 30-fail and 80-fail groups

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Mean Change ±SD</th>
<th>Within Group P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-fail Strength (kg)</td>
<td>172.27</td>
<td>39.15 ±22.00</td>
<td>0.002</td>
</tr>
<tr>
<td>80-fail Strength (kg)</td>
<td>192.88</td>
<td>35.15 ±11.66</td>
<td>0.001</td>
</tr>
</tbody>
</table>

kg = kilograms

**Statistical Evaluation of Lean Body Mass**

The second hypothesis stated the 30-fail and 80-fail training groups would both result in significant increases in pre- to post-LBM with a greater change being observed in the 80-fail group. According to t-test results, contrary to the hypothesis, the 30-fail group showed a statistically significant increase in LBM of 1.45 kg ± 1.70 kg, while the 80-fail group did not see a significant increase (0.58 kg ± 0.95 kg). Table 4.3 summarizes the within group changes of LBM in the 30-fail and 80-fail groups. There was no statistical difference in LBM changes between the two groups (t(11) = 1.042, p = 0.320). Based on these three separate test, the second hypothesis can be rejected.

Table 4.3

*Changes in LBM (kg)* pre-post mean ± SD for the 30-fail and 80-fail groups

<table>
<thead>
<tr>
<th></th>
<th>Pre LBM</th>
<th>Post LBM</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-fail LBM (kg)</td>
<td>37.68 ± 4.34</td>
<td>39.13 ± 3.92</td>
<td>0.046</td>
</tr>
<tr>
<td>80-fail LBM (kg)</td>
<td>39.05 ± 2.18</td>
<td>39.64 ±2.38</td>
<td>0.243</td>
</tr>
</tbody>
</table>

kg = kilograms
Statistical Evaluation of Affective State

Evaluation of the affective state was measured by changes in FS value at week ten from two time points: immediate post-exercise and 60 minutes post-exercise. It was hypothesized that the 30-fail and 80-fail groups would result in significant increases in the FS value from immediate post-exercise to 60 minutes post-exercise, with no significant difference between the two groups. As determined by dependent t-tests, both groups saw an increase in FS value from immediate post-exercise to 60 minutes post-exercise, while only the 30-fail group increase was statistically significant. Table 4.4 summarizes these values. Additionally, an independent t-test was conducted to assess differences in FS changes from immediate post-exercise to 60 minutes post-exercise between the two training groups; no statistical differences in affective state changes was found between the groups ($t(12) = 1.514, p = 0.156$). Based on these results, the first part of the hypothesis can be rejected, while the second part of the hypothesis is confirmed.

Table 4.4

<table>
<thead>
<tr>
<th></th>
<th>Immediate Post</th>
<th>60 Minutes Post</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-fail FS Value</td>
<td>0.25 ± 1.98</td>
<td>2.13 ± 1.36</td>
<td>0.022</td>
</tr>
<tr>
<td>80-fail FS Value</td>
<td>3.17 ± 1.94</td>
<td>3.83 ± 1.60</td>
<td>0.102</td>
</tr>
</tbody>
</table>

FS = Feeling Scale

Statistical Evaluation of Rating of Perceived Exertion

The means and standard deviations of the session rating of perceived exertion (RPE) response of the 30-fail and 80-fail groups were computed. It was hypothesized that the 30-fail group would result in lower values of RPE than the 80-fail group, despite both groups
performing repetitions to failure. There were no differences found between the two group’s session RPE responses ($t(12) = 1.032, p=0.322$). Table 4.5 summarizes these data.

Table 4.5

*Session RPE Response for the 30-fail and 80-fail groups at week 10*

<table>
<thead>
<tr>
<th>Session RPE</th>
<th>Mean ±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-fail RPE</td>
<td>17.88 ±1.36</td>
</tr>
<tr>
<td>80-fail RPE</td>
<td>18.67 ±1.51</td>
</tr>
</tbody>
</table>

RPE = Rating of Perceived Exertion
The primary aim of this study was to elucidate the effects of RT to momentary concentric failure at two different intensities (30% 1-RM and 80% 1-RM) on overall strength and muscular hypertrophy (measured as lean body mass) in untrained, young adult females. Strength was measured as an overall increase in the sum of four maximal lifts on leg extension, seated military press, leg curl, and latissimus pull down. After 10 weeks of completing repetitions to failure, both the 30-fail group and 80-fail group significantly increased their strength from baseline testing to post-intervention testing. The 30-fail group significantly increased baseline strength (172.27 ± 15.76 kg) by 39.15 ± 22 kg, while the 80-fail group significantly increased strength from baseline (192.88 ± 30.51 kg) by 35.15 ± 11.66 kg. There was no statistical difference in the degree of strength increases between the two training groups.

