THE NEUROMUSCULAR AND MUSCLE DAMAGE RESPONSES TO THE FARMERS WALK

A Thesis

by

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This thesis meets the standards for scope and quality of
Texas A&M University-Corpus Christi and is hereby approved.

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ABSTRACT

The Farmers Walk (FW) may help to supplement resistance training programs as it incorporates movements stimulating many functional tasks such as lifting and carrying weight over various distances. Minimal information exists in the literature concerning the intramuscular responses associated with performing the FW; impacting its possible use in exercise prescription and application. PURPOSE: The purpose of the study was to investigate the neuromuscular and biochemical responses to the Farmers Walk Carry (FWC) when compared to an individual's unloaded walking pattern (Non-weighted condition; NWC). METHODS: Fifteen participants (Mean ± SEM; age: 21.6 ± 0.5yr; ht: 172.5 ± 2.4cm; wt: 81.8 ± 4.0kg; body fat: 28.8 ± 2.1%; relative 1RM: 2.2 ± 0.1) completed an initial session which involved collection of body composition via Dual-energy X-ray Absorptiometry (DXA), lower body power assessment via countermovement jump (CMJ), and lower body strength evaluation via High-handled Hex-bar deadlift (HHBD). Participants completed two counter-balanced conditions with questionnaires (Visually Perceived Muscle Soreness; [VPMS]), blood draws (PRE, IP, R30, and R60), and an exercise protocol performed either carrying weight (FWC) or not (NWC). Blood draws, CMJ height, and VPMS scores were collected at three recovery time points (R24h, R48h, and R72h) for each protocol. RESULTS: Significant increases were observed for overall ($p < 0.001$) and upper body VPMS measurements ($p < 0.01$) along with decreases in Creatine Kinase (CK) ($p = 0.04$) during the FWC. No significant differences were revealed for both Myoglobin (Mb) ($p = 0.37$) and CMJ ($p = 0.47$) between the FWC and NWC. CONCLUSION: FWC performance was associated with a discrepancy between upper and lower body muscle soreness which may be

related to differences in muscle contractions implemented, indirectly minimizing the presence of biochemical muscle damage and neuromuscular inhibitions of lower body power performance.

DEDICATION

To those who have been bitten by the research bug, I truly hope your passion and hard work allows you to enjoy the process as much as I have. Embrace the moments of struggle and continue to find the lesson in every situation you are presented with, for better or worse you always have the ability to learn.

"I am the wisest man alive, for I know one thing, and that is that I know nothing."

– Plato, The Republic

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CHAPTER I

Introduction

The practice of Strongman Training (ST) may be perceived as an alternative style of resistance training which has begun to garner attention within the athletic and resistance training community due to the unique demands it places on the body. This unique style of exercise training integrates various complex movements which may include lifting and/or pulling various objects such as anvils, keg barrels, loaded bars, logs, sleds, stones, tractor tires, and trucks (Waller, Piper, & Townsend, 2003; Berning, Adams, Climstein, & Stamford, 2007; McGill, McDermott, & Fenwick, 2009; Winwood, Keogh, & Harris, 2011; Zemke & Wright, 2011; Winwood, Cronin, Brown, & Keogh, 2014a; Winwood, Cronin, Keogh, Dudson, & Gill, 2014b; Woulfe, Harris, Keogh, & Wood, 2014). ST has been integrated into everyday training sessions performed amongst athletes and resistance-trained individuals alike. However, the benefits of such functionally transient movements may provide benefits to a variety of untapped populations as well. As ST has become more popular, studies examining the effects of this training have also increased. Yet, research in this area remains limited. Furthermore, the benefits associated with ST have only been studied in a limited fashion, with gaps in knowledge regarding the biological responses occurring within the body when this training style is introduced.

The greatest number of ST studies have provided overviews of the physiological, biomechanical, and anthropometrical measures of strongman competitors and the overall relationship in these factors, with differences seen between elite and novice performers (McGill, et al., 2009; Keogh, Payne, Anderson, & Atkins, 2010b; Winwood, et al., 2011; Keogh, et al., 2014; Winwood, et al., 2014a; Woulfe, et al., 2014).

A limited number of studies have been published explaining how ST has been implemented into collegiate strength and conditioning practices (Zemke & Wright, 2011; Winwood, et al., 2014b). Winwood, et al. (2015) also compared the training effects of ST and those of typical resistance-based types of exercises to examine the possible muscular improvements during performance of strength and athletic testing.

Additionally, researchers have pursued analyses concerning the acute physiological effects of ST (Ghigiarelli, Sell, Raddock, & Taveras, 2013; Keogh, Newlands, Blewett, Payne, & Chen-Er, 2010a; Keogh, et al., 2014; Winwood, et al., 2014a). These types of exercises have routinely been prescribed within resistance exercise realms due to the potent stressor provided for multiple systems when completed (i.e., cardiorespiratory, anaerobic, and endocrine) (West & Phillips, 2012). McGill, et al. (2009) conducted a biomechanical analysis observing the muscle activation patterns of specific ST events through multiple modes of data collection. Furthermore, Berning, et al. (2007) analyzed the metabolic demands encountered between a maximal effort pull and push of a motor vehicle, determining a high demand for anaerobic capacity between both actions, associated with significant increases in maximal oxygen consumption, heart rate, and blood lactate accumulation.

The Farmers Walk (FW) falls into the category of ST exercises. The FW involves an individual carrying a predetermined load in each hand while traveling with linear momentum in order to cover a certain amount of distance (20-50 meters) as quickly as possible (Ghigiarelli, et al., 2013; Keogh, et al., 2014; Winwood, et al., 2015) or as much distance as possible within a certain time range (Waller, et al., 2003, Winwood, et al., 2011). The FW has been considered an exceptional exercise to use during periodization as it challenges the individual's whole musculoskeletal system in terms of strength, stability, and physiological demands (Winwood, et al., 2014b). The requirements of this type of exercise include great dynamic balance, and hand-grip, core, and upper-body strength; along with forceful triple extension of the lower body during the lifting and walking phases (Waller, et al., 2003, Ghigiarelli, et al., 2013; Keogh, et al., 2014; Winwood, et al., 2014a). Ultimately these types of physiological improvements from the introduction of ST could lead to benefits of the Phosphocreatine (ATP-PC) and anaerobic glycolytic energy systems such as increases in glycolytic skeletal muscle enzyme content and ATP regeneration along with decreases in metabolic acidosis (Bogdanis, Nevill, Boobis, & Lakomy, 1996; Waller, et al., 2003; Baker, McCormick, & Robergs, 2010; Zemke & Wright, 2011).

Significance of the Study

Numerous populations are required to carry substantial amounts of weight while moving (such as farmers, firefighters, law enforcement, laborers, military personnel, etc.) and/or may benefit from the training stresses imposed on the body (athletes, rehabilitation). Exercises such as the FW may provide beneficial results for these individuals by supplementing the demands encountered during the completion of daily tasks within a training environment. FW exercises can be performed over differing amounts of distance and/or time periods, and with loads personalized to the individual's performance-based ability or employment requirements (Ghigiarelli, et al., 2013; Keogh, et al., 2014; Winwood, et al., 2015). Dependent upon the individual's need, the movement could also be performed at a slow, moderate, or explosive pace and numerous physiological benefits may be obtained from these demands (Zemke & Wright, 2011; Ghigiarelli, et al., 2013; Keogh, et al., 2014; Winwood, et al., 2014a).

An advantage associated with the FW is the flexibility regarding modalities used during its completion including: traditional resistance training equipment (dumbbells, barbells, weighted plates, etc.), non-traditional resistance training equipment (high-handle hex-bars, kettlebells, etc.), miscellaneous equipment (liquid propane tanks, sandbags, etc.) or the official loaded bars used for strongman competitions (Waller, et al., 2003). These various modes allow for a participant to carry a load either predetermined for testing/performance or one associated with a certain percentage of a one-repetition maximum (%1RM) of an individual's deadlift performance. This study conducted FW exercises with a High-handle Hex-bar (HHB). The HHB was utilized due to the common availability of the bar within a majority of fitness environments. Many gymnasiums, strength and conditioning facilities, and fitness services do not have access to equipment such as loaded carrying bars due to limited clientele who are capable of potential utilization and overall cost of equipment (Winwood, et al., 2014a). Additionally, an instrument such as the HHB provides a standard effect on grip, stabilization, and gait seen with a standardized FW loaded bar or other training devices.

The implementation of ST exercises such as the FW is becoming a more common approach within the performance realm of resistance training with performance specialists, physical/occupational therapists, and physically active individuals (McGill, et al., 2009; Zemke & Wright, 2011; Ghigiarelli, et al., 2013; Keogh, et al., 2014; Winwood, et al., 2014b). These types of movements not only benefit those who encounter tasks requiring lifting and carrying heavy loads, but other populations may benefit from the physiological improvements associated with the training stimulus as well.

ST exercises, such as the FW, are easily transferable to functionally-based increases in strength which has resulted in a transition in implementation from traditional resistance training exercises (Winwood, et al., 2014b; Winwood, et al., 2015). Bryant (2011) defined functional strength as performing work against resistance in such a manner where the improvements in strength directly enhance the performance of movements by affecting the entire neuromuscular system so an individual's activities of daily living are easier to perform. An individual may reap the same benefits in the lifting and carrying performance of the FW when on the job, as an athlete may when comparing responses associated with the performance of similar traditional resistance exercises. However, with the implementation of ST, individuals may have the additional opportunity to train against a dynamic resistance (e.g. changing resistance in the form of an opposing individual or object) rather than a constant resistance typically provided by machine weights or free weights (Hedrick, 2002; Hedrick, 2003).

One limitation of ST, and specifically the FW, is the amount of research available examining muscle damage during participation. The amount of muscle damage experienced may limit the prescribed use of ST exercise due to inhibitions in performance during employment or competition. If muscle damage is too intrusive on an individual's ability to perform, it may inhibit an individual's ability to accomplish tasks competently. With this lack of knowledge considered, this study investigated the effect of the FWC which utilized the implementation of a FW with specific parameters set on intensity (70% of a one repetition maximum [1RM]), repetitions completed (10 repetitions), distance covered (20-meters), instructed pace (fast as possible) and rest intervals provided (30 seconds between each repetition and 2 minutes between each set completed). This condition was then compared to a non-strenuous unloaded walk to analyze differences in the biological, physiological, and perceived measurements associated with skeletal muscle damage.

Purpose of the Study

The purpose of this study was to investigate the amount of muscle damage incurred in response to the Farmers Walk Condition (FWC) via objective measurements of biomarker concentration, subjective inclinations of perceived muscle soreness, and indirect evaluations of neuromuscular performance in comparison to a control protocol of walking without any weight (Non-Weighted Condition; NWC). Subjects participated in nine (9) sessions of data collection to analyze responses produced during and after the exercise. This study was pursued due to the limited amount of information available regarding the metabolic responses to the FWC. More knowledge on this concept would be beneficial towards future prescription in strength training and the amount of time required for the subsequent recovery process.

Statement of the Hypotheses

H_1: There would be an increase associated with Creatine Kinase (CK) concentration, a biochemical marker of muscle damage, when comparing the control protocol (NWC) with the exercise protocol (FWC). Furthermore, both protocols (FWC and NWC) would demonstrate an increased concentration when compared to baseline (PRE) measurements.

H_2: There would be an increase associated with Myoglobin (Mb) concentration, a biochemical marker of muscle damage, when comparing the control protocol (NWC) with the exercise protocol (FWC). Furthermore, both protocols (FWC and NWC) would demonstrate an increased concentration when compared to baseline (PRE) measurements.

H_3: When compared, post-exercise sessions (IP, R60, R24h, R48h, R72h) during the exercise protocol (FWC) would result in participants reporting a greater Visually Perceived Muscle Soreness (VPMS) score than after the control protocol (NWC).

H_4: There would be a decrease in countermovement jump (CMJ) height attained after the exercise protocol (FWC) during the recovery period post-exercise (R24h, R48h, and R72h) when compared to both baseline (PRE) measurements and control protocol (NWC) measurements.

H_5: There would be a decrease in countermovement jump (CMJ) height attained when comparing trials during recovery (R24h, R48h, and R72h) testing sessions of both the exercise (FWC) and control (NWC) protocols to baseline (PRE) measurements.

Assumptions

- Participants engaged in minimal exercise activity and/or sedentary lifestyle during the duration of the study while refraining from any exercise or abnormal and excessive physical activity concentrations compared to their baseline for at least three days prior to treatment.
- Participants gave their best effort during participation within the testing protocols and responded accurately, and honestly, to all self-reported questions.
- All laboratory equipment was functioning properly with validity and reliability measurements previously established. Proper calibration and the use of qualified and trained research staff were utilized to minimize any potential errors.
- All participants arrived at each testing session in a fasted state (≥8 hours), with no ingestion of alcoholic or caffeinated beverages, or use of tobacco products during the previous night's fasting period.

Delimitations

- An intensity of 70%1RM was utilized based off an individual's 1RM-testing load during the implementation of the FWC.

- All testing sequences occurred at the same time of day for all participants associated with this study.
- Set distance of travel (20-meters) and rest intervals (alternating time sequences of 30 seconds or 2 minutes) were utilized during both exercise protocols of this study design.

Limitations

- The population available for this study design was comprised of college students (18-45 years old) who attended Texas A&M University-Corpus Christi (TAMUCC). Therefore, generalizability of the data collected to other populations (non-students, non-TAMUCC students, non-Corpus Christi residents, non-Texas residents, etc.) may not be possible.
- The sampling system used may bias the results collected based off recruiting methods such as volunteerism and convenience.
- Variability in experience with the FW exercise occurred within the study's sample size. This may have influenced the physiological effects measured during data collection.

Definition of Terms

Creatine Kinase (CK): A compact intracellular enzyme found in both the cytosol and mitochondria of tissues where energy demands are high, such as within the energy network known as the phosphocreatine system. These subunits allow for the formation of three tissue-specific iso-enzymes: CK-MB (cardiac muscle), CK-MM (skeletal muscle), and CK-BB (brain). Typically, the ratio associated with these subunits varies based on the muscle type: skeletal muscle includes 98% CK-MM and 2% CK-MB, cardiac muscle contains 70-80% CK-MM and 20-30% CK-MB, while the brain has predominantly CK-BB subunits (Baird, Graham, Baker, &

Bickerstaff, 2012). Two specific forms of mitochondrial CK within the cells include a non-sarcomeric type called ubiquitous Mt-CK expressed in tissues such as the brain, smooth muscle, and sperm, and sarcomeric type Mt-CK expressed in cardiac and skeletal muscle (Schlattner, Tokarska-Schlattner, & Wallimann, 2006). These enzymes may be released after participation in vigorous exercise which will result in the circulation of CK within the lymphatic system due to an increase in membrane permeability from damages to structures such as the sarcolemma, sarcomere, and Z-disk of the involved muscle (Baird, et al., 2012; Koch, Pereira, & Machado, 2014).

Myoglobin (Mb): An oxygen binding protein in muscle which may be released into the blood stream with an increased amount of muscle damage negatively effecting the ability of the muscle cell to adapt to new stimuli, rebuild and repair muscle fibers, and synthesize satellite cells. This protein is viewed as a biochemical muscle damage marker which permeates the cell membrane after mechanical damage, resulting in its release into the lymphatic system. Mb may permeate the cell easier than other biomarkers, such as CK, due to its smaller size; leading to a shorter length in response (hours) to the muscle damage occurring (Heavens, et al., 2014).

CHAPTER II

Review of the Literature

This chapter discusses multiple topics pertaining to the relevance of strongman training (ST), specifically the Farmers Walk (FW) exercise, within the current realm of resistance training. Initially information was provided on the importance of resistance training to sustaining good health along with comparisons between strongman training and traditional resistance training regimens and the placement of ST within periodization. Further comparisons were made between the biomechanical differentiations of the FW and normal (unweighted) walking conditions. Finally, further examination provided background on the previously conducted investigations of the FW and currently accepted evidence regarding objective and subjective measurements of muscle damage along with assessments of neuromuscular responses.

Importance of Resistance Training to Health

Recommendations from the American College of Sports Medicine (ACSM) and American Heart Association (AHA) include muscle-strengthening activities to maintain or increase muscular strength and endurance for a minimum of two days per week (Oja & Titze, 2011). The benefits of resistance training may include improvements in physical performance, movement control, walking speed, functional independence, cognitive abilities, self-esteem, and resistance of disease, additional to a reversal of other age-based factors (Westcott, 2012). Kraemer, Ratamess, and French (2002) and Westcott (2012) suggested benefits such as reductions in body fat, increased basal metabolic rate, decreased blood pressure, improved blood lipid profiles, glucose tolerance, and insulin sensitivity occurred with physical activity.

Additionally, increases in bone mineral development, and muscle and connective tissue cross-sectional area may occur with the introduction of resistance training.

Research demonstrates an effective strength training program consists of two-to-four sets consisting of eight to ten exercises while using an efficient resistance to complete eight to twelve repetitions, on two or more non-consecutive days each week with exercises focusing on major muscle groups (Oja & Titze, 2011; Westcott, 2012). To maximize these benefits basic principles such as a) progressive overload, b) specificity, and c) variation should be implemented into any training program (Kraemer, et al., 2002). Progressive overload is defined as a gradual increase of stress placed upon the body during a resistance training bout, which is essential for the long-term adaptations warranted with muscular fitness and health (Kraemer, et al., 2002). Specificity refers to the body's responses and related adaptations to certain program variables implemented during exercise such as muscle actions used, speed of movement, range of motion completed, muscle groups trained, and energy systems involved based off of the intensity and volume of training implemented (Häkkinen, Pakarinen, Alen, & Komi, 1985; Dudley, Tesch, Miller, & Buchanan, 1991; Feigenbaum & Pollock, 1999; Kraemer, et al., 2002). Finally, variation is the systematic alteration occurring over time within the resistance training program to allow for optimal training stimuli to remain established in order to sustain long-term progression (Stone, et al., 2000; Kraemer, et al., 2002).

Comparison of Resistance Training Modalities

Strength training, specifically resistance training, can encompass a variety of modalities, however the foundations for the equipment can be broken down into two specific categories; free weight and machine weight exercises. Research has found traditional resistance training exercises engage similar major muscle groups when used and are often used interchangeably; however, their use may not necessarily be considered equivalent (Wilk, et al., 1996). Previous investigators have highlighted differences between these two modalities founded on components such as type of kinetic chain exercise used, lack of stabilizer muscle involvement, amount of muscle mass contribution, and activation among primary muscle movers (Kang, Martino, Russo, Ryder, & Craig, 1996; Schwanbeck, Chilibeck, & Binsted, 2009; Clark, Lambert, & Hunter, 2012, Shaner, et al., 2014). Physiologically, differences seem to be present as well. Shaner, et al. (2014) suggested significant ($p \leq 0.05$) differences occurred between physiological variables measured, including blood lactate, heart rate, and total work performed. These results propose a higher metabolic demand may be needed for the completion of free weight exercises when compared to machine-weight exercises.

Comparisons between Traditional and Strongman Training Implements

When considering the different types of resistance training available in the current fitness industry, ST has become increasingly popular within the practice of strength and conditioning, likely due to the novelty, functionality, and competitiveness associated with the exercise. This style of training incorporates the use of compound movements which include lifting, pulling, and carrying oddly-shaped objects (Berning, et al., 2007; McGill, et al., 2009; Keogh, et al., 2010a; Keogh, et al., 2010b). The increase in ST has mostly been used by athletes within the strength and conditioning realm; however, some recommendations have been made for using ST as a rehabilitative service for injuries sustained within sports or employment services (Berning, et al., 2007; McGill, et al., 2009; Winwood, et al., 2011; Zemke & Wright, 2011; Ghigiarelli, et al., 2013; Winwood, et al., 2014b; Woulfe, et al., 2014; Winwood, et al., 2015).

Surveys conducted by Winwood, et al. (2014b) documented 88% of strength and conditioning coaches implemented ST exercises within their athletic programs. Reasons for implementing these exercises included: a) physiological development (enhanced neurological stimulus, higher demand of core musculature, grip strength, and kinetic chain stability); b) psychological development (enhanced motivation/confidence, greater psychological/mental toughness, improved competitiveness); c) support for training programs (increased training economy, enhanced athlete learning, development, and adherence); and d) the transfer from gymnasium-strength to functional strength (Winwood, et al., 2014b). Functional strength is defined as the work performed against resistance challenging the neuromuscular systems so movements performed during training may cause an individual's activities of daily living to become easier to complete (Bryant, 2011). These types of improvements may be seen as more conventional for a variety of populations who are prescribed exercise because it allows them the opportunity to improve in tasks which can be encountered during their daily routine rather than simply improving on a gym exercise used minimally throughout the week.

When considering the benefits of ST, one aspect of its increased functionality is the capability of introducing more variability during completion than traditional resistance-based training. This variability can be found with the type of movements modalities must take to ensure participant safety in completion, while traditionally-based resistance exercises require a more structured path than those seen within ST techniques (Madsen & McLaughlin, 1984; Elliot, Wilson, & Kerr, 1989; Winchester, Erickson, Blaak, & McBride, 2005). These types of restrictions do not apply to ST exercises due to the high amount of variability associated with the explosive movements occurring. McGill et al. (2009) concluded ST exercises provided different challenges compared to traditional lifting exercises, particularly seen in the carrying-based movements and their effects on core musculature stabilization. These differences could lend to support for the implementation of ST exercises for individuals interested in improving on functional movements due to these types of activities being more common within the unpredictable environments of employment, athletics, or activities of daily living (ADLs).

Most traditional resistance training (RT) exercises will also require force production to occur within a vertical direction in the sagittal or frontal plane. Yet, these movements may not transfer effectively to athletic environments because most sports require horizontal force development while performing movements throughout all three cardinal planes, supplemental to the vertical force production created during traditional RT exercises (Zemke & Wright, 2011). Similar conclusions could be drawn for elderly and diseased populations as RT alone may not lead to beneficial effects, whereas functionally specific exercises may be needed instead (Manini, et al., 2007; Earhart & Falvo, 2013). These types of disadvantages support the specificity component of ST regarding the ACSM and AHA recommendations, and can be seen in the pushing, pulling, or carrying of numerous objects implemented in ST programs. With some ST movements being performed within a horizontal plane of movement, this should allow for easier transferability to almost all individuals who choose to participate, due to similarities in movement patterns.

Finally, the concept of progressive overload can apply to ST exercises in comparable fashions to those witnessed with traditional RT techniques. Progressive overload can be found through variations in repetitions completed, load utilized, sets performed, or frequency of sessions accomplished regarding both types of training protocols (Kraemer, et al., 2002, Waller, et al., 2003; Turner, 2011; Zemke & Wright, 2011; Winwood, et al, 2014b; Woulfe, et al., 2014). In order to progress the performances associated with resistance training, these factors (progressive overload, variability, and specificity) must be individually adjusted regardless of training protocol performed. These factors allow for professionals to implement ST exercises within their training prescriptions in order to achieve training goals such as anaerobic and metabolic conditioning, explosive strength, power, muscular endurance, and agility (Waller, et al., 2003; Winwood, et al., 2013; Winwood, et al, 2014b; Woulfe, et al., 2014).

Strongman Training in Periodization

Periodization has been defined as a training plan which produces peak performance through the potentiation of biomotors along with the management of fatigue and accommodation (Turner, 2011). This concept is founded on components such as power (explosiveness), hypertrophy (muscle mass increase), strength, and endurance which are arranged within a cyclic or periodic basis progressing from general fitness to more specialized tasks (Plisk & Stone, 2003). The numerous variations associated with ST allow for the manipulation of the implements used in order to reach any goal within an individual's periodization (Waller, et al., 2003; Havelka, 2004; Zemke & Wright, 2011; Ghigiarelli, et al., 2013; Keogh, et al., 2014).

Any level of periodization will begin with a preparatory period, focusing on phases of hypertrophy and strength endurance. Traditional RT methods are well established for utilization within hypertrophic training. Participants with goals of increasing muscle hypertrophy are encouraged to perform three to four sets of eight to twelve repetitions with loads of 70-85% of maximal strength, usually involving twenty-five to forty seconds of work (Ahtiainen, Pakarinen, Alen, Kraemer, & Häkkinen, 2005; Kraemer & Ratamess, 2005; Linnamo, Pakarinen, Komi, Kraemer, & Häkkinen, 2005; MaCaulley, et al., 2009). The goal of hypertrophy has been included in 73.7% of ST athlete protocols completed when surveyed by Winwood, et al. (2011), with 85% performing repetitions and sets within the recommended limitations. These statistics support the relationship between the attainment of muscular hypertrophy and general recommendations of ST exercises. These exercises generally require athletes to work with loads for durations ranging from thirty to sixty seconds, such as traveling certain distances while performing FW or truck pulls (Winwood, et al., 2011). Physiologically, Ghigiarelli, et al. (2013) found strongman protocols resulted in similar increases in neuroendocrine responses compared to traditional RT exercise programs whose basis of work load was built towards muscular hypertrophy. This may be due to the enhanced amount of musculature activated during these exercises, along with the increased amount of time spent under tension (Bloomer & Ives, 2000; Hansen, Kvorning, Kjaer, & Sjøgaard, 2001).

Endurance training incorporates exercises of high volume, with a repetition range of twelve or more, while being performed at moderate intensities within a set scheme of greater than two allowing for the activation of the anaerobically- and aerobically-based glycolytic system (Waller, et al., 2003; Zemke & Wright, 2011). Push- and pull-based exercises such as the log clean and press or tire flips, may be recommended as exercises for total body endurance adaptations to occur, along with carrying-based exercises over prescribed distances which incorporate dynamic and isometric endurance when utilized (Zemke & Wright, 2011). Winwood, et al. (2014b) found muscular endurance was among one of the three main physiological reasons strength and conditioning coaches decided to implement strongman training into their programs, along with explosively based strength and power.

The next two phases encompassing an individual's periodization would include a basic strength and strength/power phase; with the latter beginning towards the end of the preparatory period as the participant shifts into the first transition period (Haff & Tripplet, 2015). Strength can be defined as the ability to overcome or counteract external resistance by utilizing a muscular effort (Zatsiorsky, 1995). This component can be implemented either dynamically (involving movement) or isometrically (no movement) during traditional RT or ST programs. It should be noted within the original definition of strength, the variable of time is rarely included; this is where the variable of power becomes important. Power can be described in two fashions; either as a speed-strength, or strength-speed ratio. Speed-strength is the ability to quickly execute a movement which may or may not be loaded against a relatively small external resistance (Siff & Verkhoshansky, 1999). Strength-speed is defined as a rapidly forceful muscular contraction against a maximal or submaximal load where the speed of movement is decreasing as the need for strength increases (Waller, et al., 2003). When considering the training recommendations for these types of components, Haff and Tripplett (2015) cited usual recommendations of a high intensity (80-95% of 1RM) load performed with moderate to high volume (2-6 sets of 2-6 repetitions), whereas a strength/power phase would include intensities from anywhere between 30-95%1RM (depending on the exercise) while utilizing low volumes made up of two to five sets of two to five repetitions.

When considering the use of ST protocols for maximal strength enhancement, the incorporation of large musculature throughout these total body lifts along with the aspect of time under tension associated with dynamic or isometric movements would support the use of these implements as strength training tools (Bloomer & Ives, 2000; Hansen, et al., 2001). The use of this training style is supported by the 97% of strongman competitors who reported using repetition ranges of one to six and set ranges of three to five, both within the recommended ranges of strength previously mentioned (Winwood, et al., 2011). However, limitations may be present, mostly seen in difficulties of incorporating the smaller incremental increases in weight necessary for growth to occur in maximal strength (Zemke & Wright, 2011). Implements such as stones, kegs, and tires are often difficult to appropriately increase in weight, while other modalities may be too heavy for some individuals to lift. Due to these factors, implements such as these may be better served for increasing a participant's basic strength, allowing for a broader range of weight to be used while only requiring a repetition range of four to eight (Baechle, Earle, & Wathen, 2000; Zemke & Wright, 2011).

Power can be completed while using strongman implements by moving lighter loads at a fast tempo, such as tires, medicine balls, stones, kegs, or weighted throws; tire flips, atlas stone loads; and/or log clean and presses (Waller, 2003; Zemke & Wright, 2011). Additionally, strength and conditioning professionals have used sandbags to enhance functional strength components such as postural control and the rotational power of athletes (Winwood, et al., 2014b). These powerful movements (including maximal strength) will require longer rest periods than other components due to a need for adequate neuromuscular recuperation, which can be seen with the resting stages of greater than four minutes taken by strongman athletes (Waller, et al., 2003; Winwood, et al., 2011). These rest periods coincide well with the greater enhancement of total body effort associated with ST when compared to traditional RT performed using machine and free weights (Waller, et al., 2003). All of these previously listed benefits associated with ST prescriptions may result in a more quality training stimulus for the continually changing and unpredictable external forces created by opposing individuals and objects encountered in numerous environments (Zemke & Wright, 2011).

However, investigators have refuted these conclusions; Winwood et al. (2015) found no significant (0.2 – 7% improvements; $p > 0.01$) difference in transference to functional performance when comparing traditional RT and ST prescriptions. Both programs (traditional

[RT] and strongman [ST]) provided positive training adaptations defined by strength, power, speed, and change of direction (COD) within the study design (Winwood, et al., 2015). These conclusions would suggest ST may be more effectively used as a supplement of traditional RT, rather than replacing it all together (Winwood, Keogh, & Harris, 2012; Winwood, et al., 2015). Winwood, et al. (2012) also found support for a relationship between these two types of training modalities (RT and ST) with clear moderate to very large correlations existing between overall strongman competition performance and 1RM strength measures ($r = 0.45$-0.85), and vice versa ($r = 0.44 – 0.82$). Yet, with these similarities in benefits understood, it is important to clarify the differences in injury epidemiology between traditional RT and ST protocols.

Winwood, Hume, Cronin, and Keogh (2014c) examined injuries sustained during the training of 268 total strongman athletes; 145 (54%) injuries were sustained during the performance of traditional RT exercises. The majority of these injuries ($n = 41$) occurred at the lower back, mainly caused during the performance of deadlift exercises. Comparatively, 123 (46%) injuries occurred from ST exercise implementation where the majority of exercises ($n = 26$) occurred within the neck region, with nearly one-fourth of all competitors believing their injuries occurred due to poor technique.

Regardless, with a limited amount of evidence to support or refute these studies, further examination is needed to properly evaluate the effects of different training protocols among various populations. Nevertheless, from the details collected, both anecdotal and quantitative, ST has shown the ability to deliver at least the same amount of benefits as traditional resistance training, if not more.

Farmers Walk (FW) Exercise

The Farmers Walk (FW) exercise was selected as the specific ST implement to be utilized for analysis within the contents of this study design. This exercise was chosen due to its popularity, not only among those competing and training within the ST realm (Winwood, et al., 2011), but also within the fitness industry as a whole (Winwood, et al., 2014b). Support for these claims can be found in its ranking as the sixth most utilized ST exercise among 88% of the strength and conditioning professionals who used ST within their periodization (Winwood, et al., 2014b). To perform the FW, a participant is required to assume a deadlift position (feet flat and shoulder width apart with back straight, shoulders back, head up, and chest up) while lifting two loads simultaneously (one in each hand) off of the ground into an upright position. Subsequently, the participant will travel in a horizontally forward direction in order to cover a certain amount of distance (20-50 meters) as quickly as possible (Ghigiarelli, et al., 2013; Keogh, et al., 2014; Winwood, et al., 2015), or alternatively as much distance as they can within a certain time frame (Waller, et al., 2003, Winwood, et al., 2011).

Due to the physiological challenges associated with the implementation of this exercise, the FW can be included within an individual's periodization due to its association with components such as strength, stability, and other physiological demands utilized by the whole musculoskeletal system (McGill, et al., 2009; Winwood, et al., 2014a; Winwood, et al., 2014b). As discussed by Ghigiarelli, et al. (2013), the increased amount of time under tension and enhanced activation of musculature involved with ST exercises such as the FW would be most conventional during the general physical training phase (GPT) of periodization. This is due to its emphasis on improving work capacity and neuromuscular functioning through use of trainings based on high volume and moderate intensity, in order to maximize adaptations while working towards future workloads (Bompa & Haff, 2009; Turner, 2011; Zemke & Wright, 2011).

The performance of the FW allows for the individual to improve upon important physiological components such as dynamic balance, grip and core strength, total body strength, isometric holding strength, and utilization of a forceful triple extension of the lower body during both of the lifting and walking phases (Waller, et al., 2003, Zemke & Wright, 2011; Ghigiarelli, et al., 2013; Keogh, et al., 2014; Winwood, et al., 2014a). Loaded walking associated with this exercise also requires biomechanical alterations, specifically regarding variables such as average velocity, stride rate, stride length, ground contact time, and swing time when performed (Keogh, et al., 2014; Winwood, et al., 2014a). Based off of activation patterns evaluated by McGill, et al. (2009), these adaptations occur throughout the body during the FW and may depend on the segment of the exercise, specifically the lifting and walking phases, each dominated by vertical or horizontal components, respectfully. Ultimately, these adaptations could lead to substantial benefits regarding the individual's metabolic conditioning, specifically increasing strength endurance, anaerobic energy system endurance, and explosive power (Zemke & Wright, 2011; Woulfe, et al., 2014).

Comparisons between Farmers Walk (FW) and Unweighted Walk

When considering the physiological adaptations occurring when implementing a weighted carry exercise such as the FW, biomechanical evidence must be taken into consideration as well. Relatively little data has been collected regarding this type of analysis. Keogh, et al. (2014) performed a kinematic analysis of the FW exercise and data collected suggests variables such as average velocity and stride rate were significantly increased whereas ground contact time between steps was significantly decreased as the FW progressed through the stages into the latter part of the distance (8.5-20 m) ($p < 0.05$).

Winwood et al. (2014a) compared the FW to an unweighted walk and demonstrated significant increases in stride rate and velocity along with significant decreases in stride length, ground contact time, and swing time completed ($p < 0.02$). Differences in physiological angles also occurred between the two actions, with significantly different trunk and knee flexion patterns along with ankle dorsiflexion, occurring between the foot strike and toe off phases of the walks performed ($p < 0.05$). These points were supported by the evidence collected by Keogh, et al. (2014) regarding within-subject and between-subject differences during the walking performance which resulted in decreased angles at the hip, knee, and ankle during faster performances; however, minimal comparisons supported any significance between these differences.

McGill, et al. (2009) used electromyographic and kinematic measures to provide detailed evidence on back load, low-back stiffness, and hip torque from various back and hip musculature associated with strongman training protocols. Differing muscular activation was noted between the different phases (liftoff, first step, walk, and lower) occurring within the FW. Analysis suggested the abdominals, upper body, and lower body were sources of peak activation during the walking portion of the lift, while the posterior chain seemed to absorb the most activation during the lifting phase (McGill, et al., 2009). Variables such as lumbar spine flexion, lateral bend, and twist all showed peak occurrence towards the beginning of the exercise, either within the lifting portion (lumbar spine flexion) or while taking the first step of the exercise (twist) (McGill, et al., 2009). Finally, shear forces, compression, and stiffness occurred within the anterior-posterior axis of movement during the lifting phase, whereas force occurring through the medio-lateral axis began during the walking phase of the FW (McGill, et al., 2009). These points were supported by kinetic evaluations completed by Winwood, et al. (2014a) who compared the FW liftoff and conventional deadlift, with significantly ($p < 0.02$) greater vertical and anterior forces occurring during the FW. Further kinetic evaluation of the FW, specifically compared to the unweighted walk, showed significantly ($p < 0.05$) increased movements in all planes (anterior, posterior, lateral, and medial). When comparing the FW with an unweighted walking pattern, numerous adaptations may occur when implemented. These alterations can prove to be beneficial for individuals who either carry objects for work (laborers, protective personnel, construction workers) or may benefit from the biomechanical improvements in force output, velocity, stride rate, and ground contact time (athletes, rehabilitation).

Objective (Biochemical) Muscle Damage Responses to Resistance Exercise Evidence

When participating in multiple bouts of highly intense resistance exercises during training, muscle tissue may become damaged as a consequence of both metabolic and mechanical factors (Brancaccio, Lippi, & Maffulli, 2010; Koch, et al., 2014). It seems all types of contractions (isometric, concentric, and eccentric) are capable of creating muscular damage, specifically to components such as the Z-disk, sarcolemma, basal lamina, supportive tissue, and cytoskeleton (Fridén, Kjörell, & Thornell, 1984; Clarkson, Byrnes, McCormick, Turcotte, & White, 1986; Fridén, Seger, & Ekblom, 1988; Lieber & Fridén, 1988; Duan, Delp, Hayes, Delp, & Armstrong, 1990; Stauber, Clarkson, Fritz, & Evans, 1990; Fridén & Lieber, 1996; Lieber, Thornell, & Fridén, 1996; Roth et al., 1999; Roth, et al., 2000; Koskinen, et al., 2001; Takekura, Fujinami, Nishizawa, Ogasawara, & Kasuga, 2001). However, previous investigations have determined the magnitude of muscle damage sustained is increased when eccentric contractions are utilized (Clarkson & Hubal, 2002; Dieli-Conwright, Spektor, Rice, & Schroeder, 2009). Muscle damage may present as soreness, or pain, within the muscles after completion of an exercise regimen. Methods are now obtainable to evaluate the simultaneous release of myocellular proteins into the lymphatic system allowing researchers to quantify the amount of damage sustained (Komi & Rusko, 1974; Komi & Viitasalo, 1977). Due to the availability of these investigative methods, assessments of enzymes and proteins such as creatine kinase (CK) and myoglobin (Mb) have been identified as reliable markers to examine muscle damage (Driessen-Kletter, Amelink, Bär, & van Gijn, 1990; Brancaccio, Maffulli, & Limongelli, 2007; Heavens, et al., 2014; Koch, et al., 2014).

The combination of mechanical and metabolic stress has been shown to increase the potential for muscle damage while also acting as a potent stimulus for inducing other factors as well including increases in muscular hypertrophy and strength (Clarkson, Nosaka, & Braun, 1992; Toigo & Boutellier, 2006; Mangine, et al., 2015). Usually this damage is accompanied by the release of enzymes from the musculature such as CK and Mb, both of which will be evaluated within this study design. CK has been proposed as one of the best indirect indicators of muscle damage due to its ease in identification and relatively low cost of assays needed for quantification (Koch, et al., 2014). With the implementation of muscle damage, increased permeability of the cellular membrane allows for CK to leak into the interstitial fluid before entering the lymphatic system. The level of serum CK is believed to reflect the relative amounts of CK released, degree of enzyme activity of released CK, and the rate of clearance of CK from the serum (Thompson, Scordilis, & De Souza, 2006; Baird, et al., 2012). Other indicators of muscle damage could be localized inflammation, a reduction in muscular strength and associated range of motion, and increased amounts of proteins, such as Mb, found within the lymphatic system (Driessen-Kletter, et al., 1990; Clarkson, et al., 1992; Clarkson, Kearns, Rouzier, Rubin, & Thompson, 2006). Mb is an oxygen-binding protein found within the muscle released into the blood stream when increasing amounts of muscle damage occur (Clarkson, et al., 2006). These two variables are seemingly well known for their roles in muscle disruption, with both serum CK and Mb peaking in accumulation within a time period of 24-72 hours post-exercise (Ebbeling & Clarkson, 1989; Branacaccio, et al., 2007; Deminice, et al., 2011). However, previous literature has suggested Mb may have a much shorter response regarding its accumulation within the blood and reduction back to baseline measures when compared to CK (Clarkson, et al., 2006; Machado & Willardson, 2010). An increase in circulating concentrations of intracellular proteins and enzymes can occur at numerous time points, with concentrations dependent on which type of physical activity patterns are introduced (Ascensão, et al., 2008; Cunniffe, et al., 2010).

Utilization of these biomarkers has been limited within the research scope of ST. Physical activities such as sports competitions have been used to measure the effects of muscle damage and their relationship with CK and Mb. Twist, Waldron, Highton, Burt, and Daniels (2012) evaluated biochemical markers of fatigue regarding athletes within a professional rugby league and found increases in CK ($p < 0.05$) one-to-two (1 to 2) days after the completion of matches. When evaluating soccer athletes, percent changes of CK (84%) and Mb (238%) concentration were observed from pre-match to post-match (Thorpe & Sunderland, 2012). Use of training protocols involving high-intensity strength training and 2,000-meter rowing ergometer performance within a 24-hour time period provided significant (24 and 48h, $p < 0.01$) increases in CK as well (Gee, et al., 2011).

When considering resistance exercise induced muscle damage, both CK and Mb were found to significantly ($p \leq 0.05$) increase with both male and female populations when introduced to a high intensity resistance protocol allotting shorter rest intervals (Heavens, et al., 2014). Maximal strength testing was associated with significantly ($p < 0.05$) greater CK accumulation, up to 72-hours post-exercise bout, when performing a one-repetition maximum test (Arazi & Asadi, 2013). Bartolomei, et al. (2017) suggested the presence of elevated concentrations of muscle damage markers (CK and Mb) when compared to baseline measurements for recovery responses from both high-intensity and high-volume resistance exercises; however, high-volume exercises caused a greater reduction in countermovement jump performance ($p < 0.001$).

There have been contrasting conclusions on the implementation of muscle damage associated with concentrically-based muscle contractions. Virtanen, Viitasalo, Vuori, Väänänen, and Takala (1993) found similar significant increases in CK and Mb with the implementation of high-intensity concentric exercise. CK was found to increase by 32 U/L ($p < 0.01$) within one-hour post-exercise and 49 U/L ($p < 0.01$) two-hours post-exercise. Additionally, Mb increased from baseline measurements ($p < 0.01$) within one-hour (138%) and two-hours (143%) post-exercise. However, West, et al. (2014) found no significant ($p > 0.05$) changes in CK concentrations when measuring the biochemical responses to a sled drag training session. Results regarding this study were consistent with previous studies conducted which found CK levels were lower following primarily concentric exercise when compared to eccentric exercise (Armstrong, Ogilvie, & Schwane, 1983; Newham, Jones, & Edwards, 1986; Clarkson & Hubal, 2002). Yet, even with the increases in blood protein and enzymatic accumulation, these measurements provide no indication of the magnitude of muscle damage or muscle functioning impairment (Fridén & Lieber, 2001). These enzymes and proteins are truly indirect measurements of muscle damage sustained when completing of bouts of physical activity.

Subjective (Psychological) Muscle Damage Responses to Resistance Exercise Evidence

Subjectively-based measurements, such as Visual Perceived Muscle Soreness (VPMS) ratings were used as an indirect marker for muscle damage during the implementation of this study design. Delayed Onset Muscle Soreness (DOMS) can affect numerous populations of athletes and is classified as a type I muscle strain while presenting tenderness or stiffness to palpitation and/or movement with discomfort ranging from mildly stiff to devastatingly painful (Safran, Seber & Garret, 1989; Gulick, Kimura, Sitler, Paolone, & Kelly, 1996; Cheung, Hume, & Maxwell, 2003; Burnett, Smith, Smeltzer, Young, & Burns, 2010). The Visual Analog Scale (VAS) will be implemented when measuring perceived muscle soreness measurements and previous literature has indicated the VAS as a criterion measurement to compare with other less-validated tests. Scores provided by participants are based on self-reported measurements of symptoms of pain or soreness. These can be recorded with a single mark placed at one point along the scale's continuum, usually between ends classified as 'no pain' and 'the worst pain' (Alexander, 2007).