Similar strength increases from RT to failure at low and high intensities have also been observed in trained male subjects. Schoenfeld et al. (2015) completed an eight-week study which showed significant increases in lower body strength in low intensity (30-50% 1-RM, 25-35 reps to failure) and high intensity (70-80% 1-RM, 8-12 reps to failure) training groups with no significant differences in strength changes between the two groups. Additionally, a 12-week full body RT intervention on trained male subjects revealed increases in strength at both low intensity (30-50% 1-RM) and high intensity (75-90% 1-RM), with no differences between the groups (Morton et al., 2016). In the current study with untrained females, within group significant differences in strength were also found, while the between group difference was not evident.
Contrary to the current findings and those of trained male subjects (Morton et al., 2016; Schoenfeld et al., 2015), a study examining strength changes in untrained males after 10 weeks of unilateral knee extension reported greater increases in strength in the 80% 1-RM training group compared to those in the 30% 1-RM training group (Mitchell et al., 2012). Unlike the study by Mitchell et al. (2012), whose subjects performed only knee extensions, the current study examined strength increases by the sum of all exercises completed. Furthermore, females of the current study completed a full body RT program two times per week for 10 weeks, with one week designated as body weight circuit training due to a week break in the academic calendar. As the training cycle continued, subjects were able to increase the number of repetitions completed, increasing the overall weight lifted. This allowed overload of the muscle which could have led to strength increases in both the 30-fail and 80-fail groups.

Different RT guidelines exist to maximize both strength and hypertrophy with varying sets and reps employed dependent on the desired goal (ACSM, 2014; Haff & Triplett, 2016). Typically, strength adaptations occur when following a RT prescription of two to six sets of two to six reps at 85% or greater of an individual’s 1-RM, while hypertrophy adaptations typically arise from performing two to six sets of six to twelve reps at 67% to 85% 1-RM (Haff & Triplett, 2016). While this is an accepted standard, recent research has evolved in the area of performing repetitions to failure at varying intensities and the strength and hypertrophic responses to this type of training (Mitchell et al., 2012; Morton et al., 2016). Based on the previous research on male subjects and the current study examining untrained females, it is possibly a paradigm shift in RT prescriptions is warranted.

LBM, used as a measure of muscular hypertrophy, was also assessed in the current study by completion of a DEXA scan. Results of the current study indicated increases in LBM of 1.45
± 1.70 kg and 0.58 ± 0.95 kg in the 30-fail and 80-fail groups, respectively. Although both groups saw a marginal increase in LBM, only the 30-fail group reached significance. Comparing between groups, there was no difference. The presence of a significant increase in LBM in only the 30-fail group contrasts with previous studies performed with male subjects (Jenkins et al., 2016; Mitchell et al., 2015; Morton et al., 2016; Schoenfeld et al., 2015). While there were no differences between groups, the previously mentioned studies observed significant increases in both low intensity (5.2% to 9.5%) and high intensity (5.3% to 9.3%) training groups.

To further explain the potential lack of significant increase by the 80-fail group, sex differences in the response to RT exercise and the volume of weight lifted by the 30 vs. 80-fail groups should be considered. The current study utilized females, while the comparison studies enrolled males. It is well accepted that females do not have the same hypertrophic responses to exercise (Ivey et al., 2000), particularly when you consider the study was limited to 10 weeks. Within a 10-week timeframe, we generally do not anticipate much change in the overall size of the muscle. Thus, it was fascinating that changes in the 30-fail group were evident. The mechanism that resulted in this finding may have been volume.

According to the literature, hypertrophy occurs when exercises are performed at a minimum of 67% 1-RM with moderate reps completed (Haff & Triplett, 2016; Kraemer & Ratamess, 2004). This elicits a moderate amount of volume lifted. The females in the 30-fail group lifted, on average, 4,440.85 kg of weight per session (15 total sessions) while the 80-fail group lifted, on average, 2611.21 kg of weight per session, resulting in a significant difference in volume of weight lifted per session between groups (p<0.05). Although subjects lifted a lower than recommended intensity, repetitions completed were greater than the recommended repetition range for hypertrophy, increasing the total volume lifted. It is therefore speculated the
30-fail group saw significant increases in LBM due to the large discrepancy in total volume lifted between the two groups.

Morton et al. (2016) found similar conclusions after a twelve week RT to failure intervention in trained men, where both strength and fat- and bone-free mass significantly increased in low repetition (30-50% 1-RM, 20-25 reps to failure) and high repetition (75-90% 1-RM, 8-12 reps to failure) training groups. In the study completed by Jenkins et al. (2016), 30% 1-RM and 80% 1-RM training groups showed similar increases in muscular hypertrophy, but the four weeks of elbow flexion exercises resulted in no significant difference in volume lifted between groups, which potentially is telling of why the conclusions were as they were.

The secondary aim of this study was to examine affective and psychological responses in untrained, young adult females. Affective responses were measured using the FS adapted by Hardy and Rejeski (1989). Female subjects were required to rate their feelings of pleasure on a scale of -5 (very bad) to +5 (very good) immediate post-exercise and 60 minutes post-exercise (see Appendix B). Statistical analysis of the last RT session revealed lower FS ratings by the 30-fail group (0.25 ± 1.98 immediate post-exercise and 2.13 ± 1.36 at 60 minutes post-exercise) compared to the 80-fail group (3.17 ± 1.94 immediate post-exercise and 3.83 ± 1.60 at 60 minutes post-exercise). However, the 30-fail group showed a significant increase in FS value from immediate post-exercise to 60 minutes post-exercise compared to the 80-fail group, who did not see a significant increase.

Affective state is an important consideration to examine in regards to RT programs because feelings of pleasure have been closely linked to implementation and adherence to RT programs (Ekkekakis, Hall, & Petruzzello, 2008; Rhodes & Kates, 2015). In regards to low (30-fail) and high (80-fail) intensity groups, findings by Arent et al. (2005) revealed decreases in
positive feelings at both intensities immediately after exercise. Focht et al. (2015) examined RT at 40% 1-RM (low intensity) and 70% 1-RM (high intensity) and saw pleasure increases immediately following exercise in both groups. The current study agreed with the findings by Focht et al. (2015), as both the 30-fail and 80-fail groups reported positive affect immediately after exercise and increased positive affect 60 minutes post-exercise. Furthermore, Bibeau et al. (2010) showed a low intensity group (50-55% 1-RM) revealed larger increases in positive affect after exercise compared to a high intensity group (80-85% 1-RM). This is in agreement with the current findings, as the 30-fail group showed significant increases in positive affect from immediate post-exercise to 60 minutes post-exercise. The findings of the current study revealed positive affect from both groups post-RT session, indicating females may be more likely to adopt a RT to failure program, and may be particularly inclined to experience positive feelings after exercise ends if they lift a lower weight. Additionally, increased rates of pleasure from both groups from immediately post-exercise to 60 minutes post-exercise could imply this is a RT program untrained female’s find appealing.

Psychological response to exercise was measured by assessing the subjects’ session RPE at the end of the RT session. Females were asked to identify a single number that most closely associated to the perceived feeling of exertion throughout the entire exercise session. Borg’s RPE scale was used for this quantification (see Appendix B). Females in the 30-fail group showed a lower rating of RPE (17.88 ± 1.36) compared to the 80-fail group (18.67 ± 1.51) at the end of the RT session at week 10 (p=0.322). This is an interesting find as the 80-fail group reported greater feelings of pleasure even though the reported RPE value revealed a harder exertion throughout the overall session. Although both groups completed repetitions to failure, it is possible the 80-fail group felt the work was harder due to a higher intensity of weight being
Performing RT repetitions at 80% 1-RM is consistent with traditional RT guidelines recommended by respected governing bodies (ACSM, 2014; Haff & Triplett, 2016). The increased RPE reported by the 80-fail group could provide evidence as to why it is not uncommon for complaints of intensities prescribed for strength adaptations to be too challenging. Since the 80-fail group is in the strength adaptation spectrum in regards to intensity used, it is likely females of the 80-fail group found this weight intensity to be challenging. Additionally, the 30-fail group completed repetitions to failure at 30% 1-RM, which is well below the recommended guideline for strength or hypertrophy adaptations (Haff & Triplett, 2016). Although repetitions were still completed to failure, it is possible the effort throughout the entire session did not feel as challenging as a heavier intensity would elicit.