Majority of VAS implements used within previous literature have been completed via pencil and paper; however, this study used modern technological advancements (computers) for the completion of these scales. Delgado, et al. (2018) found measurement agreement (mean difference, 0.0% ± 0.5%; no proportional bias detected) and no significant ($p > 0.05$) difference between assessments conducted via laptop or traditional pen and paper. This study did find a significant ($p < 0.05$) difference in scores between mobile phone-based (32.9% ± 0.4%) and paper-based platforms (31.0% ± 0.4%); no measurement agreement between the platforms were noted (mean difference, 1.9% ± 0.5%; proportional bias detected). Regardless, despite the differences found, no clinically relevant differences between the modes of assessment were detected (Delgado, et al., 2018). Impellizzeri and Maffiuletti (2007) determined the use of a seven-point Likert scale VAS to measure perceived muscle soreness provided significant correlations between each standardized measurement (mean r = 0.80 ± 0.07; range, 0.65 to 0.94). Evangelista, Pereira, Hackney, and Machado (2012) found no differences in muscle soreness among an untrained population, measured at multiple time points via VAS, when comparing exercise bouts of similar intensities with differing rest intervals. Furthermore, assessments utilizing VAS have continually been used in quantifying musculoskeletal pain in previous literature as well (Slater, Thériault, Ronningen, Clark, & Nosaka, 2010; Hosseinzadeh, Andersen, Arendt-Nielsen, & Madeleine, 2013; Lau, Blazevich, Newton, Wu, & Nosaka, 2015).

Neuromuscular Responses to Resistance Exercise Evidence

Acute fatigue has been described as an exercise-induced reduction of force production or work performance within the capacity of the neuromuscular system, either peripherally (distal to neuromuscular junction) or centrally (proximal to neuromuscular junction) (Bigland-Ritchie, 1981; Gandevia, 1992). When central fatigue is induced, the recruitment of new motor units along with the firing frequency of active units may experience a decrease, while peripheral fatigue is primarily associated with the contractile processes (Bigland-Ritchie, 1981; Bigland-Ritchie, Furbush, & Woods, 1986; Green, 1987). When intensive muscular work is performed, these actions can lead to fatigue dependent on factors such as the intensity, amount, condition, or type of loading, the fiber composition of the musculature involved, the specificity of the physiological site being loaded, or the movement specific to the individual's athletic background (DeLorme, 1945; Berger, 1962; Komi & Rusko, 1974; Komi & Viitasalo, 1977; Thorstensson &

Karlsson, 1976; Häkkinen, Pakarinen, Alen, Kauhanen, & Komi, 1988; Häkkinen & Keskinen, 1989; Häkkinen & Myllylä; 1990; Linnamo, Häkkinen, & Komi, 1998; Campos, et al., 2002).

Previous literature has evaluated the concept of fatigue through the use of isometric contractions associated with various loading protocols. Specific evidence differing between concentrically- and eccentrically-based contractions deduced a lesser EMG amplitude and motor unit activation occurrence when eccentric contractions were applied (Moritani, Muramatsu, & Muro, 1987; Westing, Cresswell, & Thorstensson, 1991; Grabiner, Owings, George, & Enoka, 1995; Enoka, 1996; Kay, St. Clair, Mitchell, Lambert, & Noakes, 2000; Madeleine, Bajaj, Søgaard, Arendt-Nielsen, 2001; Grabiner & Owings, 2002). Assumed causative processes of fatigue regarding these contractions included factors such as metabolite accumulation and lowering of muscle pH levels, reduced neural drive, and decreases in Calcium transport (Sahlin, 1986; Duchateau, de Montigny, & Hainaut, 1987; Brody, Pollock, Roy, De Luca, & Celli, 1991; Taylor, Butler, & Gandevia, 1999; Søgaard, Gandevia, Todd, Peterson, & Taylor, 2006; Todd, et al., 2007). Collecting physiological and muscular activation measurements, such as electromyograms, during the course of fatigue makes it possible to formulate an idea of the central and peripheral factors operating during the different types of exercise performed (Linnamo, et al., 1998).

Garner, Blackburn, Weimer, and Campbell (2008) refuted these claims citing evidence of similarities between eccentrically- and concentrically-loaded isometric contractions and the related electromyographic activity produced. However, limitations within the study design must be taken into consideration as intensities only reached 50%1RM for each participant (Garner, et al., 2008). Other study designs have also been considered in the pursuit of support between the two contractions; however, significant differences in protocols used to obtain maximal or submaximal isometric contractions have caused for the potential inhibition of comparability between the studies as a whole (Moritani, et al., 1987; Westing, et al., 1991; Carpentier, Duchateau, & Hainaut, 1998; Blackburn, Mynark, Padua, & Guskiewicz, 2006).

Isometric contractions are prevalent during the performance of the FW as the upper body must support the load being carried while the lower body dynamically propels the body forward. This type of isometric contraction would be considered a concentrically-based contraction as the muscle will be contracted into a shortened state in order to maintain the load. Due to this previously discussed information, fatigue may occur rapidly within the posterior chain of the upper torso when bracing. Fatigue may be imminent from lifting the weight from the floor over multiple repetitions along with continually holding the isometric contraction in an effort to not drop the load while performing the FW as seen by peak muscular activation during implementation (McGill, et al., 2009).

Conversely, dynamic contractions have not received the same attention with fatigue-based responses as isometric contractions have in previously published literature. Walker, Davis, Avela, and Häkkinen (2012) examined the neuromuscular fatigue associated with dynamically-based strength and hypertrophic resistance loadings. The outcomes of the study suggested dynamically-based strength training movements utilizing maximal strength loads led to decreased concentric and isometric contractions with reduced EMG amplitude ($p < 0.05$) when compared to the responses of hypertrophic resistance loads. When maximal and explosive strength were compared, overall decreases in variables such as bilateral leg extension force production, maximal rate of force production, and average force across multiple time points showed greater decreases in maximal strength loading ($p < 0.05$) when compared to explosive strength loading while utilizing a bilateral leg extension exercise (Linnamo, et al., 1998). The acute decreases in force production and maximal EMG activity associated with the introduction of the maximal strength loading protocol showed similarities with several previously published studies (Kraemer, Noble, Clark, & Culver, 1987; Tesch, Dudley, Duvoisin, Hather, & Harris, 1990; Häkkinen, 1994). Contrariwise, Linnamo et al. (2000) observed no differences between heavy resistance loading and explosive loading while evaluating for neuromuscular responses. However, limitations on the range of motion, short duration of action time, lack of eccentric work, and constant resistance regarding the use of a leg press may have been factors in these results.

Unfortunately, the amount of research regarding longitudinal neuromuscular responses within the ST realm is fairly limited, especially when considering the FW. As previous literature discussed, an acute kinematic and kinetic analysis of the FW provided an insight into the adaptations which could occur regarding variables such as force output, stride rate, stride length, ground contact time, swing time, velocity, and others (McGill, et al., 2009; Keogh, et al., 2014; Winwood, et al., 2014a). Winwood, et al. (2014a) suggested neuromuscular adaptations such as improvements in production of anterior-propulsive forces, ankle strength and stability, lower body kinetic chain development, and core strength and stability may result from the inclusion of an exercise such as the FW into an individual's training program. This recommendation was supported by Ghigiarelli, et al. (2013) who suggested the multi-joint movements associated with ST involve a large amount of muscle mass with each action taken, imposing a substantial amount of neuromuscular stress on the body. Another ST implement evaluated included the sprint-style sled pull. Keogh, et al. (2010a) concluded the only differences in thigh angle during the toe-off phase could be seen between faster and slower trials conducted during the acceleration phase during within-subject comparisons. These inferences differed from other variables such as velocity, step rate, step length, and knee extension at toe-off which were significantly ($p < 0.01$) greater than slower trials conducted during the maximum velocity phase of the protocol. A between-subject analysis found variables such as step length and swing time were greater during quicker trials completed within the acceleration phase, while the maximum velocity phase saw significantly greater average velocity, step length, and step rate along with decreases in each individual's ground reaction time ($p < 0.01$). Both phases found an increase in the vertical trunk, along with increased hip flexion and knee extension, were associated with faster trials during both phases analyzed (Keogh, et al., 2010a). Physiologically, the sprint-style sled pull seems to demonstrate small to minimal improvements on sprint time when utilized as a potentiating training effect (Winwood, Posthumus, Cronin & Keogh, 2016). Evidence concluded on attempts using 150% of the participant's body weight actually increased their proceeding sprint time, whereas sprint-style sled pulls utilizing 75% of their body weight led to some, however, fairly small ($ES = >0.2$) improvements in sprinting speed. There should not be an assumption regarding these adaptations and how they may affect an individual's neuromuscular functional capacity during the recovery phase. West, et al. (2014) examined the neuromuscular effects of implementing a backward sled drag exercise bout and found due to the concentrically-based contractions associated with the movement, neuromuscular functioning had returned to baseline function within one hour after completion of the exercise bout. Thus, limited amounts of muscle soreness and fatigue may be associated with the implementation of a backward sled drag exercise. The lack in detrimental responses to this exercise provides evidence of physiological benefits due to its completion as exercises can be performed without inhibition during the recovery period. No evidence regarding these types of claims currently exist for an exercise such as the FW.

For this study design, countermovement jump (CMJ) performance was utilized as a measure of the longitudinal effects on neuromuscular function during the recovery phases of the FWC protocol. Pre- and post-exercise protocol CMJs were performed by each participant in order to measure the effect of the FWC on an individual's neuromuscular functionality. This test has been one of the most popularized performance tests used for monitoring neuromuscular status within individual and team sports, as well as military personnel. (Nindl, et al., 2007; Oliver, Armstrong, & Williams, 2008; Welsh, et al., 2008; McLean, Coutts, Kelly, McGuigan, & Cormack, 2010; Fortes, et al., 2011; Taylor, Chapman, Cronin, Newton, & Gill, 2012; Loturco, Ugrinowitsch, Roschel, Tricoli, & González -Badillo, 2013; Mooney, Cormack, O'brien, Morgan, & McGuigan, 2013; Twist & Highton, 2013; Balsalobre-Fernández, Tejero-González, del Campo-Vecino, 2014; Freitas, Nakamura, Miloski, Samulski, & Bara-Filho, 2014; Gathercole, Sporer, Stellingwerff, & Sleivert, 2014; Loturco, et al., 2015). Testing the CMJ has become a common procedure for the evaluation of lower-body power and neuromuscular responses due to factors such as its simplicity, effectiveness, and minimal additional fatigue during assessment (Taylor, et al., 2012; Twist & Highton, 2013; Claudino, et al., 2017).

Numerous researchers agree CMJs can be used as an objective marker for fatigue; however, mixed results have been documented due to a combination of factors associated with the test along with no standardization regarding the use of highest or average values during assessment (Coutts, Reaburn, Piva, & Murphy, 2007; Coutts, Reaburn, Piva, & Roswell, 2007; Cormie, McBride, & McCaulley, 2009; Balsalobre-Fernandez, et al., 2014; Freitas, et al., 2014; Gathercole, et al., 2014; Malone, et al., 2015; Claudino, et al., 2017). A meta-analysis concluded the use of CMJs was sufficient for measuring neuromuscular status (Claudino, et al., 2017). Other variables such as peak power, mean power, peak velocity, peak force, mean impulse, and concentric contraction flight time were also found to be sufficient variables with the assessment of supercompensatory effects following a training intervention (Cormack, Newton, McGuigan, & Doyle, 2008; McLean, et al., 2010; Taylor, et al., 2012; Mooney, et al., 2013).

In order to properly measure these physiological responses, specific parameters were placed on the acute training variables associated with the implementation of the FW to allow for control on the influence of the exercise. As previously described, a FW can be performed over various distances with acknowledgeable alterations in intensity, pace, and rest intervals depending on the needs of the participant. For this specific study design the Farmers Walk Condition (FWC) was implemented to control these training variables in an attempt to enhance the reliability of the responses observed among all participants. The FWC was performed for five sets comprised of two repetitions each with a High-handle Hex-bar (HHB) modality while carrying 70% of the individual's 1RM load. Participants were instructed to complete each of the ten repetitions over a distance of 20-meters as quickly as possible. Finally, rest periods were specifically oriented towards the completion of each repetition (30 seconds) or set (2 minutes) during the exercise protocol. Similar parameters were applied to the control protocol (Non-Weighted Condition; NWC), however the participants were not tasked with carrying any additional weight and were instructed to finish each repetition at a self-reported leisurely pace.

In conclusion, the purpose of this study design was to investigate the neuromuscular and muscle damage responses following the completion of the FWC. Previous literature within the field of ST is relatively minimal, with information produced prioritizing its implementation into strength and conditioning realms or evaluating biomechanical and physiological responses during exercise completion. Biochemical and neuromuscular evidence supporting this literature is limited, which the current study aims to add to with the completion of the FWC, a specified testing protocol regarding the FW which has been classified as a popularized exercise used throughout multiple fitness populations. The use of these indirect markers, both on a practical and biochemical scale, provided a new outlet of information not available in previous literature regarding this exercise. The author and research team expected to provide the research community with new and validated information to improve the knowledge-base of popular strength and conditioning tools, such as the FW for the benefit of numerous populations.

CHAPTER III

Methods

This chapter discusses the methodology used to conduct this study design. Parameters regarding inclusion of subjects, testing procedures, and instrumentation utilized are elucidated and illustrated when necessary. Additionally, methods for sample and statistical analysis are clarified.

Subjects and Sampling

This study was approved by the Institutional Review Board (HREC #96-18) (see *Appendix 1*) and the Institutional Biosafety Committee (04-18; BSL-2 Level) (see *Appendix 2*) at Texas A&M University-Corpus Christi. Participants were provided a copy of the informed consent (see *Appendix 3*) and then selected for participation in the study upon approval. A set of specific exclusionary criteria were utilized for this study design which required subjects to: a) fall within the age range of 18-45 years old, b) be considered apparently healthy with no current contraindications or use of medications excluded from this study, c) not be supplementing with any pharmacological aid to enhance their performance, d) not be pregnant, and e) be free of any musculoskeletal injury diagnosis over a six-month time period previous to participation. This information was evaluated through the use of a health-history questionnaire (HHQ) and physical activity questionnaire (PAQ) completed in association with the study's consent documentation (see *Appendix 4 and Appendix 5*). Further details on these exclusionary criteria are detailed in *Table 1*.

Table 1: Participant Exclusionary Criteria

Criteria	Exclusionary
Age	Individual falls outside of specified age range (18-45 years old)
Health	Diagnosed with any of the following: Anemia Blood disorders Cardiometabolic diseases Cardiovascular diseases Kidney/Liver diseases Metabolic disorders Neuromuscular diseases
Pregnancy	Participant knows or is unsure if they are pregnant
Musculoskeletal injury	Diagnosis of any type of injury within six-months prior to participation
Pharmacological supplementation	Use of any of the following: Anabolic steroids β-Alanine (<3 g/day) Caffeine (>400 mg/day) Creatine (<5 days before) HMB (β-HYDROXY β-METHYLBUTYRATE) (<3g/day) Iron supplementation (> 18mg in a multivitamin) Nonsteroidal anti-inflammatory drugs (NSAIDS) Recreational drugs (excluding alcohol) Sodium Bicarbonate (<300 mg/kg*BW)
Ergogenic Aids	Use of any of the following was forbidden during the duration of both protocols and supplemental recovery periods of the study: Compression clothing Electrical stimulation Hydrotherapy Cryotherapy (Ice) Massage (Manual or Electronic)
Medical Implantation Device	Implantation of the following: Pacemaker Internal Defibrillator

Procedures

This was a quasi-experimental study which followed an equivalent time-samples design template (*Figure 1*). The independent variable for this study was the amount of load sustained by the participant while completing the Farmers Walk Condition (FWC). The dependent variable(s) for the study were the objective muscle damage biomarker concentrations regarding creatine kinase (CK) and myoglobin (Mb), subjective self-reported measurements of muscle soreness via visually perceived muscle soreness (VPMS) evaluation, and indirect measurements of neuromuscular deficiency via countermovement jump (CMJ) height assessment. Data points were collected by blood samples, survey utilizing a 10-point visual analog scale (VAS), and mobile technological devices used in association with the study, respectively.

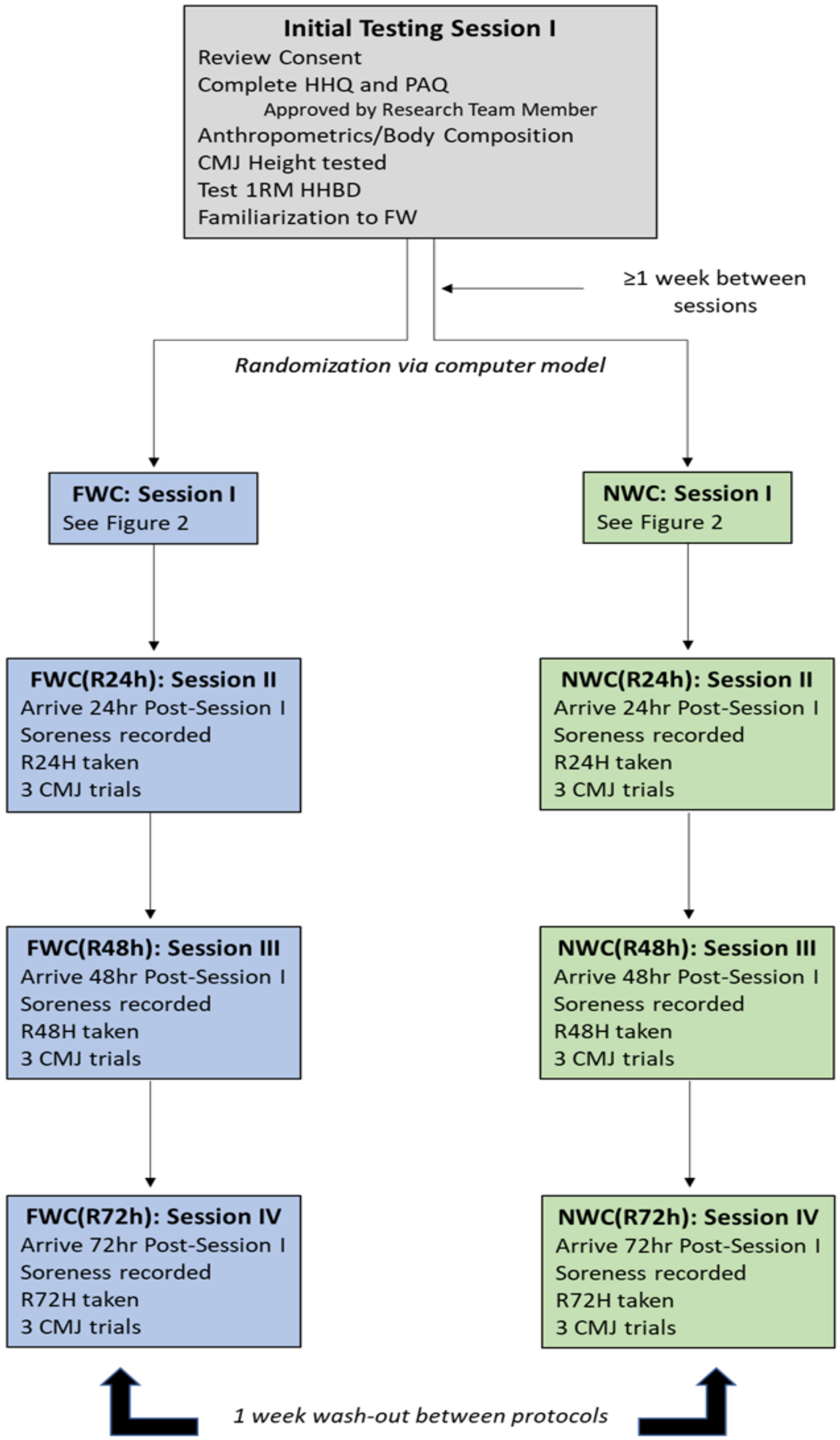


Figure 1: Illustration of Study Design Flow

General study design schematic. (HHQ = Health History Questionnaire; PAQ = Physical Activity Questionnaire; CMJ = Countermovement Jump; 1RM = One Repetition Maximum; HHBD = High-handle Hex-bar Deadlift; FWC = Farmers Walk Condition; NWC = Non-Weighted Condition).

Session One (1)

Participants completed a total of three separate data collection sessions over a time period of at least three weeks during their involvement with this study design, with Sessions two (2) and three (3) counterbalanced between conditions (*Figure 1*). Session one (1) involved the participant meeting with a research team member where the research design was explained in full detail along with the provision of any answers to questions asked during the process. The participant was asked to read and sign an Institutional Review Board (HREC #96-18) approved informed consent form (see *Appendix 3*) and acknowledgement of risk documentation (see *Appendix 6*). Once finalized they completed a health history questionnaire (HHQ) and physical activity questionnaire (PAQ) to evaluate inclusionary/exclusionary criteria (see *Appendix 4 and Appendix 5*). Once qualification for inclusion was confirmed and all questions had been answered, measurements were collected.

Height and weight, used for anthropometrical analysis, were measured through use of a stadiometer and balance-beam scale (Detecto Model 439; Detecto, Webb City, MO), respectively, along with Dual-energy X-Ray Absorptiometry (DXA) technology (iDXA, Lunar Prodigy; GE Healthcare, Madison, WI) used to analyze body composition.

Next, the participants completed the countermovement jump (CMJ) height assessment via the Just Jump System (Probiotics, Huntsville, AL) after being given five minutes to warm-up via cycle ergometer (Monark Ergomedic 828E, Monark Exercise; HealthCare International Inc., Langley, WA). Participants were instructed on the proper technique for performance of a CMJ (hands kept on hips [akimbo], to crouch down as comfortable and then perform an explosive jump vertically). One practice trial was allowed with feedback provided by the research team member prior to CMJ assessment. Participants were asked to perform a CMJ for three total trials with two minutes of rest allotted between each attempt; the average of the trials was calculated and recorded.