The discrepancy in FS and RPE reported by the two groups could lead to adoption or maintenance issues between the subjects. Considerations about FS and RPE responses should be leveraged to assist in adoption and maintenance of RT among females who are untrained. The 30-fail group reported lower FS values and lower RPE, which could mean subjects would find that RT prescription boring or lacking enjoyment. However, it is critical to note that this group had significant increases within 60-minutes post-exercise. This should not be overlooked or understated. They may very well be inspired by that FS change post-exercise and desire that feeling again. Although significant increases in both strength and LBM were observed in the 30-fail group, lower values of affect immediately after exercise and lower perceived effort for the session could deter an individual from pursuing this type of RT program.

On the contrary, the 80-fail group reported higher FS values and higher RPE values with concurrent significant increases in strength and insignificant increases in LBM. Increases in both
RT adaptations are evident with higher values of pleasure, indicating performing repetitions to failure at a higher intensity may lead to greater adoption and adherence by this group of females.

**Recommendations for Future Research**

1. A larger sample size is needed to provide further evidence of the strength and hypertrophy adaptations to resistance training to failure at low and high intensities.
2. Muscle protein synthesis should be analyzed in this population to determine changes occurring at the cellular level. Muscle protein synthesis analysis will provide greater insight at the hormonal level and what is actually occurring in regards to strength and hypertrophy signaling of the muscle fiber.
3. Menstrual cycle was not taken into consideration during this 12-week intervention. Two subjects specifically mentioned increased fatigue and decreased performance during week 5 of the training program, which led to decrements in their repetitions completed and weight lifted. It is important to monitor this in future research to detect any differences in strength or repetitions completed to failure during the different menstrual phases.
4. Neural activation via EMG analysis should be considered to detect muscle activation differences between the two intensity groups and if that correlates to volume completed and, in turn, LBM changes.

**Conclusion**

Based on the findings of the current study, females with no prior RT experience saw significant increases in overall strength if completing repetitions to failure at a low (30% 1-RM) or high (80% 1-RM) intensity. In regards to LBM, both groups resulted in increases in LMB from pre- to post-RT intervention, with the 30-fail group showing the only significant increase.
Affective state, as measured by the FS, were higher in individuals of the 80-fail group, but the 30-fail group showed significant increases in pleasure from immediate post-exercise to 60 minutes post-exercise. Additionally, RPE responses were reported, on average, higher in the 80-fail group than in the 30-fail group. These findings suggest untrained females who engage in a RT program will see positive strength and hypertrophy adaptations, as long as repetitions are completed to failure.
References


## Pre-RT Protocol 1RM Session Data Recording Sheet

**Directions:** Record the weight and RPE for each 1RM attempt.

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<th>1. CP</th>
<th>2. LE</th>
<th>3. S. MP</th>
<th>4. LC</th>
<th>5. LPD</th>
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- Seat: ___  
- Knee: ___  
- Ankle: ___

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## RT To Failure Data Set

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### DAY TWO

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**Notes:**
**Self-Efficacy Resistance Training to Failure**

**CHEST PRESS**

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The items listed below are designed to assess your **beliefs in your ability to complete the same number of repetitions during the next set of your resistance training program**. Using the scales listed below, please indicate how confident you are in your ability to do the number of repetitions listed in the question.

For example, in question #1, if you **have complete confidence** that you will be able to complete the same number of repetitions in the subsequent set as the previous set, you would **circle 100%**. However, if you had **no confidence at all** that you will be able to complete the same number of repetitions on the next set you would **circle 0%**.

Please remember to answer honestly and accurately. There are no right or wrong answers.