Subsequently, the participant's one-repetition maximum (1RM) was assessed for the High-handle Hex-bar deadlift (HHBD) exercise. This exercise was completed while using a forty-five-pound High-handle Hex-bar (HHB) (Rogue Fitness, Columbus, OH) with additional weight supplied through the use of rubberized Olympic bumper plates (Fringe Sport, Austin, TX; Body-Solid, Forest Park, IL). Participants were given four specific warm-up sets along with three to five minutes of recovery between each set. The protocol was adopted from Lockie, et al. (2018), and proceeded with the first HHBD set comprised of ten repetitions at a load of 50% of 1RM, as self-reported by the participant. The following sets included five repetitions performed at 70% of self-reported 1RM, three repetitions at 85% of self-reported 1RM, and one repetition at 90% of self-reported 1RM. Once completed, the load was then increased by approximately 5% per lift until the subject was unable to complete any more repetitions. The load of the previous repetition (Full 1RM) was then documented for data collection. The successful completion of a repetition was defined as the subject standing erect within the frame of the hexagonal bar while holding the high handles. This involved proper extension of the knees, retraction of the shoulders, and standing in an upright position; assessed by an investigator positioned adjacently to the performing participant (Scott, Slattery, Sculley, Hodson, & Dascombe, 2015). If a subject did not achieve the final designated position, if the bar was lowered at any point during the ascent, or if improper form (i.e., rounding of back, early rise of hips, etc.) were noted potentially resulting in harm to the participant; then the repetition was not scored and was immediately stopped.

The initial consent and testing session (Session 1) concluded with a familiarization process for the individual to the FWC exercise to be performed in either Session two (2) or three (3) of the testing protocol. An unweighted HHB was provided, and the research team member instructed the participant on proper form and provided coaching cues to correct any mistakes. The participant was asked to walk a maximum of ten meters no more than five times in order to become familiar with the technique to be performed. Once the subject reported confidence in the expectations of the testing protocol (FWC), they were then dismissed after scheduling future sessions for data collection.

Session Two (2)

The second session of the testing protocol occurred more than four days after the completion of the subject's first session (Session 1). These sessions were randomized and counter-balanced among participants between the Non-Weighted Condition (NWC) and the Famers Walk Condition (FWC). For these specific research sessions, the participants arrived at the Exercise Physiology Laboratory (EPL; IH 146) at the designated time (~ 06:20AM) and were met by a member of the research team outside of the lab to be escorted inside.

Upon entering the lab, the procedures were explained and understanding of each procedure was confirmed before proceeding. To begin, the participant was asked to provide their visually perceived muscle soreness (VPMS) rating on a 10-point visual analog scale (VAS) (*Figure 2*). Next, the participant was escorted to the examination table to have a blood sample collected. A venipuncture in the antecubital region of the arm was performed by a designated, trained individual, using standard venipuncture protocols to collect two 7-ml tubes of blood (see *Appendix 8*). Direct pressure was applied to the venipuncture site with gauze after removal of the hypodermic needle. Following the desisting of bleeding, an adhesive bandage was placed over the venipuncture site and was secured with self-adhesive flexible tape. At this point, two concurrent events occurred: 1.) Samples were taken into the Exercise Biochemistry Laboratory (EBL; IH 146 B/C) for analysis and storage; and 2.) The participants were escorted to the Biomechanics Laboratory (BML; IH 142) and began the exercise portion of the protocol. Upon entering the BML, the participant was escorted to the WOODWAY Curve Treadmill (Woodway World Headquarters, Waukesha, WI) to participate in a standardized five-minute warm-up protocol.

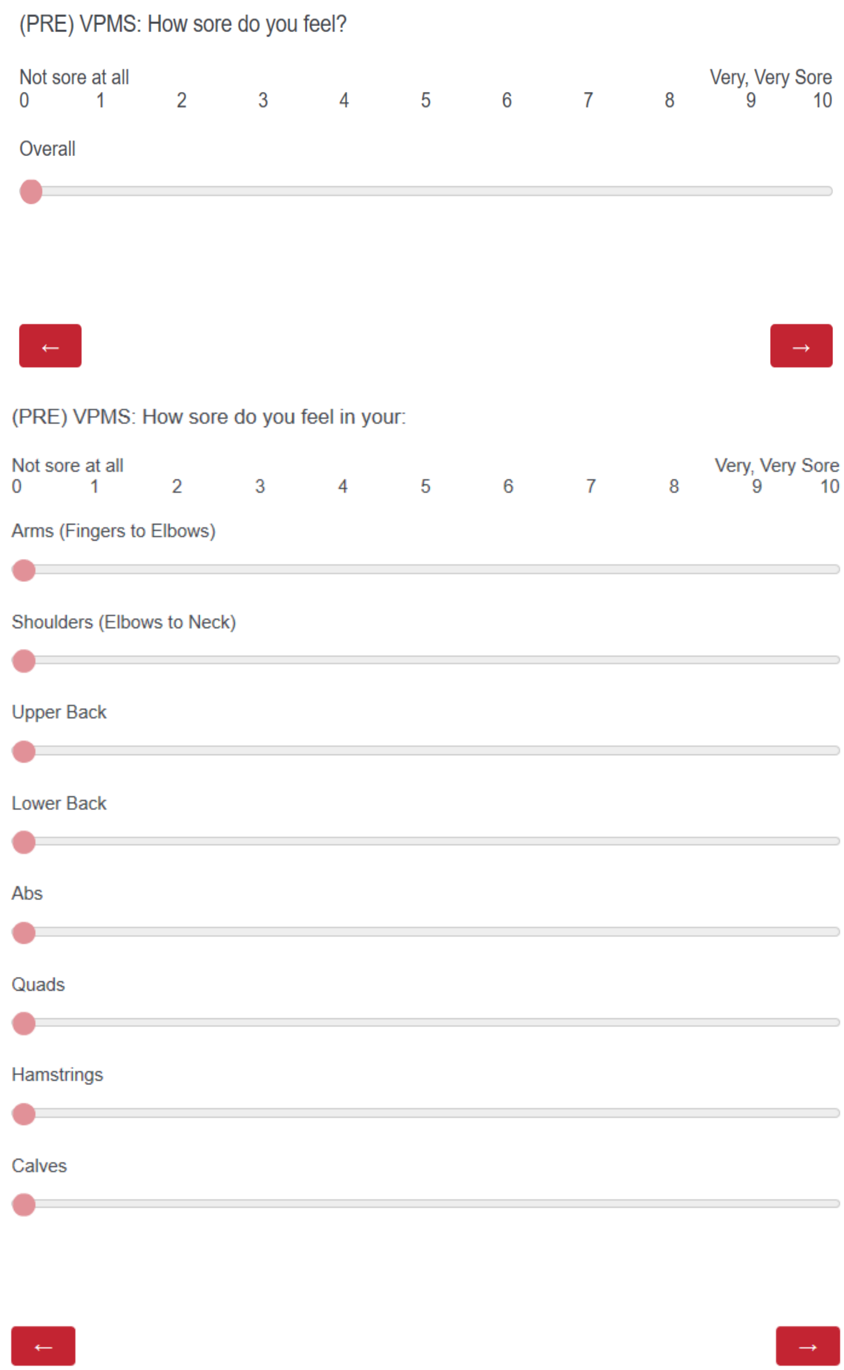


Figure 2: Visually Perceived Muscle Soreness (VPMS) Scale

Example of VPMS Scale format used for study design. (PRE = Pre-exercise measures, Upper Back = 7th Cervical Vertebrae to 7th Thoracic Vertebrae; Lower Back = 8th Thoracic Vertebrae to 5th Lumbar Vertebrae; Abs = Abdominals; Quads = Quadriceps).

Upon completion of the warm-up procedure, the participants were escorted to the specified starting position for the exercise portion of the protocol. The exercise portion of the protocol included five sets of two 20-meter walks while either carrying (FWC) or not carrying (NWC) additional weight; see *Table 2*. During the FWC protocol, weight (70%1RM) was supplied via similar HHB and rubberized Olympic weights used during the 1-RM HHBD testing procedure. The participants were required to use proper form during the testing protocol and were instructed to finish each FWC repetition as quickly as possible. When completing the NWC, the participants were instructed to maintain a consistent leisurely self-reported walking pace. At the completion of each set's initial repetition (20-m walk) the participant was sat down in a chair adjacent to each finish line and thirty seconds of rest was provided. At the conclusion of each set (two 20-m walks), the participant was instructed to sit down and was given two minutes of rest before the next exercise bout was initiated.

Immediately after the completion of the final exercise bout (the last [10^{th}] 20-m walk), the participant was escorted back to the EPL (IH 146), and two 7-ml blood samples along with VPMS scores were collected. Finally, the participant was required to remain in the EPL (IH 146) for further data was collected from participants thirty-minutes post-exercise (blood draw only) and again at sixty-minutes post-exercise (blood draw and VPMS).

An Authorware program (Macromedia, 1999) was programmed to maintain consistency in data collection timing for both exercise testing sessions. Following the completion of the last blood collection, the participant was provided information regarding care of the venipuncture sites and then allowed to depart. This completed the conduction of the FWC and NWC testing sessions. The two testing conditions were conducted within thirteen days of each other (sessions 2 and 3), and more than four days after Session One (1).

Table 2: Data Collection Protocol for the Exercise Portion of FWC and NWC.

Time	Event	Measures Collected
Session 2		
-45 min	Arrival at lab; procedure explanation	Compliance check; affirm client's understanding of procedures
-35 min	Psychometric evaluation	VPMS
-30 min	PRE (BD1)	Blood
-5 min	Dynamic Warm-Up	Prepare body for exercise
0 min	Begin Exercise (20-meter walk)	
0:30 min	30 sec rest	
1:00 min	Exercise (20-meter walk)	
1:30 min	120 sec rest	
3:30 min	Exercise (20-meter walk)	
4:00 min	30 sec rest	
4:30 min	Exercise (20-meter walk)	
5 min	120 sec rest	
5:30 min	Exercise (20-meter walk)	
6 min	30 sec rest	
6:30 min	Exercise (20-meter walk)	
8 min	120 sec rest	
10:00 min	Exercise (20-meter walk)	
10:30 min	30 sec rest	
11:00 min	Exercise (20-meter walk)	
11:30 min	120 sec rest	
13:30 min	Exercise (20-meter walk)	
14 min	30 sec rest	
14:30 min	Exercise (20-meter walk)	
15 min	IP (BD2)	Blood; VPMS
45 min	R30 (BD3)	Blood
75 min	R60 (BD4)	Blood; VPMS

VPMS = Visually Perceived Muscle Soreness; PRE = Pre-exercise measurement; BD1 = Blood draw one; IP = Immediately Post; BD2 = Blood draw two; R30 = 30-minutes post-exercise; BD3 = Blood draw three; R60 = 60-minutes post-exercise; BD4 = Blood draw four.

Session 2/3 Recovery: 24-, 48-, and 72-hours Post-exercise

Subsequent to the FWC and NWC sessions, VPMS scores, a venipuncture blood draw of two 7-ml tubes of blood, and measurements of CMJ height were collected at 24-hours, 48-hours, and 72-hours (R24h, R48h, R72h) post-completion time of the exercise protocol. For these testing sessions, participants arrived at the EPL (IH 146) at the designated time (recorded time of completion of exercise protocol for each respective condition; ~07:20AM) and were escorted inside by a member of the research team. Venipuncture blood samples were collected as previously described and once blood collection had concluded, the participants performed their CMJ assessment. Upon completion of the testing protocol, the participant was allowed to depart. *Table 3* has been provided to outline a mock protocol for a sample participant within this study design.

Table 3: Sample Protocol

Week (#)	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1	Session 1				
Week 2	FWC	FWC(R24h)	FWC(R48h)	FWC(R72h)	
Week 3	*RECOVERY / WASH-OUT WEEK*				
Week 4	NWC	NWC(R24h)	NWC(R48h)	NWC(R72h)	

FWC = Farmers Walk Condition; R24h = 24-hours post-exercise; R48h = 48-hours post-exercise; R72h = 72-hours post-exercise; NWC = Non-Weighted Condition.

Instrumentation

Farmers Walk Condition (FWC) Exercise

For the FWC exercise, a forty-five-pound HHB (Rogue Fitness, Columbus, OH) was provided with each participant's 70%1RM loaded weight via rubberized Olympic bumper plates (Fringe Sport, Austin, TX; Body-Solid, Forest Park, IL). In the event 70%1RM was not attainable with the weights provided (i.e., calculated load not ending in a 5 or 0), the weight was rounded-up to the next available weight (*Figure 3*). This exercise was conducted within a marked off area consisting of 20-meters on the turf-like surface of the BML (IH 142). Additionally, a 5-yard area was marked off directly past each ending point of the 20-meter lane to provide a breakdown zone as participants were expected to complete each repetition of the FWC at maximum speed. The lane used during the exercise bout was clearly marked for each participant to efficiently use during their participation.

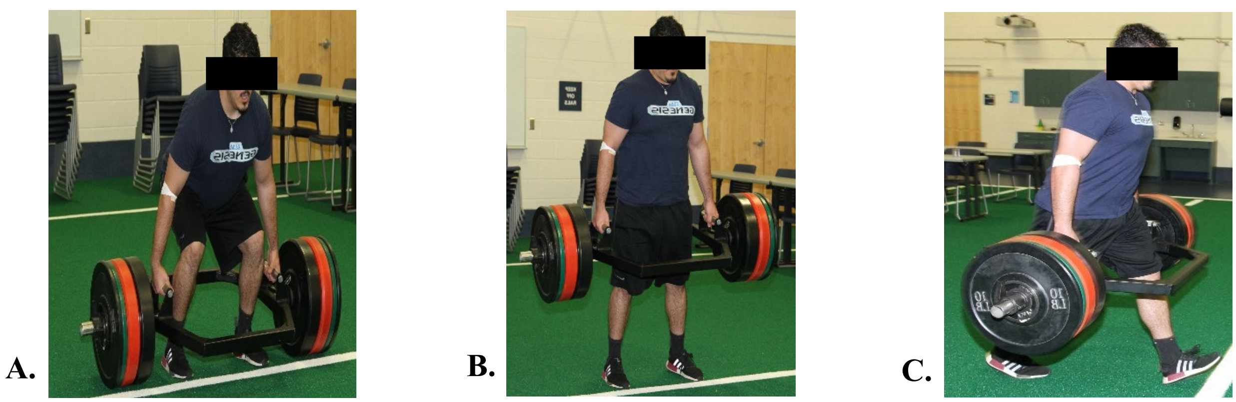


Figure 3: Visual of FWC Completion.
A. Participant initiated 'ready position'. **B.** Participant lifted HHB into an upright position**. C.** Participant crossed 20-meter distance as quickly as possible.

Upon completion of each repetition, the participant was instructed to drop the HHB from an erect position and sit in the provided chair adjacent to their lane to begin their rest interval. During this time, a research team member would assist with returning the HHB to the starting line for the following repetition. Time for each completed repetition was tracked via stopwatch. Time for each repetition was begun at any initiation of movement in a forward direction after the participant had performed a proper deadlift motion and was standing in an erect position. These parameters were set to allow for proper comparison of locomotion patterns between the two conditions (FWC and NWC). Stopping time for each repetition was when any body part of the participant had successfully crossed the 20-meter lane line. Furthermore, timing during the testing sessions was maintained through use of an automated Authorware program (Macromedia, 1999) which was specifically written to maintain consistency in data collection timing during each exercise testing session.

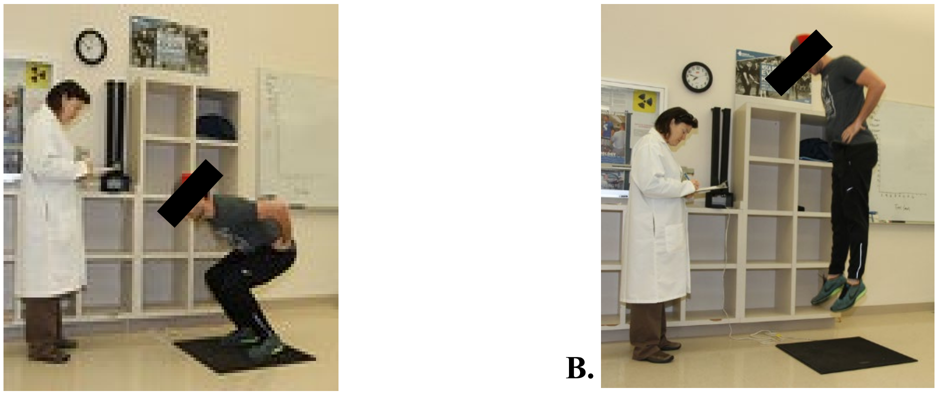
Countermovement Jump (CMJ) Height Technology

The Just Jump System (Probiotics, Huntsville, AL) was utilized to measure the participant's force production ability relative to the FWC and NWC (*Figure 4*). This apparatus provided a sixty-eight square centimeter mat area attached to a hand-held computer. Microswitches embedded within the mat are used to calculate jump height by measuring the interval of time between liftoff of the individual's feet from the mat to return of pressure to the mat (Isaacs, 1998; McMahon, Jones, & Comfort, 2016). This device used a basic kinematic equation to calculate an individual's jump height by flight time.

$$JH = (FT^2 \times g)/8 \qquad \text{(Eq 1)}$$

Where JH = jump height, FT = flight time, and g = gravity (i.e., 9.81 m/s^2) (McMahon, et al., 2016).

CMJ measurements were used to indirectly assess the amount of neuromuscular damage resulting from the NWC and FWC protocols by comparing jump heights attained during baseline testing to those collected during the recovery sessions (R24h, R48h, R72h) of each protocol. These assessments directly measured force production of the lower limbs, specifically the quadriceps, hamstrings, and gluteals, with no upper body momentum available due to the jumps completed in akimbo.



A. B.

Figure 4: Visual of CMJ Completion.
A. Participant will initiate countermovement jump (CMJ) with hands akimbo (on hips). **B.** Participant will jump vertically with hands on hips and land directly on mat below.

For performance of the CMJ, the participant stood on the mat with feet shoulder-width apart and hands placed on their hips (arms akimbo). From this position the participant was allowed to perform a countermovement jump (bend knees without the use of any arm movement) into liftoff, to solely focus on power production from the lower limbs (*Figure 4*). The take-off performance of each vertical jump attempt was evaluated to ensure extension of the legs and hips occurred until there was recontact with the mat. If any flexion of the knees or hips was noted prior to landing, the test was invalidated, and the participant was asked to perform another jump attempt after proper recovery was allotted. Any flexion-based movements of these limbs would directly affect the air time of the participant causing unintended inflation resulting in an overestimated jump height (Isaacs, 1998).

Leard, et al. (2007) found the Just Jump System provided a valid measurement for jump height due to similarities (0.438 ± 0.094 m vs 0.442 ± 0.103 m; $P = 0.972$) and high associations with ($r = 0.967$; $P < 0.01$) jump-height values derived from a 3-camera motion-capture system, the gold-standard method for jump height attainment. The comparison of the 3-camera motion-capture system to the Just Jump System was completed by quantifying the jump height of the individual through the location of a reflective marker placed on their sacrum used for recording by the motion-capturing system. The jump height was then analyzed by calculating the difference between the initial height of the marker, taken while the individual stood before take-off, and the height of the reflective marker at the highest peak during flight. Additionally, McMahon, et al. (2016) determined the Just Jump System was reliable when compared to a force-platform when measuring CMJ height. An excellent within-session reliability was documented regarding countermovement jumps performed between the Just Jump System and a force platform with a comparable ICC value of 0.96 ($P < 0.001$) and CV values of 3.7% (Just Jump System) and 4.7% (force platform).

Blood Sampling and Analysis

A total of 14-ml of blood were sampled at each blood draw conducted. When completing the blood draw portion of the study design participants sat either on an examination table (if completing the exercise protocol of the study design) or in a seat at a supplementary table (if present for recovery sessions [R24h, R48h, R72h]). A venipuncture was performed in the antecubital region of the arm by a designated, trained individual, using standard venipuncture protocols (see *Appendix 8*). Direct pressure was applied to the venipuncture site after removal of the hypodermic needle, and after the site was checked to ensure bleeding and/or oozing had ceased. An adhesive bandage was placed over the venipuncture site and secured with self-adhesive flexible tape. Blood was drawn at the following time intervals during the testing portion of Sessions two (2) and three (3): 30-minutes prior to the start of the exercise (PRE), immediately at the completion of exercise (IP), as well as 30- (R30) and 60-minutes (R60) post exercise. Additionally, blood draws occurred at 24-hours (R24h), 48-hours (R48h), and 72-hours (R72h) post-exercise completion during the recovery portion of Sessions two (2) and three (3). The participant was discouraged from reading or interacting with any materials besides those associated with the testing procedures, they were also prevented from falling asleep or leaving the laboratory once testing had begun. For each of these seven time points, CK and Mb were measured.

Blood was drawn into a Serum Separator Tube (SST) which contained a polymer gel and powdered glass clot activator vacutainer. Upon completion of collection, SST blood samples were immediately centrifuged at 4500 revolutions per minute (rpm) once initial hematocrit and hemoglobin assessment had been completed. After, plasma samples were pipetted into cuvettes systematically stored at -80^{0}C for future analysis. Both CK (creatine kinase) and Mb (myoglobin) analysis samples were allowed to clot at room temperature or overnight at 4^{0}C before analysis in duplicate for both CK and Mb. The supernatant was collected for assaying immediately upon preparation. Both CK and Mb samples were measured using a TMB (3,3',5,5'-tetramethylbenzidine) Substrate solution assay (ELISA) (ALPCO, Salem, NH, USA) using an iMark Bio-Rad microplate absorbance reader (Life Science Research, Hercules, California, USA). CK-MB mass was measured by sandwich-type ELISA immunoassay which used anti-CK-MB and anti-CK-MM monoclonal antibodies (Fenton, Brunstetter, Gordon, Rippe, & Bell, 1984). The interassay coefficient of variation for CK was 5.26% and the intraassay coefficient of variation was 7.69%. The standard curve for the range of 0 to 200 ng/ml had a correlation coefficient of $r = 0.97$. The interassay coefficient of variation for Mb was 5.38% and the intraassay coefficient of variation was 8.06%. The standard curve for the range of 0 to 1000 ng/ml had a correlation coefficient of $r = 0.97$.

Design and Statistics

Statistical analysis was performed using GraphPad Prism (version 4.00 for Windows; GraphPad Software, San Diego, CA, USA, www.graphpad.com) with a significance set a priori at $p \leq 0.05$ with 95% confidence intervals for estimation of subject mean difference. Data was presented within the results as mean ± SEM. Repeated measures analysis of variance (RMANOVA) was used to evaluate changes in all variables measured during this study design. Biomarkers creatine kinase (CK) and myoglobin (Mb) were used for the analysis of biochemical muscle damage and measured with a 2 (condition) by 7 (time) repeated measures ANOVA (RMANOVA). Subjective muscle damage measurements were assessed via Visually Perceived Muscle Soreness (VPMS), a measure of soreness within specific muscles identified by the research team which were self-reported by the participants and measured with a 2 (condition) by 6 (time) repeated measures ANOVA (RMANOVA) during the protocol. Average CMJ performance was used to measure neuromuscular assessment measured with a 2 (condition) by 4 (time) repeated measures ANOVA (RMONAVA). These variables were used to examine the differences in the amount of neuromuscular and muscle damage sustained by the subject while participating in the Farmers Walk Condition (FWC) with α-level set at $p \leq 0.05$, and a priori set at 0.80. Significant interactions were further analyzed utilizing one-way ANOVA and paired t-tests when necessary.

CHAPTER IV

Results

This chapter presents the results of the statistical analyses conducted on the data collected for this investigation. Analyses regarding neuromuscular responses were presented followed by measurements used to investigate the occurrence of muscle damage through objective and subjective measurements regarding the conditions implemented during the study design.

Demographics

Fifteen college-aged individuals volunteered to complete the exercise protocol associated with this study design. This sample population included eleven males and four females who self-identified among various ethnic backgrounds (Caucasian [7], African American [4], Hispanic [3], Other [1]). Additional demographic data for the subjects is listed in *Table 4*. Each subject participated in both the FWC and NWC during this study design. Conditions were randomized and counterbalanced to ensure no order-effect occurred from one condition onto the other. Eight individuals initially performed the FWC and seven individuals began with the NWC. No order effects were seen for any of the proceeding variables.

Table 4: Participant Demographic Characteristics.

Variable	**Mean ± SEM**
Age (years)	21.60 ± 0.45
Height (cm)	172.53 ± 2.34
Weight (kg)	81.80 ± 4.01
Percent Body Fat (%)	28.80 ± 2.10
Lean Body Mass (kg)	55.23 ± 2.77

Training Status

Training status was self-reported by the participants via Health History Questionnaire (HHQ) and Physical Activity Questionnaire (PAQ) during the initial session of the study (Session 1) (see *Appendix 4 and Appendix 5*). Of the fifteen individuals within our sample, ten individuals were classified as trained and five classified as untrained. A trained subject was defined as an individual who participated in physical activity at a regular frequency of at least two to three times per week (Garber, et al., 2011). The type of training was also taken into consideration with anaerobically-based resistance training taking precedence due to the nature of the FWC. Additionally, participants who self-reported the completion of daily tasks requiring the ability to lift and carry objects considered to be 50% or more of their body weight were classified as trained in regards to the FWC. Additional training characteristics can be found in *Table 5*.

Table 5: Participant Training Demographics.

Variable	**Mean ± SEM**
Absolute 1RM (kg)	121.24 ± 9.42
Relative 1RM (LBM – kg)	2.17 ± 0.09
Calculated 70%1RM (kg)	84.87 ± 6.59
Actual 70%1RM (kg)	85.15 ± 6.60

Comparison of Weight Carried and Walk Time Between Conditions

A paired-samples t-test was conducted to compare the calculated 70%1RM and actual 70%1RM load carried during the FWC. There was not a significant difference ($t[14] = 1.46$, $p > 0.05$) in weight calculated (84.87 ± 25.54kg) versus weight carried (85.15 ± 25.55kg) during the FWC. A paired-samples t-test was conducted to compare the time to complete each repetition of the walk in the FWC and NWC. A significant difference ($t[14] = 6.96$, $p < 0.0001$) was found between the two conditions, with participants completing the FWC (10.24 ± 0.78 sec) at a much faster pace than the NWC (16.70 ± 0.77 sec).

Neuromuscular Response Analysis

Countermovement Jump (CMJ) Height

A 2 x 4 (condition x time) repeated-measures ANOVA (RMANOVA) for CMJ height was conducted to compare the neuromuscular performance between exercise conditions over the four specific data time points collected (Baseline, R24h, R48h, and R72h). There was no significant interaction effect for CMJ ($F[3, 28] = 0.41$, $p = 0.47$), or main effect for condition ($F[1, 28] = 0.02$, $p = 0.18$). However, a main effect for time ($F[3, 28] = 2.99$, $p = 0.04$) was demonstrated, with CMJ decreasing in both conditions (FWC and NWC) compared to baseline measurements as seen in *Figure 5*.

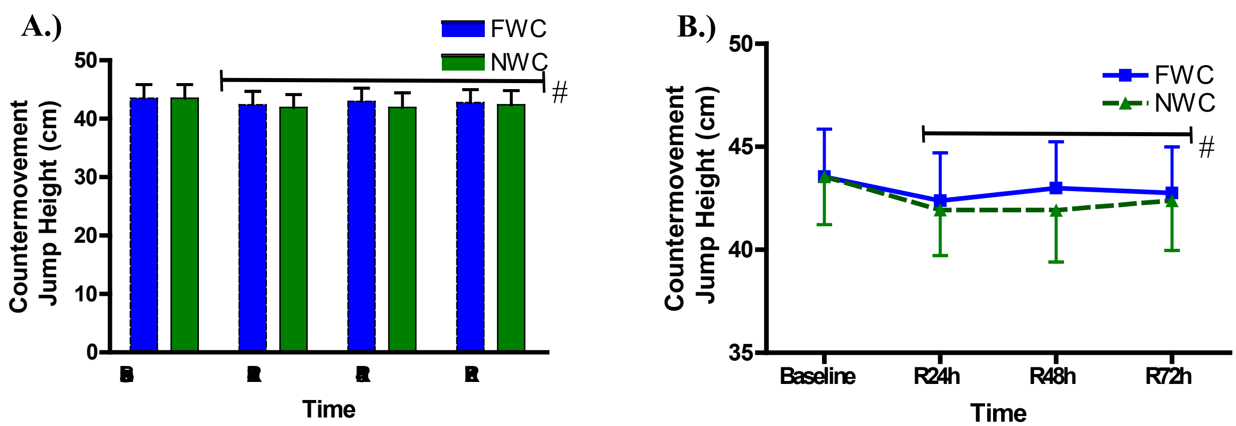


Figure 5. CMJ height in the FWC and NWC recovery portion of the protocol. No significant interaction effects ($p = 0.47$) or main effects for condition ($p = 0.18$) were present. However, significant differences were found across time, showing a significant decrease across all time points from baseline measurements (# $p = 0.04$). **A.)** Bars represent the height of vertical jumps performed at four specific time points after the completion of exercise. Vertical lines represent errors within the samples collected and analyzed. **B.)** Points represent the height of vertical jumps during each protocol performed at four specific time points after the completion of exercise. Vertical lines represent errors within the samples collected and analyzed.

Objective Muscle Damage Analysis

A 2 x 7 RMANOVA was conducted for creatine kinase (CK) and myoglobin (Mb) at seven specific time points (Pre, IP, R30, R60, R24h, R48h, and R72h). Results for both CK and Mb were standardized from baseline and by lean body mass (kg) for analysis via RMANOVA and from baseline for Area Under the Curve (AUC) interpretation. Interpolation and extrapolation were conducted for missing data points during analysis. Additionally, outliers were identified by the research team during analysis and removed if not within two standard deviations of the mean due to their lack of representation of the overall sample.

Creatine Kinase (CK) Response

CK measurements revealed a significant interaction effect (F[6,28] = 2.29, p = 0.04) and main effect for condition (F[1,28] = 3.05, p = 0.05) but not for time (F[6,28] = 2.89, p = 0.22). Further analysis via t-test for AUC (t[6] = 2.64, P = 0.04) showed a significant difference between conditions with concentrations of NWC (5.87 ± 0.12 ng/ml*Time) demonstrated as significantly greater than FWC (5.35 ± 0.11 ng/ml*Time). Additionally, analysis via t-test demonstrated significantly greater NWC concentrations at R30 (t[14] = 2.45, p = 0.03), R24h (t[14] = 2.57, p = 0.02), and R72h (t[14] = 2.29, p = 0.04) when compared to FWC concentrations as seen in *Figure 6*.

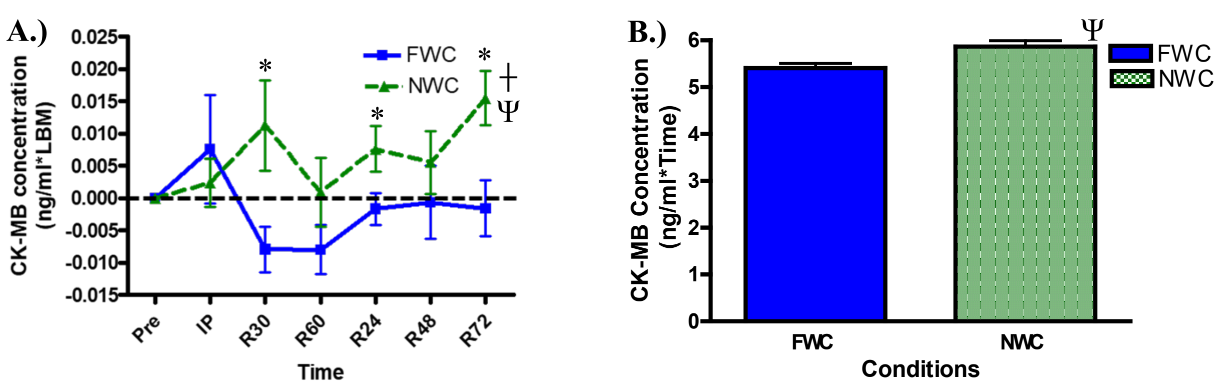


Figure 6. Creatine Kinase (CK-MB) concentration accumulation during the FWC and NWC. **A.)** Amount of CK-MB provided significant interaction effects (┼ p = 0.038) and overall differences between each examined condition (Ψ p = 0.046) in favor of NWC with no significant differences seen across time (p = 0.22). Significant differences between conditions were demonstrated at time points R30 (* p = 0.03), R24h (* p = 0.02), and R72h (* p = 0.04). Points represent the reported accumulation during the protocol with concentrations standardized by lean body mass (LBM) and as a difference from baseline. Vertical lines represent errors within the samples collected and analyzed. **B.)** AUC analysis for CK-MB accumulation standardized from baseline between the FWC and NWC conditions. A significant difference (Ψ p = 0.04) was noted between the two conditions. Bars represent the amount of concentration present throughout the completion of the protocol between the two conditions. Vertical lines represent errors within the samples collected and analyzed.

Myoglobin (Mb) Response

Measurements for Mb showed no significant interaction effects ($F[6,28] = 1.09$, $p = 0.37$), main effects for time ($F[6,28] = 1.47$, $p = 0.19$) or condition ($F[6,28] = 3.53$, $p = 0.07$) as seen in *Figure 7*.

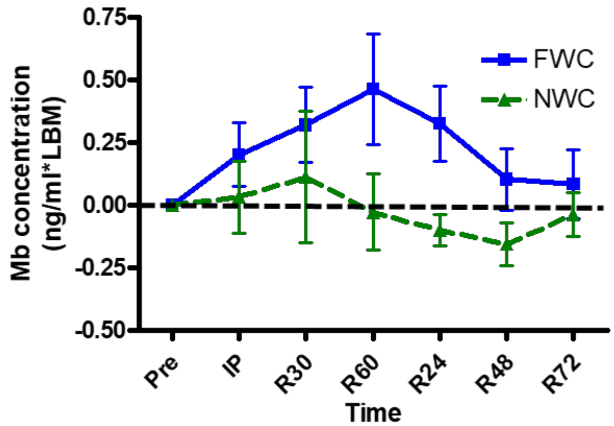


Figure 7. Myoglobin (Mb) concentration accumulation during the FWC and NWC. Amount of Mb did not provide significant interaction effects ($p = 0.37$) nor main effects for time ($p = 0.19$) or condition ($p = 0.07$). Points represent the reported accumulation during the protocol with concentrations standardized by lean body mass (LBM) and as a difference from baseline. Vertical lines represent errors within the samples collected and analyzed.

Subjective Muscle Damage Analysis

A 2 x 6 RMANOVA was conducted for VPMS (Overall [OA], Shoulders [Shldrs], Arms [Arms], Upper Back [UB], Lower Back [LB], Quadriceps [Quads], Hamstrings [HS], Abdominals [Abs], and Calves [Calf]) measurements at six specific time points (Pre, IP, R60, R24h, R48h, and R72h).

VPMS – Overall (OA) Score

Self-reported VPMS responses for Overall (OA) revealed significant interaction effects ($F[5,28] = 8.46$, $p < 0.001$) and main effects for time ($F[5,28] = 9.71$, $p < 0.001$) and condition ($F[1,28] = 13.94$, $p < 0.001$). Additionally, analysis via t-test revealed significantly greater VPMS scores during the FWC at IP ($t[14] = 2.75$, $p = 0.02$), R60 ($t[14] = 5.49$, $p < 0.001$), R24h ($t[14] = 5.61$, $p < 0.001$), R48h ($t[14] = 4.63$, $p < 0.001$), and R72h ($t[14] = 3.68$, $p < 0.01$) when compared to NWC VPMS scores as seen in *Figure 8*.

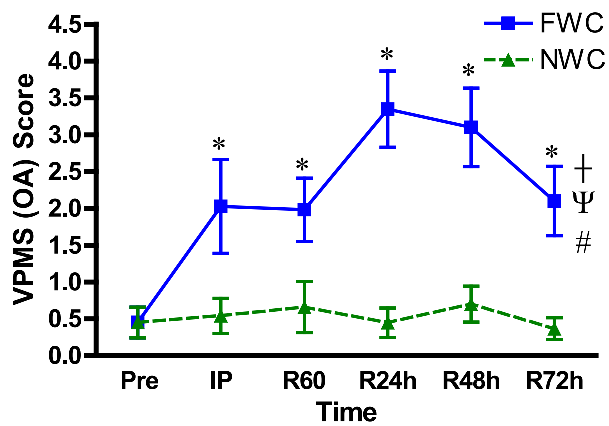


Figure 8. VPMS – Overall (OA) score during the FWC and NWC. Significant interaction effects (┼ $p < 0.001$) along with differences between conditions (Ψ $p < 0.001$) and over time (# $p < 0.001$) were present. Significant differences between conditions demonstrated at time points IP (* $p = 0.02$), R60 (* $p < 0.001$), R24h (* $p < 0.001$), R48h (* $p < 0.001$), and R72h (* $p < 0.01$). Points represent the score reported by participants during the protocol over six specific time points. Vertical lines represent errors within the samples collected and analyzed.

VPMS – Arms (Arms) Score

Self-reported VPMS responses for Arms (Arms) demonstrated significant interaction effects ($F[5,28] = 4.21$, $p < 0.01$) and main effects for time ($F[5,28] = 6.56$, $p < 0.0001$) and condition ($F[1,28] = 9.50$, $p < 0.01$). Additionally, analysis via t-test revealed significantly greater VPMS scores during the FWC at R60 ($t[14] = 2.85$, $p = 0.01$), R24h ($t[14] = 2.99$, $p < 0.01$), R48h ($t[14] = 3.49$, $p < 0.01$), and R72h ($t[14] = 2.83$, $p = 0.01$) when compared to NWC VPMS scores as seen in *Figure 9*.

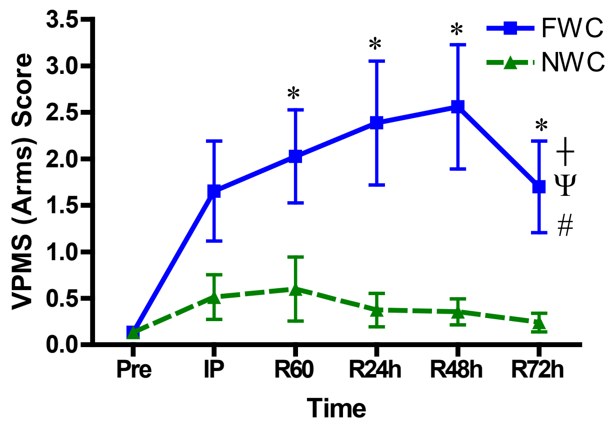


Figure 9. VPMS – Arms score during the FWC and NWC. Significant interaction effects (┼ $p = 0.001$) along with differences between conditions (Ψ $p = 0.005$) and over time (# $p < 0.0001$) were present. Significant differences between conditions demonstrated at time points R60 (* $p = 0.01$), R24h (* $p < 0.01$), R48h (* $p < 0.01$), and R72h (* $p = 0.01$). Points represent the score reported by participants during the protocol over six specific time points. Vertical lines represent errors within the samples collected and analyzed.

VPMS – Shoulders (Shldrs) Score

Self-reported VPMS responses for Shoulders (Shldrs) revealed significant interaction effects ($F[5,28] = 10.00$, $p < 0.0001$) and main effects for time ($F[5,28] = 12.45$, $p < 0.0001$) and condition ($F[1,28] = 13.06$, $p < 0.01$). Additionally, analysis via t-test revealed significantly greater VPMS scores during the FWC at IP ($t[14] = 2.53$, $p = 0.04$), R60 ($t[14] = 2.33$, $p = 0.04$), R24h ($t[14] = 4.32$, $p < 0.001$), R48h ($t[14] = 4.46$, $p < 0.001$), and R72h ($t[14] = 3.32$, $p < 0.01$) when compared to NWC VPMS scores as seen in *Figure 10*.

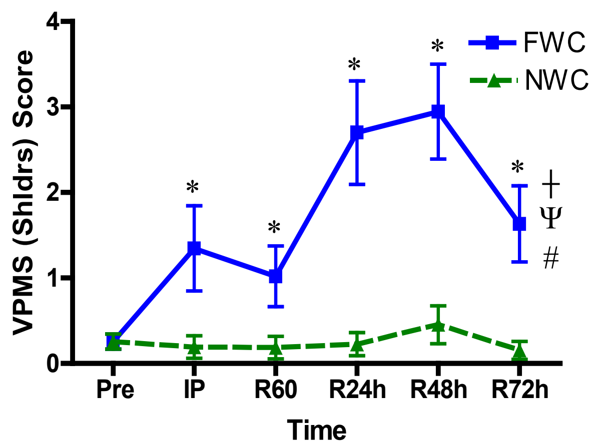


Figure 10. VPMS – Shoulders (Shldrs) score during the FWC and NWC. Significant interaction effects (┼ $p < 0.0001$) along with differences between conditions (Ψ $p = 0.001$) and over time (# $p < 0.0001$) were present. Significant differences between conditions demonstrated at time points IP (* $p = 0.04$), R60 (* $p = 0.04$), R24h (* $p < 0.001$), R48h (* $p < 0.001$), and R72h (* $p < 0.01$). Points represent the score reported by participants during the protocol over six specific time points. Vertical lines represent errors within the samples collected and analyzed.

VPMS – Upper Back (UB) Score

Self-reported VPMS responses for Upper Back (UB) determined there were significant interaction effects ($F[5,28] = 5.73$, $p < 0.0001$) and main effects for time ($F[5,28] = 8.10$, $p < 0.0001$) and condition ($F[1,28] = 4.89$, $p < 0.01$). Additionally, analysis via t-test revealed significantly greater VPMS scores during the FWC at R24h ($t[14] = 3.12$, $p < 0.01$) and R48h ($t[14] = 2.34$, $p = 0.03$) when compared to NWC VPMS scores as seen in *Figure 11*.

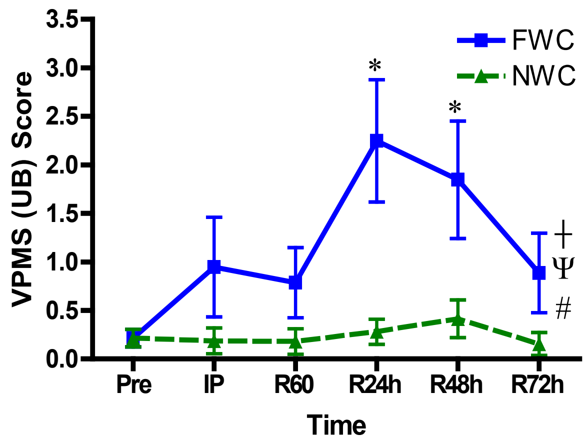


Figure 11. VPMS – Upper Back (UB) score during the FWC and NWC. Significant interaction effects (┼ $p < 0.0001$) along with differences between conditions (Ψ $p < 0.01$) and over time (# $p < 0.0001$) were present. Significant differences between conditions demonstrated at time points R24h (* $p < 0.01$) and R48h (* $p = 0.03$). Points represent the score reported by participants during the protocol over six specific time points. Vertical lines represent errors within the samples collected and analyzed.

VPMS – Lower Back (LB) Score

Self-reported VPMS responses for Lower Back (LB) demonstrated no significant interaction effects ($F[5,28] = 0.77$, $p = 0.58$) or main effects for condition ($F[1,28] = 0.49$, $p = 0.49$), however a significant main effect for time ($F[5,28] = 2.43$, $p = 0.04$) was found. Analysis via t-test demonstrated significantly greater VPMS scores during the FWC at R48h ($t[14] = 3.07$, $p < 0.01$) when compared to the NWC as seen in *Figure 12*.