**Mark you answer by circling a %:**

<table>
<thead>
<tr>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
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</table>

1. I can complete the **same number** of repetitions on each set using the same weight lifted.

   0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

2. I can complete **1 less** repetition on each set using the same weight lifted.

   0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

3. I can complete **2 less** repetitions on each set using the same weight lifted.

   0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

4. I can complete **3 less** repetitions on each set using the same weight lifted.

   0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

5. I can complete **4 less** repetitions on each set using the same weight lifted.

   0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

6. I can complete **5 or more less** repetitions on each set using the same weight lifted.

   0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

**Enjoyment/Intention Immediately Post**
**Feeling Scale**

**Directions:** Circle the number that best indicates how you feel right now, at the present moment.

<table>
<thead>
<tr>
<th>-5</th>
<th>-4</th>
<th>-3</th>
<th>-2</th>
<th>-1</th>
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<tbody>
<tr>
<td>Very Bad</td>
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<td>Very Good</td>
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</table>

The following questions address how you think and feel about the resistance training session you just completed. Please circle the answer that best represents your overall evaluation of the entire exercise session.

1. I enjoyed it  
2. I felt bored  
3. I disliked it  
4. I found it pleasurable  
5. It was no fun  
6. It was very pleasant  
7. I felt as if there was nothing else I’d rather be doing  
8. I was very absorbed in the activity  

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| I hated it | I felt interested | I liked it | I found it displeasurable | It was a lot of fun | It was very unpleasant | I felt like I’d rather be doing something else | I was not very absorbed in the activity |
Directions: *Circle* the number that best indicates the **probability** that you would **intend to continue to complete repetitions to momentary concentric failure** during one of your own recreational resistance training sessions in the next month.

1. I can complete 1 full session of training to momentary concentric failure (for each set) during one of my own training sessions in the next **week**.

   0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

   NO INTENTION MODERATE INTENTION STRONG INTENTION

2. I can complete 1 full session of training to momentary concentric failure (for each set) during one of my own training sessions in the next **month**.

   0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

   NO INTENTION MODERATE INTENTION STRONG INTENTION
APPENDIX B
FEELING SCALE AND RPE SCALE
FEELING SCALE AND RPE RATINGS

**Feeling Scale**
*Directions*: Choose the number that best indicates how you feel *right now, at the present moment*.

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<th>Description</th>
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<tr>
<td>-4</td>
<td>Bad</td>
</tr>
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<td>Neutral</td>
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</tr>
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<td>-1</td>
<td>Very Good</td>
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<td>Hard</td>
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**RPE**

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<td>Really Easy</td>
</tr>
<tr>
<td>16</td>
<td>Easy</td>
</tr>
<tr>
<td>17</td>
<td>Moderate</td>
</tr>
<tr>
<td>18</td>
<td>Sort of Hard</td>
</tr>
<tr>
<td>19</td>
<td>Hard</td>
</tr>
<tr>
<td>20</td>
<td>Maximal; Hardest</td>
</tr>
</tbody>
</table>
Identification of Researchers: This research is being conducted by Taylor Dinyer, a graduate student, Alex Rickard, a graduate student, Dr. Steve Burns, a professor, and Dr. Matthew Garver, a professor. We are with the Department of Nutrition and Kinesiology at the University of Central Missouri.

Purpose of the Study: The purpose of this study is to determine the effects of resistance training to momentary concentric failure at a low and high intensity on muscular strength, body composition, and affective responses (pleasure-displeasure, self-efficacy, intention to continue engaging) in untrained females.

Request for Participation: We are inviting you to participate in this study which focuses on key physiological and psychological responses to resistance training to momentary concentric failure at a low or high intensity. It is up to you whether you would like to participate. If you decide not to participate, you will not be penalized in any way. You can also decide to stop at any time without penalty. You may withdraw your data at anytime during the study.

Exclusions: You must be between the ages of 18 and 35, not pregnant, free of any musculoskeletal injuries, currently not participating in weight training and have not participated in a structured (≥ 2 days per week > 4 weeks) resistance training program for the past two years, low risk for CV disease according to ACSM risk stratification, and demonstrate readiness for physical activity (PAR-Q).

Description of Research Method: You will complete one-repetition maximum testing on five weight machines (seated chest press, leg extension, seated military press, leg curl, and lat pull down) and a DEXA scan. Resistance training will occur during weeks 2-11. You will then come in twice a week for 10 weeks to perform two sets of resistance training on the same lifts at a low or high intensity until momentary concentric failure. You will answer questions regarding pleasure-displeasure, self-efficacy, and intention for continuing RT during and after each exercise session. During weeks five through ten, you will perform 3 sets of each lift to momentary concentric failure. After the 10-week training protocol, you will do a post one-repetition maximum on all five lifts. To elucidate potential changes in body composition, an X-ray-like scan called a DEXA scan will be performed on you at the baseline, 4-week, and 12 week points.