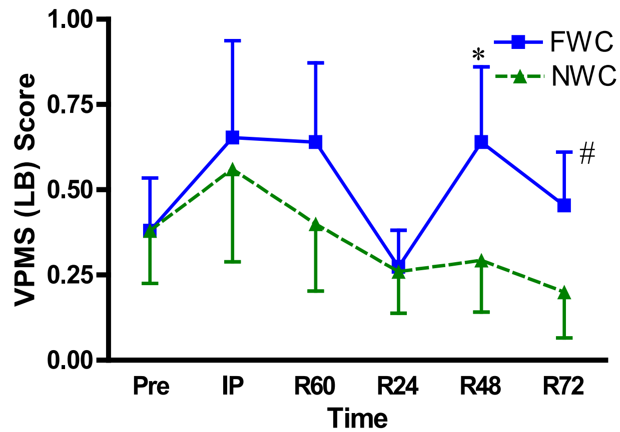


Figure 12. VPMS – Lower Back (LB) score during the FWC and NWC. No significant interaction effects ($p = 0.58$) or main effects between conditions ($p = 0.49$) were present. However, significant main effects across time (# $p = 0.04$) were found. Significant differences between conditions demonstrated at time point R48h (* $p < 0.01$). Points represent the score reported by participants during the protocol over six specific time points. Vertical lines represent errors within the samples collected and analyzed.

VPMS – Abdominals (Abs) Score

Self-reported VPMS responses for Abdominals (Abs) revealed no significant interaction effects (F[5,28] = 0.65, p = 0.67) or main effects for time (F[5,28] = 1.44, p = 0.21) or condition (F[1,28] = 0.82, p = 0.37) between the FWC and NWC as seen in *Figure 13*.

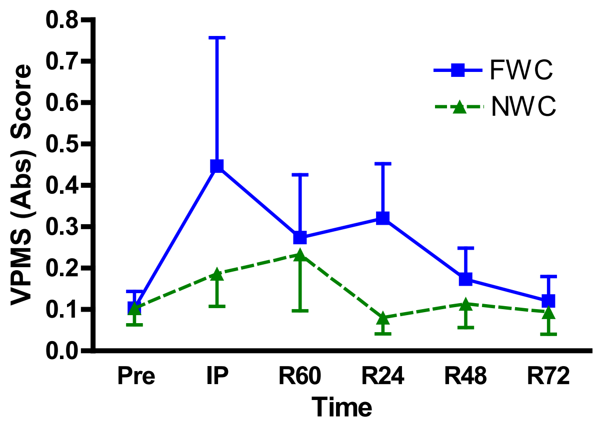


Figure 13. VPMS – Abdominals (Abs) score during the FWC and NWC. No significant interaction effects (p = 0.67) or main effects between conditions (p = 0.37) or across time (p = 0.21) were found. Points represent the score reported by participants during the protocol over six specific time points. Vertical lines represent errors within the samples collected and analyzed.

VPMS – Quadriceps (Quads) Score

Self-reported VPMS responses for Quadriceps (Quads) revealed no significant interaction effects ($F[5,28] = 0.65$, $p = 0.90$) or main effects for time ($F[5,28] = 1.42$, $p = 0.22$) or condition ($F[1,28] = 1.20$, $p = 0.28$) between the FWC and NWC as seen in *Figure 14*.

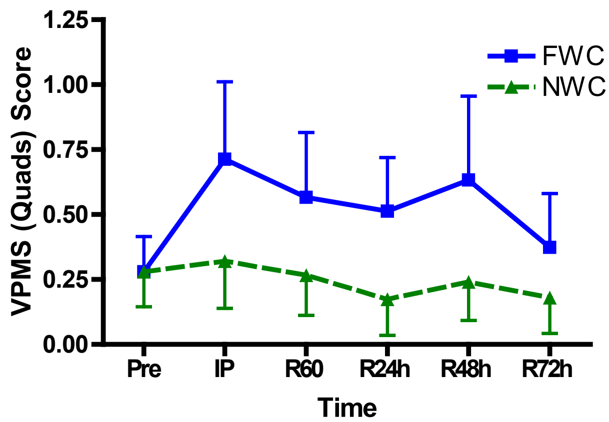


Figure 14. VPMS – Quadriceps (Quads) score during the FWC and NWC. No significant interaction effects ($p = 0.90$) or main effects between conditions ($p = 0.28$) or across time ($p = 0.22$) were found. Points represent the score reported by participants during the protocol over six specific time points. Vertical lines represent errors within the samples collected and analyzed.

VPMS – Hamstrings (HS) Score

Self-reported VPMS responses for Hamstrings (HS) determined there was no significant interaction effects ($F[5,28] = 1.22$, $p = 0.30$) or main effects for time ($F[5,28] = 1.88$, $p = 0.10$) or condition ($F[1,28] = 2.88$, $p = 0.10$) between the FWC and NWC as seen in *Figure 15*.

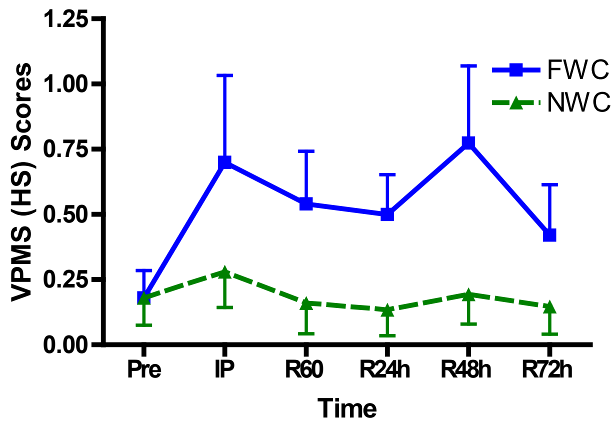


Figure 15. VPMS – Hamstrings (HS) score during the FWC and NWC. No significant interaction effects ($p = 0.30$) or main effects between conditions ($p = 0.10$) or across time ($p = 0.10$) were found. Points represent the score reported by participants during the protocol over six specific time points. Vertical lines represent errors within the samples collected and analyzed.

VPMS – Calves (Calf) Score

Self-reported VPMS responses for Calves (Calf) demonstrated no significant interaction effects ($F[5,28] = 1.39$, $p = 0.23$) or main effects for time ($F[5,28] = 1.62$, $p = 0.16$) or condition ($F[1,28] = 2.92$, $p = 0.10$) between the FWC and NWC as seen in *Figure 16*.

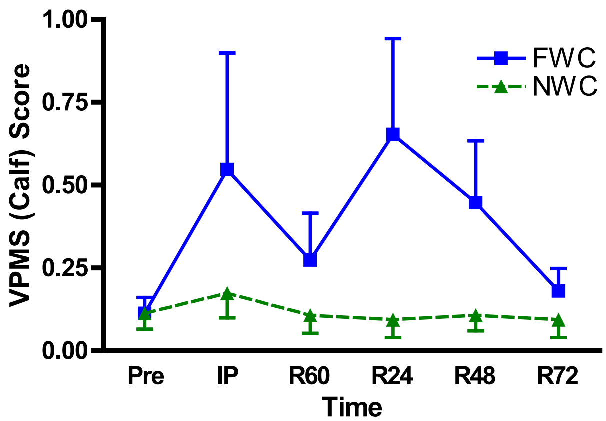


Figure 16. VPMS – Calves (Calf) score during the FWC and NWC. No significant interaction effects ($p = 0.23$) or main effects between conditions ($p = 0.10$) or across time ($p = 0.16$) were found. Points represent the score reported by participants during the protocol over six specific time points. Vertical lines represent errors within the samples collected and analyzed.

CHAPTER V

Discussion

This study was conducted to quantify the amount of muscle damage which occurred while performing a strongman training (ST) exercise such as the Farmers Walk (FWC). Measurements implemented included objective biochemical analysis of blood biomarkers creatine kinase (CK) and myoglobin (Mb), subjective analysis via survey-based perceived muscle soreness (VPMS), and neuromuscular responses measured by countermovement jump (CMJ) height attained. Previous literature concerning strongman practices have provided extensive overviews of the physiological, biomechanical, anthropometrical, and performance measures associated with their performance (McGill, et al., 2009; Winwood, et al., 2011; Winwood, et al., 2012; Keogh, et al., 2014; Winwood, et al., 2014a; Woulfe, et al., 2014). Among these studies, a handful have taken in-depth ventures into the biological factors associated with their performance (Ghigiarelli, et al., 2013; West, et al., 2014), and none of these have provided detailed analyses of biological responses present with the implementation of the FW specifically.

This study utilized a FW implemented with 70% of an individual's HHBD 1RM carried across 20-meters as fast as possible for ten repetitions with rest intervals varied between repetitions (30 seconds) and sets (2 minutes) completed. These specified parameters resulted in minimal muscle damage responses as CK demonstrated a decrease in concentration along with a non-significant increase in Mb during the recovery period post-FWC. Additionally, no neuromuscular deficiencies post-FWC were reported, with similar decreases in CMJ height from baseline measurements observed during both the FWC and NWC recovery periods. Visually Perceived Muscle Soreness (VPMS) measurements were determined to be significantly different with locations specific to the upper body, but minimal perceived impact occurring in the lower limbs. These results indicated no detrimental effects on performance and minimal detectable levels of muscle damage. Additionally, contradictory impacts on muscle damage may have occurred between the upper and lower body, which could possibly be the result of differences in duration of muscle recruitment and/or differences within the type of contraction utilized during the completion of the FWC.

H_1 and H_2: Objective Muscle Damage Analysis

Initial hypotheses regarding the biochemically-founded objective measurements of muscle damage suggested there would be increased concentrations of CK and Mb post-exercise completion in the FWC when compared to the NWC. However, the data suggested significantly ($p = 0.04$) decreased concentrations of CK were present during the post-FWC data collection when compared to both baseline measurements (PRE) and the control protocol (NWC). These findings occurred in five of the six post-exercise blood draws. The only CK concentration increase within the FWC seemed to occur during the immediate post (IP) blood draw when compared to baseline (PRE) measurements. The CK concentration then appeared to decrease and then plateau between 30- and 60-minutes post-FWC before returning back to baseline measurements (*Figure 6*). The decreases in CK concentrations did not match those seen for Mb as statistically non-significant increases were documented in Mb concentrations post-FWC ($p = 0.37$). The greater concentrations of Mb were noted in comparison to both baseline (PRE) measurements and Mb concentrations of the control protocol (NWC) at each of the post-exercise data collection time points. At sixty-minutes post-FWC there was a documented steady decrease in concentration of Mb towards baseline measurements for the duration of the recovery period

(*Figure 7*). Therefore, H_1 was not found to be tenable by these findings. Additionally, due to a lack in statistically significant increases in Mb concentration post-FWC, H_2 cannot be supported by the data collected in this study as well.

This was the first study to investigate the responses of muscle damage biomarkers such as CK and Mb with the performance of a functionally-based resistance exercise such as the FW. Previous studies performed with male soccer and rugby players had demonstrated mixed results regarding Mb and CK responses post-match (Thorpe & Sunderland, 2012; Twist, et al., 2013; Silva, et al., 2013). Furthermore, while increases in CK and Mb had been demonstrated after high intensity and longer duration activities (Gee, et al., 2011; Arazi & Asadi, 2013; Heavens, et al., 2014, Bartolemei, et al, 2017), this study used a 70% HHBD 1RM intensity and short duration (≤ 2 minutes total activity), thus suggesting an exercise such as the FW, performed at this level of intensity over the provided duration of time, did not significantly impact CK and Mb concentrations. Previous investigators had documented increased concentrations of both CK and Mb while utilizing exercise intensities ≥75%1RM, which were greater than the 70%1RM intensity used in this study. Brancaccio, et al. (2007) suggested a direct effect may be seen between exercise intensity and the amount of muscle permeability occurring with higher levels of intensity having a greater effect when compared to lower levels (mild to moderate). Thus, the lack in variation regarding CK and Mb concentrations after completing the FWC may possibly be attributed to a lack of loading intensity during the given exercise (70%1RM HHBD). Therefore, the exercise intensity provided may have ultimately failed to exceed the threshold needed to see an associated presence (rise) in muscle damage biomarkers during blood collection periods (Brancaccio, Maffulli, Buonauro, & Limongelli, 2008). Further research should be conducted to examine the biological responses associated with varying exercise intensities

(≥75%1RM). This information may assist future research and implementation when considering an exercise such as the FWC which can be performed at a variety of intensities within a generalized fitness environment.

Interestingly, one major difference from previous studies was the presence of isolated concentric contractions that occurred during the FWC protocol. Winwood et al. (2014a) demonstrated significant increases in stride rate and decreases in stride length and swing time when comparing the FWC to normal unweighted human locomotion ($p < 0.02$). The latter part of the swing phase has been associated with dominant muscular contractions of the knee flexors where eccentrically-based negative work may occur when the muscle is stretched to maximal capacity. This type of contraction could possibly result in an increased susceptibility to injury related to the magnitude of the fiber strain induced (Garrett, Safran, Seaber, Glisson, & Ribbeck, 1987; Winter & Yack, 1987; Lieber & Fridén, 1993; Lieber & Fridén, 2002). Eccentric contractions have been shown to cause more muscle damage when compared to concentric contractions with evidence of calcium buffering irregularities, myofibrillar disruption, and Z-disk damage in the sarcomeric structure (Clarkson & Hubal, 2002; Dieli-Conwright, et al., 2009).

The damage caused by eccentric contractions may result in different metabolic and mechanical demands compared to concentric contractions. These differences may alter the mechanisms of AMP-activated Protein Kinase (AMPK) control which could have an increased effect on muscle damage biomarker concentrations found within the blood (Baird, et al., 2012). The primary role of AMPK is to phosphorylate proteins while regulating the activity of enzymes in order to operate important reactions and pathways (Baird, et al., 2012). This role may relate to CK activity regulation and ATP use within the phosphocreatine system (Neumann, Schlattner, & Wallimann, 2003). Thus, when contractile disruption occurs during physical activity and reduction in ATP pools are observed, a protective reaction is implemented by AMPK where CK is eliminated from the cytosol to regulate metabolic and mechanical destruction while limiting its use of ATP for resynthesis within the phosphocreatine system (Saks, 2008). This phosphorylation mechanism would allow for ATP to be used for energy expenditure during exercise while other substrates, such as glucose, are pursued for ATP production within glycolysis (Baird, et al., 2012).

The nature of the FW has demonstrated the utilization of both lower-body concentric and eccentric contractions during its performance, with peak activation of the knee flexor occurring during the lifting portion and peak activation of the knee extensor occurring during the walking portion of the exercise (McGill, et al., 2009; Swinton, Stewart, Agouris, Keogh, & Lloyd, 2011). When completing the FWC exercise protocol, the walking and lifting phases were accomplished at relatively differing portions of each completed repetition. The walking portion occurred during the majority of the exercise compared to a relatively shorter lifting phase completed at the beginning of each repetition. Additionally, there was no lowering phase implemented in this protocol as participants were instructed to drop the weights from an erect position at the completion of each repetition. Due to the nature of the FWC regarding the proportional differences between each phase of the exercise and its associated contractions, concentric contractions primarily dominated the musculature of the lower limbs. Therefore, a reduction of eccentric contractions during the FWC exercise due to decreases in the swing phase completed and a difference in exercise proportion between the walking and lifting phases, may provide an explanation for the significant decreases in CK response between conditions.

Comparatively, the upper body musculature was required to perform isometric contractions to stabilize the torso during both the lifting and locomotion portion of the FWC.

Research has reported similar increases in muscle damage biomarkers observed between isometric and eccentric contractions, accompanied by muscle damage persisting as delayed muscle soreness over a period of recovery days post-exercise (Clarkson, Byrnes, McCormick, Turcotte, & White, 1986; Philippou, Maridaki, & Bogdanis, 2003; Philippou, Bogdanis, Nevill, & Maridaki, 2004). Regardless of the lower proportion of skeletal muscle mass found within the upper body (Men: 42.9%; Women: 39.7%) compared to the lower body (Janssenn, Heymsfield, Wang, & Ross, 2000), greater increases in muscle damage biomarkers were revealed following the completion of isotonic exercise specific to the upper body compared to the lower body (Koch, Machado, & Mayhew, 2015). The disparities between upper and lower body muscle damage markers may be based on factors such as differences in musculoskeletal architecture, amount of mechanical stress per muscle unit, vascularity, and training status (Lieber & Fridén, 2000; Eiken & Kölegård, 2004; Jamurtas, et al., 2005; Saka, et al., 2009; Chen, Lin, Chen, Lin, & Nosaka, 2011). Furthermore, McGill, et al. (2009) documented a higher proportion of muscle activation within the upper torso compared to the lower body during all phases of the FW. Due to this increased muscle recruitment sustained throughout the exercise, it may be possible that the primary muscle damage response specific to the FWC was centralized within the upper body musculature. Comparable contractions and muscle damage responses were seen with the implementation of a backward sled drag using a similar prescription of distance and rest intervals, while pulling weight calculated to be 75% of the individual's body mass (West, et al., 2014), which provides further support for the lack of observed muscle damage responses obtained post-exercise for the FWC.

A final consideration for these biochemical results would be the direct influence on the metabolic responses to resistance exercise by the alterations of acute training variables such as duration and rest intervals (Toigo & Boutellier, 2006; ACSM, 2009). Rest intervals between sets of resistance exercise could be an overlooked variable effecting the resulting CK concentration (Mangine, et al., 2015). Mayhew, Thyfault, and Koch (2005) found significant ($p = 0.022$) increases in serum CK with shorter rest intervals (1-minute) in comparison to longer ones (3-minutes). However, when identifying the response of Mb to differentiated rest intervals, no significant differences occurred ($p > 0.05$) (Masuda, Choi, Shimojo, & Katsuta, 1999). The current study design utilized rest intervals of thirty seconds at the completion of each repetition with a two-minute rest interval after the completion of each set, mimicking the protocol utilized by West et al. (2014). The data collected from this study indicated significant decreases in CK concentration while the West et al. (2014) protocol did not. Factors such as differing intensity loads and/or other external factors, such as the presence of friction, may account for the variation in results.

Effects of the duration of exercise, due to factors such as pace of movement, should also be considered to explain the differences in CK accumulations post-exercise. Previous investigators have reported differences in pacing instructions during loaded carries which have led to variations in physiological responses reported from the exercises completed (Knapik, et al., 1991; Ainslie, et al., 2003; Fallowfield, Blacker, Willems, Davey, & Layden, 2012). Pacing instructions within the current study design were similar to those provided by Knapik et al. (1991); participants were asked to complete each repetition of the FWC as quickly as possible. However, when concentric contractions are performed at a higher velocity, a smaller rate of force production occurs within the skeletal muscle due to a reduction in number of cross-bridges formed and an increased rate of detachment between actin and myosin (Hill, 1938; Huxley, 1957; Rome, et al., 1999; Fenwick, Wood, & Tanner, 2017). This increase in cross-bridge formation would have a direct effect on the release of CK due to its relationship with Myosin ATPase (Bessman, Yang, Geiger, & Erickson-Viitanen, 1980; Saks, Ventura-Clapier, Huchua, Preobrazhensky, & Emelin, 1984). The functional coupling with Myosin ATPase allows for ATP to be preferentially supplied by CK rather than cytosolic ATP (Saks, Chernousova, Vetter, Smirnov, & Chazov, 1976; Wallimann, Schlösser, & Eppenberger, 1984; Arrio-Dupont, Bechet, & d'Albis, 1992). Therefore, with a reduction in movement speed allowing for a greater binding of myofibrillar cross-bridges, the amount of ATP provided by CK would increase, regulating its release into the lymphatic system for the rephosphorylation of ADP produced at the expense of the phosphocreatine energy system (Ventura-Clapier, Mekhfi, & Vassort, 1987). Thus, the increase in pace performed may have resulted in decreased concentrations of serum CK as an inverse relationship between force and velocity has been associated with concentric contractions (Koch, et al., 2014).

H_3: Subjective Muscle Damage Analysis

A 10-point analog Visually Perceived Muscle Soreness (VPMS) scale was used to assess self-reported muscle soreness within the current study (*Figure 2*). Perceived muscle soreness scores were hypothesized to increase during the post-exercise supplemental recovery sessions at time points of IP, R60, R24h, R48h, and R72h of the FWC when compared to the NWC. Results indicated the majority of muscle soreness reported was within the upper-body when compared to the rest of the body. VPMS measurements of the wrist to elbow (arms), elbow to shoulder (shoulder), and the seventh cervical vertebrae to seventh thoracic vertebrae (upper back) revealed significant differences between FWC and NWC ($p < 0.01$), as well as for the overall VPMS measurement ($p < 0.001$), which took into consideration how much overall soreness the participant felt between the two conditions (FWC and NWC).

The findings of this study partially supported H_3 as perceived muscle soreness did increase post-FWC across time (IP, R60, R24h, R48h, and R72h) and was different between conditions (FWC and NWC); however, the hypothesis was only tenable for the upper body measures, as lower body VPMS measures showed no differences across time or between the two conditions. Previous literature demonstrated differences in self-reported muscle soreness between pre- and post-exercise measurements, with significant increases in muscle soreness noted upon completion of resistance and aerobic exercise (Vincent & Vincent, 1997; Burnett, et al., 2010). Furthermore, this study was the first to compare muscle soreness ratings between a functional resistance exercise and non-strenuous walking. Increased muscle soreness was recorded at a majority of post-exercise recovery time points between post-FWC and post-NWC, likely due to differences in intensity implemented. Additionally, this study was the first to indicate greater soreness occurred within the upper extremities during the completion of a FW with minimal to no change in lower body soreness. The results suggested greater muscular strain was placed on the upper body compared to the lower body which could be dependent on both physiological and contractile differences between the extremities when performing the FWC.