Privacy: All of the information we collect will be kept confidential. We will not share your information individually but only as an aggregate of the data collected as a group average. All data will be stored in a locked office in a locked file or password protected computer. Data will be destroyed according to University of Central Missouri policy.
**Explanation of Risks:** As with any exercise there exists the possibility of certain changes occurring during the exercise. Risks include: delayed muscle soreness, an abnormal response of blood pressure, fainting, irregular fast or slow heart rhythm, and in rare instances, heart attack, stroke, or death. **If you require medical treatment or emergency service, any associated costs will be the responsibility of the participant.**

**Explanation of Benefits:** You will benefit from participating in this study by receiving researcher-led resistance training guidance for a 10-week period. Apart from the investment of time, there is no cost associated with the research. You may enjoy knowing how your strength and fitness levels change during the research. Also, there may be some altruistic consideration as you participate in research that is important for society and females, specifically.

**Questions:** If you have any questions about this study, please contact Dr. Stephen Burns at 660-543-8894 or sburns@ucmo.edu. If you have any questions about your rights as a research participant, please contact the Human Subjects Protection Program at (660) 543-4621.

If you would like to participate, please sign a copy of this letter and return it to me. The other copy is for you to keep.

I have read this informed consent and agree to participate.

Signature: ________________________________

Print Name: ________________________________

Date: ________________________________

Witness Signature: ________________________________
APPENDIX D
HEALTH QUESTIONNAIRES
AHA/ACSM Health/Fitness Facility Preparticipation Screening Questionnaire
Assess your health status by marking all true statements

History
You have had:
___ a heart attack
___ heart surgery
___ cardiac catheterization
___ coronary angioplasty (PTCA)
___ pacemaker/implantable cardiac
___ defibrillator/rhythm disturbance
___ heart valve disease
___ heart failure
___ heart transplantation
___ congenital heart disease

If you marked any of these statements in this section, consult your physician or other appropriate health care provider before engaging in exercise. You may need to use a facility with a medically qualified staff.

Symptoms
___ You experience chest discomfort with exertion.
___ You experience unreasonable breathlessness.
___ You experience dizziness, fainting, or blackouts.
___ You take heart medications.

Other health issues
___ You have diabetes.
___ You have asthma or other lung disease.
___ You have burning or cramping sensation in your lower legs when walking short distances.
___ You have musculoskeletal problems that limit your physical activity.
___ You have concerns about the safety of exercise.
___ You take prescription medication(s).
___ You are pregnant.

Cardiovascular risk factors
___ You are a man older than 45 years.
___ You are a woman older than 55 years, have had a hysterectomy, or are postmenopausal.
___ You smoke, or quit smoking within the previous 6 months.
___ Your blood pressure is >140/90 mm Hg.
___ You do not know your blood pressure
___ You take blood pressure medication.
___ Your blood cholesterol level is > 200 mg/dL
___ You do not know your cholesterol level.
___ You have a close blood relative who had a heart attack or heart surgery before age 55 (father or brother) or age 65 (mother or sister).
___ You are physically inactive (i.e., you get <30 minutes of physical activity on at least 3 days per week).
___ You are > 20 pounds overweight.

If you marked two or more of the statements in this section you should consult your physician or other appropriate health care provider before engaging in exercise. You might benefit from using a facility with a professionally qualified exercise staff to guide your exercise program.
None of the above

You should be able to exercise safely without consulting your physician or other appropriate health care provider in a self-guided program or almost any facility that meets your exercise program needs.
MOMENTARY CONCENTRIC FAILURE 60

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

Yes  No
1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
2. Do you feel pain in your chest when you do physical activity?
3. In the past month, have you had chest pain when you were not doing physical activity?
4. Do you lose your balance because of dizziness or do you ever lose consciousness?
5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?
6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
7. Do you know of any other reason why you should not do physical activity?

If you answered YES to one or more questions:
Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

• You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
• Find out which community programs are safe and helpful for you.

No to all questions:
If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:
• Start becoming much more physically active — begin slowly and build up gradually. This is the safest and easiest way to go.
• Take part in a fitness appraisal — this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

Delay becoming much more active:
• If you are not feeling well because of a temporary illness such as a cold or a fever — wait until you feel better; or
• If you are or may be pregnant — talk to your doctor before you start becoming more active.

Please note:
If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional.
Ask whether you should change your physical activity plan.

Informed use of the PAR-Q:
The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

Name: ____________________________ Date: ________________

Signature: ____________________________

Signature of parent or guardian (for participants under the age of majority): ____________________________

Witness: ____________________________

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

© Canadian Society for Exercise Physiology www.csep.ca/forms
APPENDIX E
HUMAN SUBJECTS APPROVAL

Full Review
12/20/2016
Protocol Number: 632
Dear Taylor Dinyer:

Your research project, 'Effects of Resistance Training Intensity to Momentary Concentric Failure on Muscular Strength, Body Composition, and Affective Responses in Untrained Females', was approved by the University of Central Missouri Human Subjects Review Committee on 12/19/2016. You may collect data for this project until 12/19/2017.

If an adverse event (such as harm to a research participant) occurs during your project, you must IMMEDIATELY stop the research unless stopping the research would cause more harm to the participant. If an adverse event occurs during your project, notify the committee IMMEDIATELY at researchreview@ucmo.edu.

The following will help to guide you. Please refer to this letter often during your project.

- If you wish to make changes to your study, submit an “Amendment” through Blackboard under the “Amendment and Renewals” tab. You may not implement changes to your study without prior approval of the UCM Human Subjects Review Committee.
- If the nature or status of the risks of participating in this research project change, submit an “Amendment” through Blackboard under the “Amendment and Renewals” tab. You may not implement changes to your study without prior approval of the UCM Human Subjects Review Committee.
- If you are nearing the expiration date for collecting data for this project (12/19/2017) and you have not finished collecting data:
  1. submit your project application via Blackboard under the “Amendment and Renewals” tab (include any revisions and/or amendments approved since you submitted your application initially)
     AND
  2. submit a “Renewal Report” through Blackboard under the “Final/Renewal Report” tab.
- When you have completed your collection of data, please submit the “Final Report” found on Blackboard under the “Final/Renewal Report” tab.

If you have any questions, please feel free to contact me at researchreview@ucmo.edu.

Sincerely,

Kathy Schnakenberg
Program Administrator/Research Compliance Officer
Office of Sponsored Programs and Research Integrity
University of Central Missouri
cc: burns@ucmo.edu
APPENDIX F
HUMAN SUBJECTS AMENDMENT APPROVAL

Amendment
2/24/2017
Protocol Number: 632
Dear Taylor Dinyer:
Your request to amend your research project, 'Effects of Resistance Training Intensity to Momentary Concentric Failure on Muscular Strength, Body Composition, and Affective Responses in Untrained Females', was approved by the University of Central Missouri Human Subjects Review Committee on 2/22/2017. You may collect data for this project until 12/19/2017. If an adverse event (such as harm to a research participant) occurs during your project, you must IMMEDIATELY stop the research unless stopping the research would cause more harm to the participant. If an adverse event occurs during your project, notify the committee IMMEDIATELY at researchreview@ucmo.edu.

The following will help to guide you. Please refer to this letter often during your project.

• If you wish to make changes to your study, submit an “Amendment” through Blackboard under the “Amendment and Renewals” tab. **You may not implement changes to your study without prior approval of the UCM Human Subjects Review Committee.**

• If the nature or status of the risks of participating in this research project change, submit an “Amendment” through Blackboard under the “Amendment and Renewals” tab. **You may not implement changes to your study without prior approval of the UCM Human Subjects Review Committee.**

• If you are nearing the expiration date for collecting data for this project (12/19/2017) and you have not finished collecting data:
  1. submit your project application via Blackboard under the “Amendment and Renewals” tab (include any revisions and/or amendments approved since you submitted your application initially)
  2. submit a “Renewal Report” through Blackboard under the “Final/Renewal Report” tab.

• **When you have completed your collection of data, please submit the “Final Report” found on Blackboard under the “Final/Renewal Report” tab.**

If you have any questions, please feel free to contact me at researchreview@ucmo.edu.

Sincerely,

Kathy Schnakenberg
Program Administrator/Research Compliance Officer
Office of Sponsored Programs and Research Integrity
University of Central Missouri
cc: sburns@ucmo.edu