Physiological differences in muscle composition and vascularity could explain the presence of such differences in upper and lower body musculature soreness. Previous research determined an increased presence of muscle soreness within the upper body compared to the lower body due to larger ratios of type II muscle fibers which have been associated with higher susceptibility to muscle damage than type I muscle fibers (Fridén & Lieber, 2001; Plomgaard, et al., 2006; Koch, et al., 2015). However, when considering the increases in ground reaction forces associated with the FW, type II muscle fibers would also be utilized due to their association with greater contractile velocity and power output when compared to type I muscle fibers (Larsson & Moss, 1993; Bottinelli, Canepari, Pellegrino, & Reggiani, 1996; He, Bottinelli, Pellegrino, Ferenczi, & Reggiani, 2000; Keogh, et al., 2014; Winwood, et al., 2014a). Therefore, muscle composition may not play a primary role when comparing the differences in muscle soreness between upper and lower body musculature. However, due to the longer duration of contractions utilized within the upper torso in order to provide stabilization throughout all phases of the FW (McGill, et al., 2009), an effect on type I muscle fibers may have occurred as well. This increase in type I muscle fiber weakness may be related to the symptoms of muscular tenderness and/or stiffness to palpation associated with the commencement of Delayed Onset Muscle Soreness (DOMS) (Safran, et al., 1989; Gulick, et al., 1996; Cheung, et al., 2003; Burnett, et al., 2010). Additionally, differences in vascular compliance between upper body and lower body blood vessels may be linked to greater perceptions of pain post-exercise (Arndt & Klement, 1991; Wooley, Sparks, & Boudoulas, 1998; Eiken & Kölegård, 2004). Furthermore, previous investigators have reported similar muscle damage responses during isometric and eccentric contractions, both sustaining a more pronounced presence of muscle soreness when compared to concentric contractions (Jones, Newham, & Torgan, 1989; Philippou, et al., 2003; Philippou, et al., 2004).

Peak levels of muscle recruitment were found predominantly in the upper body during all phases of the FW (McGill, et al., 2009). More specifically, all phases measured during the FW revealed increased muscle recruitment associated with the posterior chain (lifting portion), gluteus medius and maximus (first step), and quadriceps, abdominal region, and back (walking portion) (McGill, et al., 2009). Interestingly, when considering the greater amount of walking completed compared to any other phase of the FWC, participants did not perceive any difference in muscle soreness between the quadriceps and abdominals when compared to the control protocol (NWC). Further analysis of the muscle recruitment patterns showed that the abdominals were the most highly recruited musculature throughout the duration of the lift (McGill, et al., 2009). These patterns of trunk recruitment may be associated with maintenance of balance and spinal stability which could be at a higher requirement when performing an exercise that produces unbalanced limb movements while carrying weight (Arokoski, et al., 1999; Cresswell, Oddsson, & Thorstensson, 1994; Arokoski, Valta, Airaksinen, & Kankaanpää, 2001). Therefore, a lapse in perceived muscle soreness has been identified among the subjects during the recovery period of the FWC. The addition of the current results with previously collected evidence of muscle activation provides support for a lack in reliability regarding subjective measurements such as the VPMS scale for the quantification of muscle damage that may occur within skeletal muscle. Further investigative measures should be taken to determine the reliability of a subjective muscle damage measurement such as the VPMS using different sample populations when performing the FWC. Additionally, a more thorough investigation of muscle activation may be required due to a lack of association between areas of greatest perceived soreness and measurement of muscle activation completed by McGill, et al. (2009). Regardless, an increased presence of isometric muscle recruitment occurring within the upper body may help to explain the differences in upper body soreness when compared to the lower body.

H_4 and H_5: Neuromuscular Response Analysis

Countermovement jump (CMJ) tests are a commonly used method to monitor neuromuscular performance due to its simplicity, effectiveness, and lack of fatigue induced from testing (Taylor, et al., 2012; Twist & Highton, 2013; Balsalobre-Fernandez, et al., 2014; Freitas, et al., 2014; Claudino, et al., 2017). CMJ height was hypothesized to decrease over both the post-exercise and control protocol supplemental recovery sessions (R24h, R48h, R72h) with a greater decrease in CMJ height associated with the FWC. H_4 was not supported as there was not a greater decrease in performance measurements for the FWC compared to the NWC during the recovery protocol (*Figure 5*). However, H_5 was supported due to similar decreases in neuromuscular responses found between the two measured conditions (FWC and NWC) in comparison to baseline (PRE) measurements (*Figure 5*).

The findings from this study concur with West et al. (2014) which indicated minimal neuromuscular deficiencies via CMJ performance with a return to baseline measurements within one-hour of completing a backward sled drag exercise protocol. Additionally, similar neuromuscular responses were seen with a return to baseline CMJ height within twenty minutes of a heavy deadlift exercise bout (Arias, Coburn, Brown, & Galpin, 2016). In contrast to, and as a result of the West et al. (2014) study, this testing protocol utilized a longer post-exercise recovery period to investigate if performance deficits remained up to 72-hours post-FWC. However, data indicated CMJ performance in both the FWC and NWC had returned to baseline measures within 24-hours post-exercise (*Figure 5*).

The weight chosen for implementation in other loaded carry studies was standardized either by uniform requirements or materials used within the performance environment (Knapik, et al., 1991; Ainslie, et al., 2003; Fallowfield, et al., 2012). Furthermore, pacing instructions varied among instructions from “self-paced”, “finish as fast as possible”, and “paced by instructors” (Knapik, et al., 1991; Ainslie, et al., 2003; Fallowfield, et al., 2012). For the current study design, loads were determined by testing the individualized maximal strength of each participant and then carrying 70% of their tested HHBD 1RM load. Additionally, each participant was instructed to complete each repetition of the FWC as quickly as possible. This methodology was chosen to provide an intensity mimicking traditional exercise within a fitness facility. Yet, even with a load used dependent on the strength of the individual, minimal neuromuscular deficiencies were found after the FWC. Furthermore, increases in rate of movement and associated concentric contractions may have allowed for a greater rate of torque development within the knee extensors which have demonstrated a significant relationship with CMJ performance when previously investigated (Tsiokanos, Kellis, Jamurtas, & Kellis, 2002; Thompson, et al., 2013; Wilhelm, et al., 2013; Chang, Norcross, Johnson, Kitagawa, & Hoffman, 2015). Nonetheless, it is likely the intensity and speed of movement applied were not optimal to initiate neuromuscular performance detriments. However, the data collected has a clinical relevance indicating the benefit of the movement within strength and conditioning, rehabilitation, and employment environments based on the FWC parameters.

Additionally, due to the presence of differing contractions between the upper and lower body, different mechanisms of fatigue may have had an effect on the neuromuscular responses of the FWC. Thompson, Conchola, and Stock (2015) observed quicker recovery rates for concentric contractions when compared to isometric contractions. These variations in force production may be due to mechanistic differences in intramuscular metabolic accumulation, excitation contraction coupling impairments, and intracellular alterations (Baker, Kostov, Miller, & Weiner, 1993; Miller, Kent-Braun, Sharma, & Weiner, 1995; Allen & Westerblad, 2001). However, methods were not implemented to measure the effects of fatigue among specific muscle groups, rather an indirect measure was assessed; therefore, only suggestions can be made regarding these outcomes and how the absence of these responses may be related to the lack in neuromuscular deficiencies observed post-FWC. Regardless, due to observed differences in recovery between types of contractions, the use of the CMJ to document a deficit in power performance may have been beneficially supplemented with other evaluations to assess the neuromuscular responses to the FWC exercise. Based upon VPMS results and understanding the demands of differing muscular contractions between the upper and lower extremities, there may have been variability in the demands of the muscle groups during the FWC. Therefore, in addition to using a validated measurement of lower body neuromuscular response such as the CMJ, using a validated neuromuscular response test sensitive to fatigue and specific to the sustained isometric contractions utilized in the upper body may provide more representative information on the responses observed. The use of validated upper body measurements of strength (hand grip test) or power (ballistic push-up or medicine ball put) may provide more accurate measurements of upper body muscle fatigue with the FWC (Bohannon, 2001; Leyk, et al., 2006; Clemons, Campbell, & Jeansonne, 2010; Harris, et al., 2011; Wang, et al., 2017). Further investigation is needed to examine the neuromuscular responses associated with movements such as the FWC.

Practical Implications, Limitations, and Future Research

The implementation of a FWC performed at an intensity of 70%1RM for ten total repetitions over a set distance of 20-meters with specified intervals of rest between each set and repetition completed did not result in the occurrence of physiological measures of muscle damage or neuromuscular deficiencies. The outcomes of this study provided a point of consideration for practitioners who may consider implementing an exercise such as the FWC. Clinicians may be concerned with potential muscular damage and recovery delays with the implementation of the FWC exercise within a training protocol. A variety of populations are tasked with carrying objects of varying weight from one point to the next due to athletic, rehabilitation, or employment situations. This study suggested minimal muscle damage occurred when the exercise was performed at a moderate intensity.

The acute responses noted during recovery from the FWC provides additional information on the occurrence of physiological responses regarding its implementation. The lack of detrimental responses may provide further clinical support for the implementation of an exercise such as the FWC within an individual's periodization scheme. However, further research must be completed regarding the chronic physiological responses of the FWC along with the variety of training variables that can be altered with its implementation. This may include variations in factors such as distance covered, pace of completion, intensity utilized, or rest intervals implemented between repetitions and sets completed. Additionally, elite strongman training (ST) athletes have reported the utilization of the FW exercise during the tapering period up to 6.1 ± 1.8 days before competition (Winwood, et al., 2018). The minimalized neuromuscular detriments observed post-FWC provide support for these observations as the FW may cause less muscular damage and/or fatigue compared to other ST or traditional resistance training (RT) exercises. Finally, to echo previous recommendations, the FWC should be considered for implementation as a rehabilitation exercise which may be beneficial to numerous patient populations. These justifications are based on minimal muscle damage and neuromuscular responses post-exercise, a lack in eccentric contractions due to alterations in human locomotion, and improvements in balance, overall strength, and lower body power reported previously (Waller, et al., 2003; McGill, et al., 2009; Zemke & Wright, 2011; Ghigiarelli, et al., 2013; Keogh, et al., 2014; Winwood, et al., 2014a; Winwood, et al., 2014b).

There are limitations in this study design identified, which should be examined and controlled for future studies. Analysis of walk time in performance of the 20-meter walk revealed a significant difference between the FWC and NWC ($p < 0.0001$), with the FWC taking a considerably less amount of time to complete each repetition than the NWC. These differences in elapsed time to completion may have had an indirect effect on the outcome of this study. Time differences resulted in varied intensities of work between conditions. These differences could have resulted in a variation of external factors associated with these different intensities masking the effect of the condition on the measured physiological variables. Additionally, inter- and intra-variability among the sample may have influenced the responses seen within this study design. Variations in training status have been determined as sources of alterations of serum CK responses post-exercise (Koch, et al., 2014), with lower increases in serum CK occurring after a bout of exercise in trained subjects when compared to their untrained counterparts (Vincent & Vincent, 1997; Fehrenbach, et al., 2000; Garry & McShane, 2000). A possible explanation for this outcome may be directed toward the phenomenon known as the repeated bout effect. This protective effect is founded within adaptations including a shift of muscle composition recruitment towards slow-twitch muscle fibers and their corresponding motor units, hypertrophic responses in order to reduce any corresponding microtrauma, and downregulation of inflammation to limit the extent of cell damage occurring within the subsequent post-exercise timeline (Stupka, Tarnopolsky, Yardley, & Phillips, 2001; McHugh, 2003). Familiarization to the FW exercise was not immediately apparent within the testing sample, but there may have been a protective effect from other activities performed during the individual’s daily activities. Academic, employment, or personal obligations may have provided the necessary effects to stunt any significant cellular damage from occurring post-exercise.

Due to the novelty of the study design within a ST regimen, numerous questions could be pursued from the information gathered during the current study. To begin, future research should investigate the responses of the FW to different loading patterns based in different zones of intensity. This could be completed with altering acute training variables such as the load used, pace of completion allowed, or rest intervals provided; all of which would provide even more valuable information on such a commonly used physical activity. Additionally, the investigation of responses when using different modalities may also be of interest due to a wider variety of equipment available in current fitness facilities. Furthermore, future research regarding neuromuscular adaptations should consider the benefits of using a validated upper body power assessment tool to see if more accurate measurements may be obtained.

In conclusion, at a prescribed intensity of 70%1RM, the FWC exercise did not seem to promote muscular damage and fatigue. Furthermore, there were noted discrepancies between upper and lower body soreness indices. Associated improvements in balance, overall strength, and lower body power would be beneficial to not only athletes but clinical populations as well. Furthermore, due to its presence within all three planes of movement (horizontal, sagittal, and transverse) further functionally-based adaptations may be acquired that cannot be obtained with the implementation of traditional resistance training protocols. These results would provide further support for the utilization of a functionally transient exercise such as the FWC within rehabilitative and clinical populations. Due to the flexibility of training variables associated with the FW, further research must be pursued regarding the acute and chronic physiological, biological, and perceptual responses in differing populations to ensure its safety and regulation in practice.

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APPENDIX 1

Office of Research Compliance Institutional Review Board (IRB) Approval for Human Subjects

TEXAS A&M UNIVERSITY
CORPUS CHRISTI

OFFICE OF RESEARCH COMPLIANCE
Division of Research, Commercialization and Outreach
6300 OCEAN DRIVE, UNIT 5844
CORPUS CHRISTI, TEXAS 78412
O 361.825.2497 • F 361.825.2

Human Subjects Protection Program | Institutional Review Board

DATE: September 6, 2018

TO: Dr. Heather Webb, Faculty
College of Education and Human Development

CC: Jeb Struder, Graduate Student
College of Education and Human Development

College of Graduate Studies (gradcollege@tamucc.edu)

FROM: Office of Research Compliance

SUBJECT: Full Board IRB Approval

On August 24, 2018, the Texas A&M University-Corpus Christi Institutional Review Board IRB reviewed the following submission:

Type of Review:	Initial Review
Level of Review:	Full Board
Protocol Title:	The Neuromuscular Responses to a Farmers Walk
Investigator:	Dr. Heather Webb
IRB ID:	96-18
Funding Source:	None
Documents Reviewed:	96-18 Struder Revision HEW v1.1_9_6_2018 Consent_v2.2_9_6_2018 Acknowledgment of Risk (Pregnancy)_9_6_2018 FW Scripts_9_6_2018 HHQ Exclusionary Criteria (Cheat Sheet)_9_6_2018 HHQ Exclusionary Criteria_9_6_2018 PAQ_9_6_2018 Procedure for Venipuncture_9_6_2018 Procedures_9_6_2018 Venipuncture Care - Struder_9_6_2018

The IRB has approved this submission from September 6, 2018 to September 5, 2019. You may now begin the research project.

Additional Determinations: None

Reminder of Investigator Responsibilities: As principal investigator, you must ensure:

1. **Informed Consent:** **Ensure informed consent processes is followed** and information presented ensures individuals can voluntarily decide whether or not to participate in the research project.

   Attached is an approved consent form. Use the latest IRB-approved consent forms to consent subjects.

2. **Continuing Review:** Before September 5, 2019, you are to submit a continuing review form. If continuing review approval is not granted before the expiration date, **the protocol expires and all research activities must stop**.

OFFICE OF RESEARCH COMPLIANCE
Division of Research, Commercialization and Outreach
6300 Ocean Drive, Unit 5844
Corpus Christi, Texas 78412
O 361.825.2497 • F 361.825.2

3. **<u>Amendments:</u>** This approval applies only to the activities described in the IRB submission and does not apply should any changes be made. **Any changes requires an amendment to the IRB.** The Amendment must be approved before any change is implemented.

4. <u>Completion Report:</u> **Upon completion of the research project (including data analysis and final written papers), a Completion Report must be submitted.**

5. **<u>Reportable Events:</u>** Reportable events must be reported to the Research Compliance Office immediately.

Please do not hesitate to contact the Office of Research Compliance with any questions at irb@tamucc.edu or 361-825-2497.

Respectfully,

Rebecca Ballard, JD, MA, CIP
Digitally signed by Rebecca Ballard, JD, MA, CIP
Date: 2018.09.06 15:48:08 -05'00'

Rebecca Ballard, JD, MA, CIP
Director, Research Compliance and Export Control Officer
Division of Research, Commercialization and Outreach

APPENDIX 2

Office of Research Compliance Institutional Biosafety Committee (IBC) Approval

TEXAS A&M UNIVERSITY CORPUS CHRISTI

OFFICE OF RESEARCH COMPLIANCE
Division of Research and Innovation
6300 Ocean Drive, Unit 5844
Corpus Christi, Texas 78412
Office 361.825.2497

Biosafety Program | Institutional Biosafety Committee

DATE: February 25, 2019

TO: Heather Webb, College of Education and Human Development

FROM: Office of Research Compliance

SUBJECT: IBC Amendment Approval

On February 25, 2019, the Texas A&M University-Corpus Christi Institutional Biosafety Committee reviewed the following submission:

Type of Review:	Amendment
Protocol Title:	Effect of Walking
Investigator:	Heather Webb
IBC ID:	04-18 Amendment 1
Funding Source:	N/A
BSL Level:	BSL-2
NIH Guidelines Section:	Not Applicable
Documents Reviewed:	04-18 Struder Amendment (signed) occ health and training list
Description of Change:	Protocol change: Personnel Added Daniel Newmire Jordan Wainwright Cody Haenitsch Noe DeAnda Jospeh Eberhart Arriiana McDonald Zeina Nader

Your amendment was reviewed and approved as of 2/25/2019.

Further action required: This amendment approval is approved with the removal of Souhad Bachnack and Stephen Cumberledge who have not completed training or occupational health enrollment. **These individuals are not approved to begin working on this protocol at this time.** To allow these individuals to work on this permit please add via a personnel change amendment when training/OHP enrollment is complete.

Approved changes detailed in this letter may now be implemented.

Please do not hesitate to contact the Office of Research Compliance with any questions at ibc@tamucc.edu or 361-825-2497.

Respectfully,

Rebecca Ballard, JD, MA, CIP
Digitally signed by Rebecca Ballard, JD, MA, CIP
Date: 2019.02.25 14:44:17 -06'00'

Office of Research Compliance

Page 1 of 1

APPENDIX 3

Informed Consent

Department of Kinesiology
College of Education
6300 Ocean Drive, Unit 5820
Corpus Christi, Texas 78412-5820
O 361.825.6072 F 361.825.3708
http://kinesiology.tamucc.edu

Consent to Participate in an Experimental Study
The Neuromuscular Responses to a Farmers Walk

Investigators: Jeb F. Struder, B.S., CSCS, Heather E. Webb, Ph.D., ATC, LAT, Daniel E. Newmire, Ph.D., CSCS, CISSN, Mikaela Boham, Ph.D., ATC, LAT

Introduction

The purpose of this form is to provide you information that may affect your decision as to whether or not to participate in this research study. If you decide to participate in this study, this form will also be used to record your consent.

You are being asked to participate in a research project studying the effect walking with a relatively heavy weight (70% of your maximal capability) on measures of muscle damage, stress hormones, and psychological indices when compared to performing the same exercise without the weight. You should know we have specific exclusion criteria for this study, including that you do not have a history of chronic illness or are taking any medications that may impact the measures we are taking. Additionally, you should have not any musculoskeletal injuries that may impact your ability to perform the activities involved in the study. Finally, you cannot be pregnant or attempting to become pregnant. There are other possible reasons you may not qualify and these reasons are detailed in the addendum. This information will be gathered during the initial testing session.

What will I be asked to do?

Your participation will include coming to the Biomechanics Lab (Room 142, Island Hall), the Exercise Physiology Lab (Room 146, Island Hall), and Exercise Biochemical Lab (Room 146 B/C, Island Hall) for nine testing sessions. Below is an explanation of what you will be asked to do during these sessions. We have included a more detailed timeline of the procedures in the addendum.

During the first session you will be introduced to the research team, informed of the protocols involved within the research testing sessions, and begin with the completion of a medical history questionnaire, physical activity questionnaire, and a short questionnaire regarding your feelings and thoughts during the previous month. Upon completion, the research team will assess your documents for qualification. If allowed to proceed and still interested in participating, you will complete body composition measurements, a maximal jump height assessment, a maximal strength measurement, and allowed to familiarize yourself with the Farmer's Walk exercise. This session should last approximately 1.5 hours.

For two of the sessions, you will be asked to report to the Biomechanics Lab at 7:00AM after fasting for at least eight (8) hours. Upon arrival, the procedures will be explained to you once more and your 24-hour dietary recall will be collected. You will then be asked to complete four questionnaires about how you are feeling, along with providing a saliva sample for stress hormone measurement. Upon completion of this, you will be fitted with our mobile research equipment and then escorted to the Exercise Physiology Laboratory. Here you will have your resting oxygen consumption measured for 30 minutes by breathing into an apparatus to collect your expired air for analysis. Next, we will perform a blood draw in order to obtain about a tablespoon (14 mL) of your blood in order to measure markers of muscle stress (creatine kinase, myoglobin, & blood lactate). We will also collect a small sample of your blood using a device to stick your finger in order to measure blood lactate levels. Next, we will have warm-up on a treadmill for five minutes before you start the exercise portion of the protocol. For both these sessions, you will walk a distance of 20-meters a total of ten times. You will be given 30 seconds of rest after each even-numbered walk, and 2 minutes of rest after each even-numbered walk. In one of these sessions you will walk normally, and in the other session, you will be asked to carry additional weight (~70% of your 1-RM) using a high-handled hex bar. After you complete the last (10th) walk, we collect blood and saliva samples from you. After this, we will measure your oxygen consumption levels again, and complete the same questionnaires you did at the start of the session. Finally, we will also collect blood and saliva samples from you 30 minutes and 1 hour after completion. The total time for each of these two sessions should be approximately 2 hours.

We will need you to return the lab 24-hours, 48-hours, and 72-hours after the completion of each of the previously described conditions. In these subsequent sessions, we will collect a blood sample and have you perform a vertical jump test. For each of these sessions, the data collection should take no more than 15 minutes to complete.

During the testing sessions (except session 1), a venipuncture blood draw will be performed by a trained professional, and blood will be drawn at four (4) specific time points during the weighted-walk and non-weighted walk condition, and once during each recovery (post 24, 48, and 72 hours) session. For each blood draw we will collect approximately 1 tablespoon (two 7mL tubes) of blood, for a total of approximately 6 ounces (196 ml) of blood during the entire research project. In order to allow for proper recovery, you will be asked to wait approximately one (1) week between session one and each of the exercise sessions. The total duration of the research study is approximately 3 weeks.

What are the risks involved in this study?
Your participation in this study may involve some risks. The most common are the possibility of feeling a "shortness of breath", dizzy/lightheaded, and general fatigue during one or all of the testing procedures. If you cannot tolerate the feeling of "shortness of breath", dizziness, or fatigue, you can stop at any point during the experiment. In addition, due to the activity you will be participating in, musculoskeletal injury could occur. A certified, state-licensed athletic trainer will be available on-site should a musculoskeletal injury occur and will evaluate and recommend treatment or referral as necessary should an injury occur.

During the data collection sessions, you might also experience discomfort from the collection of blood samples. The possibility of infection from these needlesticks does exist, but will be minimal due to the use of sterile techniques. A physician approved allied health care provider will perform these procedures to minimize discomfort and provide optimal care. Instructions for care of the insertion site will be given to you at the conclusion of each session.

In the case of any injury resulting from this study, treatment is available at the University Health Center, but will be provided at the usual charge. It will be your responsibility to pay for the treatment. The University Health Center does not have funds set aside to pay research participants if you are injured. By signing this form, you are not giving up any legal rights to seek compensation for injury.

What are the possible benefits of this study?
You will also receive information on how your body composition measures relate to your health and how they compare to others of your age and sex. You will also be provided with information involving how your body responds to the exercise you performed, along with details regarding an exercise prescription involving this type of exercise if you so desire.

Do I have to participate?
No. Your participation is voluntary. You may decide not to participate or to withdraw at any time without your current or future relations with Texas A&M University-Corpus Christi being affected.

What are the alternatives to being in this study?
Instead of being in this study, you may simply choose not to participate. You also have the right to drop out of the study at any point during the protocol, with no consequence from the university or research team.

Who will know about my participation in this research study?
The results of the tests and all the associated records will be kept strictly confidential, and only members of the investigative team will have access to these documents*. If your individual test results are reported at a scientific meeting or published in a scientific journal, only your assigned participant number, rather than full name, will be used.

On occasion, we may take photos or videotape you during your participation in the study for presentations at conferences or in manuscripts. We will make every attempt to keep you from being recognized in the video and/or photos. We will inform you if we wish to photograph or record you. You may choose to participate in this research, while opting out of being photographed or recorded by initialing your preference below. Any audio or video recordings will be stored securely and only the research team will have access to the recordings. Any recordings will be kept for two (2) years and then erased.

Is there anything else I should consider?
If you discover that you are pregnant, use any excluded pharmacological or ergogenic aids, or participate in extraneous exercise during the course of this study, you may not be allowed to continue your participation in this study.

Whom do I contact with questions about the research?
If you should have any questions about this research project, please feel free to contact Jeb Struder at 919-337-5881 or jstruder@islander.tamucc.edu or Dr. Heather Webb at 361-825-3749 or heather.webb@tamucc.edu.

Whom do I contact about my rights as a research participant?
This research study has been reviewed by the Research Compliance Office and/or the Institutional Review Board at Texas A&M University-Corpus Christi. For research-related problems or questions regarding your rights as a research participant, you can contact the Research Compliance Office, at (361) 825-2497 or send an email to IRB@tamucc.edu.

Signature
Please be sure you have read the above information, asked questions and received answers to your satisfaction. You will be given a copy of the consent form for your records. By signing this document, you consent to participate in this study. You also certify that you are 18 years of age or older by signing this form.

I agree to allow photographic and videographic recording of my participation in the study entitled, "*The Neuromuscular Responses to a Farmer's Walk*".

_________ I agree to be photographed and/or video recorded.

_________ I do not want to be photographed and/or video recorded.

You will be given a copy of this form for your records

______________________________ ______________

Signature of Participant Date

____

Printed Name

______________________________ ______________

Signature of Person Obtaining Consent Date

____

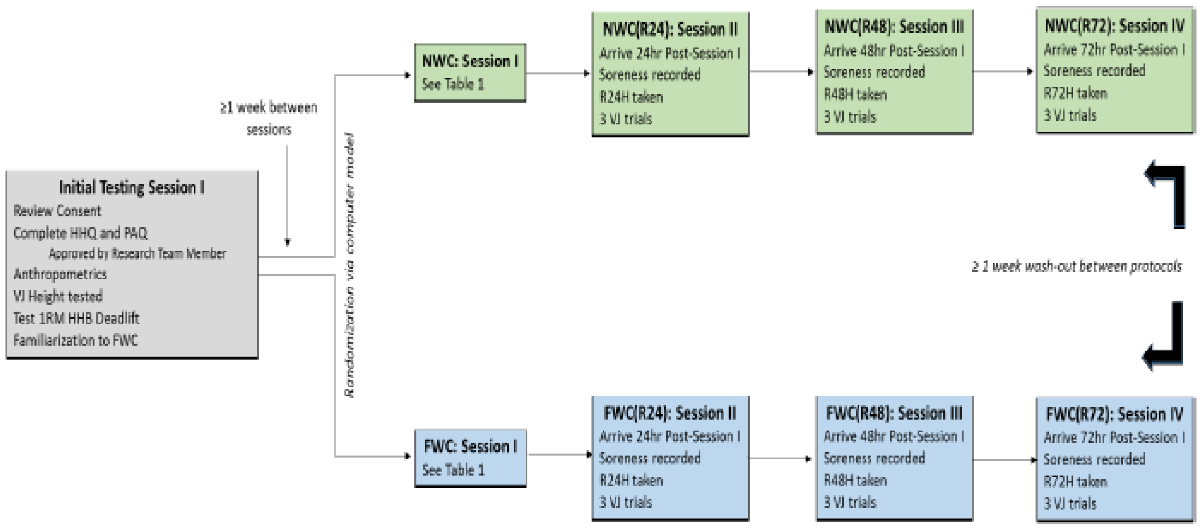
Printed Name

Exclusionary (Disqualifying) Criteria Addendum

Due to the nature of this research protocol, we have specific criteria for excluding individuals from being participants in this study. These criteria include:

- being younger than 18 years old or older than 45 years of age
- that you report history of psychological disorders or chronic illness (metabolic, cardiovascular, neuromuscular, pulmonary, kidney, or liver diseases) which may impact the measurements we are collecting
- use of any prescription or non-prescription medications that specifically impact or may impact cardiometabolic, pulmonary, and/or renal function,
- use of certain ergogenic or health-related supplements (not including vitamins or calcium),
- use of tobacco products (including smoking cessation products)
- consuming an average of greater than 10 alcoholic beverages per week
- consuming an average of more than 400 mg of caffeine per day (greater than 5 cups of coffee, 2.5 energy drinks, etc.)
- if you have experienced any recent major life events [e.g. death in family, divorce, wedding] in the past 3 months,
- have donated blood within the previous month,
- have suffered a musculoskeletal injury within the previous 6 months or have a chronic musculoskeletal injury or condition that limits your ability to perform the exercises safety
- are pregnant or attempting to become pregnant
- have an implanted pacemaker or internal defibrillator.

Detailed Protocol (Timeline) Addendum



Session 1 – Introductory/Preliminary Session

Arrival (0 min)	Welcome and introduction of research team
5 min	Explanation of research question/research protocol to subject and provide answers to any questions
10 min	Obtain informed consent
15 min	Completion of health history questionnaire (HHQ and physical activity questionnaires (PAQ) • If participants report exclusionary criteria, it is at this point their participation in the study will end. Reasons will exclusion will be explained.
25 min	Completion of Perceived Stress Scale (PSS)
27 min	Perform anthropometric measures (height, weight, dual X-ray absorptometry)
45 min	Perform baseline measurements for vertical jump
55 min	Perform 1-RM (repetition maximum) for high-handled hex-bar deadlift testing
75 min	Allow for familiarization of Farmer's Walk (FW) exercise and provide corrective coaching cues as needed
85 min	Schedule participant for session 2
90 min	Participant departs

Exercise Sessions (there will be a 1-week interval between the two exercise sessions)

Time	Event	Measures Collected
-60 min	Arrival at lab; procedure explanation	Compliance check; affirm client's understanding of procedures
-55 min	Dietary Recall	Dietary Recall
-50 min	Psychometric evaluations	Saliva sample; VMS; SAI; AD-ACL; PSS
-45 min	Bioharness fitting	
-40 min	Oxygen Consumption	VO_2, CO_2, RER
-10 min	Pre-Exercise (BD1)	Blood sample
-5 min	Dynamic Warm-Up	Treadmill Walk
0 min	Begin Exercise (20-meter walk)	Bioharness
0:30 min	30 sec rest	RPE
1:00 min	Exercise (20-meter walk)	Bioharness
1:30 min	120 sec rest	RPE
3:30 min	Exercise (20-meter walk)	Bioharness
4:00 min	30 sec rest	RPE
4:30 min	Exercise (20-meter walk)	Bioharness
5 min	120 sec rest	RPE
5:30 min	Exercise (20-meter walk)	Bioharness
6 min	30 sec rest	RPE
6:30 min	Exercise (20-meter walk)	Bioharness
8 min	120 sec rest	RPE
10:00 min	Exercise (20-meter walk)	Bioharness
10:30 min	30 sec rest	RPE
11:00 min	Exercise (20-meter walk)	Bioharness
11:30 min	120 sec rest	RPE
13:30 min	Exercise (20 meter walk)	Bioharness
14 min	30 sec rest	RPE
14:30 min	Exercise (20-meter walk)	Bioharness
15 min	Immediately Post-Exercise (BD2)	RPE; Saliva & Blood Sample
17 min	Psychometric evaluations	SAI; AD-ACL; VMS
20 min	Oxygen Consumption	VO_2, CO_2, RER
45 min	R30 (BD3)	Blood
75 min	R60 (BD4)	Blood, VMS, SAI

Abbreviations:

BD – blood draw
VMS – visual perceptions of muscle soreness scale
SAI – state anxiety inventory
AD-ACL – activation, deactivation adjective checklist
PSS – perceived stress scale
VO_2 – ventilatory oxygen consumption
CO_2 – ventilatory carbon dioxide exhalation
RER – respiratory exchange ratio
RPE – rating of perceived exertion

Recovery Sessions – 24, 48, 72 hours Post-Exercise Session Recovery

Arrival (0 min)	Welcome & VMS; SAI measures
2 min	Bioharness fitted
5 min	Blood collection
10 min	Vertical Jump measures
15 min	Subject departs

APPENDIX 4

Health History Questionnaire (HHQ)

PARTICIPATION AND HEALTH HISTORY QUESTIONNAIRE

Complete each question accurately. All information provided is strictly confidential.

Part I: Participant Information

Name (Print) ______________________________	Home Phone # ______________________________
Current Mailing Address ______________________________	Work/Cell Phone # ______________________________
Personal Physician ______________________________	Email Address ______________________________
Emergency Contact (relationship) ______________________________	Emergency Contact Phone # ______________________________
Gender: _____ Female _____ Male _____ Other	Date of Birth (mm/dd/yyyy) ______________________________
Height(in.): ______ Weight (lb.): ______	Age (years): ____________________

Part II. Health History

List any physical injuries/limitations you currently suffer from or have sustained in the LAST SIX (6) MONTHS: ____
____

Have you ever been diagnosed as having any cardiovascular abnormalities?
______ Yes ______ No

If yes, what was diagnosed and when was the diagnosis conducted? ________________________
____

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

ANEMIA	ARRHYTHMIA	BYPASS SURGERY	HEART ATTACK
HEART MURMER	HEART PALPITATIONS	HEART RHYTHM ABNORMALITIES	HEART VALVE PROBLEMS
PACEMAKER/IMPLANTABLE DEFIBRILLATOR	SHORTNESS OF BREATH	STROKE	CHEST PAIN

Do you have any form of respiratory (breathing) ailments? Please circle those that apply.

ASTHMA	BRONCHITIS	COMMON COLD
COPD	EMPHYSEMA	PULMONARY DIEASE

Have you been diagnosed with any of the following? If yes, please circle the appropriate ailment.

DIABETES/METABOLIC DISEASE	HIGH CHOLESTEROL	HIGH BLOOD PRESSURE	HEMOPHILIA
KIDNEY / LIVER DISEASE	NEUROMUSCULAR DISEASE	OBESITY	RHEUMATIC FEVER

Does anyone in your family have any of the conditions previously listed? If yes, please list relation to family member and problem: ____
____

Is your mother living? _____ Yes _____ No (age at death _____; cause_____________)

Is your father living? _____ Yes _____ No (age at death _____; cause_____________)

Do you have any allergies (latex, food, drug, etc.)? _____ Yes _____ No

If yes, please list: ____
____

Have you had a prior graded exercise test? _____ Yes _____ No

If yes, when and what were the results? ____
____

Have you ever experienced any adverse responses during or after exercise (i.e. dizziness, difficulty breathing, racing heartbeat, fainting, concerns regarding safety, burning sensations in limbs)? _____ Yes _____ No

If yes, what were the symptoms? ____
____

<u>Part III. Health Related Behavior</u>

DO YOU SMOKE? _____ YES _____ NO

If yes, indicate number of cigarettes per day?
_____ Less than ½ a pack _____ 1 pack ____ Greater than 1 pack

DO YOU DRINK ALCOHOL? _____ YES _____ NO

IF YES, INDICATE NUMBER OF ALCOHOLIC BEVERAGES PER WEEK?
_____ LESS THAN 10 _____ 10 _____ GREATER THAN 10

DO YOU DRINK CAFFEINE? _____ YES _____ NO

IF YES, INDICATE AMOUNT CONSUMED PER DAY?
_____ LESS THAN 400mg* _____ MORE THAN 400mg*
*400mg of caffeine = 4 cups of brewed coffee, 10 cans of cola OR 2 "energy shot" drinks.

Do you exercise regularly (30 minutes, 3 times weekly, or greater)? _____ Yes _____ No

If so, what exercises do you participate in regularly? ______________________________
____

Have you recently (within the previous 6 months) experienced a major life event (i.e., death in family, divorce; wedding; birth of a child)? _____ Yes _____ No

Have you donated blood or plasma within the previous month? _____ Yes _____ No

Are you taking any medications (prescription/nonprescription) associated with the following diseases or supplements (pharmacological aids)? If so please circle all that apply.

CARDIOVASCULAR	KIDNEY/LIVER	METABOLIC	NEUROMUSCULAR
PULMONARY	β-ALANINE	BRANCHED-CHAIN AMINO ACIDS (BCAAs)	CREATINE
HMB (β-HYDROXY β-METHYLBUTYRATE)	ILLEGAL DRUGS/HORMONES	IRON	L-CARNITINE
NONSTEROIDAL ANTI-INFLAMMATORY DRUGS (NSAIDS)	SODIUM BICARBONATE	VITAMIN E	VITAMIN K
OTHER			

If other is chosen, please list: ____
____

APPENDIX 5

Physical Activity Questionnaire (PAQ)

PHYSICAL ACTIVITY QUESTIONNAIRE

Complete each question accurately. All information provided is strictly confidential.

Part I: Cardiovascular Training

Frequency: How often (per week) do you participate in aerobic (cardiovascular, pulmonary) training (cycling, running, walking, rowing, etc.): ___________________________________
____

Time: How long (minutes) do you participate in these aerobic (cardiovascular, pulmonary) training bouts per session?: ____
____

Please circle any of the following exercise modes you frequently implement while training:

BIKE/CYCLE (STATIONARY)	HIIT	KAYAK (STATIONARY)
JOGGING/RUNNING	ROWING (STATIONARY)	WALKING
OTHER		

If other, please list: ____
____

Part II: Resistance Training

Frequency: How often (per week) do you participate in anaerobic (resistance) training (free weights, machine weights, plyometrics, etc.): ____
____

Time: How long (minutes) do you participate in these anaerobic (resistance) training bouts per session?: ____
____

Experience: How long have you utilized resistance training (free weights, machine weights, etc.) within your training program? __________ ≤ 2 years __________ ≥ 2 years

When training, how would you rank your goal(s) (1 (not a priority) – 10 (must achieve)) for each of the following strength gains associated with resistance training?

_____ ENDURANCE _____ HYPERTROPHY (INCREASED SIZE)

_____ POWER _____ STRENGTH _____ TONING (DEFINITION)

_____ OTHER

If other, please list: ____
____

Please circle any of the following exercise modes you frequently implement while training:

BODY WEIGHT EXERCISES	CROSSFIT	FREE WEIGHTS	INSTABILITY
MACHINE WEIGHTS	OLYMPIC LIFTING	PLYOMETRICS	POWER LIFTING
STRONGMAN TRAINING	UNILATERAL TRAINING	VARIABLE-RESISTANCE (CHAINS, RESISTANCE BANDS, ETC.)	OTHER

If other, please list: ____
____

Part III: Incidental Physical Activity

Are you currently employed? _____ Yes _____ No

If yes, are you exposed to jobs that require physical labor (roofer, gardener, construction, etc.) or physical activity (waiter/waitress, lifeguard, policeman, military, etc.)?
_____ Yes _____ No

If yes, please explain: ____
____
____

How much time do you spend walking throughout a normal day (To work, to class, extra-curricular activities, etc.)? : ____

Do you participate in any extra-curricular activities (club sports, athletics, Greek life, social life, ROTC, competitions, etc.) that have not been previously listed? _____ Yes _____ No

If yes, please list: ____
____

APPENDIX 6

Acknowledgement of Risk

TEXAS A&M UNIVERSITY
CORPUS CHRISTI

DEPARTMENT OF KINESIOLOGY
COLLEGE OF EDUCATION
6300 OCEAN DRIVE, UNIT 5820
CORPUS CHRISTI, TEXAS 78412-5820
O 361.825.6072 F 361.825.3708
HTTP://KINESIOLOGY.TAMUCC.EDU

Acknowledgment of Risk

Participant Name: ____________________ **A#: ________________________**

We sometimes ask the cooperation of our participants by asking "personal" but necessary and important questions in order to provide the utmost respect and care for our research study designs. For this specific project, two risks may be seen for individuals who consider themselves pregnant or are attempting to become pregnant. These would include the introduction to radiation during body composition measurement along with the physiological effects that may occur during their participation in consecutive bouts of highly strenuous physical activity. The amount of radioactivity used in the Dual X-Ray Absorptiometry (DXA) scanning is small and the slight risk of radiation exposure to you is warranted in view of the diagnostic information to be gained; however, it is recognized that this radiation can be harmful to a fetus. The risk of radiation exposure to an unborn fetus is significant in that it may cause genetic effects. When considering the intensity of exercise that will be performed during this study, there is a slight risk to women who are pregnant that choose to perform high-intensity (vigorous) exercise, and minimal evidence to support their safety when performing Strongman Training (ST) exercises, such as the Farmer's Walk. For these reasons, women who are pregnant or who might be pregnant will not be allowed to participate and your participation for the study will be postponed until such a time that we could ensure that you are not pregnant.

This is to certify that, to the best of my knowledge, I am not pregnant, and the PI and/or Co-PI has my consent to participate within this study design and permission to perform a diagnostic DXA examination. I have been advised that certain X-ray examinations, particularly involving the pelvis, and intensity classifications can be hazardous to an unborn child.

______________________________________ ____________________

Participant Signature **Date**

APPENDIX 7

Protocol Data Collection Sheet

Thesis Project: The Neuromuscular Responses to the Farmers Walk

Data Sheet

Name: ______________________________ Date: ____________________

Code#: ______________________________ Collector(s): ______________________________

Testing Session

Anthropometrics

Age: __________

Balance-beam Scale

Height: __________(in) x 2.54 = __________ (cm)

Weight: __________ (lb) / 2.2 = __________ (kg)

Dual Energy X-ray Absorptiometry (DXA)

Lean Body Mass (LBM): __________ (lb) / 2.2 = __________ (kg)

Fat Mass (FM): __________ (lb) / 2.2 = __________(kg)

Bone Mineral Content (BMC): __________ (lb) / 2.2 = __________ (kg)

Body Fat Percentage (BF%): __________ (%)

Lean Body Mass Percentage (LBM%): __________(%)

Power / Strength Testing

Did you complete a five-minute warm-up?	
Yes	No

Vertical Jump Testing	
Attempt	Vertical Jump Height (in)
1	
2	
3	
Average:	

High-handle Bar Deadlift One-repetition Maximum (HHBD 1RM)				
Set	Intensity (%1RM)	Repetitions Completed	Weight (lb)	Weight (kg)
1	50%1RM	10		
2	70%1RM	5		
3	85%1RM	3		
4	90%1RM	1		
5	*5% Increase*	*1*		
6	*5% Increase*	*1*		
7	*5% Increase*	*1*		
8	*5% Increase*	*1*		

Did you complete a familiarization of Farmers Walk?	
Yes	No

Session I

Please circle one:

NWC	FWC

PRE-EXERCISE BOUT:

Has the following been completed?			
Variables	Yes	No	Notes
AD-ACL			
SAI			
VPMS			
Saliva Swab			
Fitted Bioharness			
Metabolic cart calibration			
EPOC testing			
BD1 (PRE) – Blood draw 1 taken			
Taken to IH146 for DWU			
PRE Saliva Swab			

Did you complete a five-minute treadmill warm-up?	
Yes	No

Set	Repetition	Time to Complete (sec)	Rest
1	1		30 seconds
	2		120 seconds (2 minutes)
2	3		30 seconds
	4		120 seconds (2 minutes)
3	5		30 seconds
	6		120 seconds (2 minutes)
4	7		30 seconds
	8		*120 seconds (2 minutes)*
5	9		30 seconds
	10		**Walk back to IH146**

Ratings of Perceived Exertion (RPE)	Score (6-20)
RPE #1	
RPE #2	
RPE #3	
RPE #4	
RPE #5	
RPE #6	
RPE #7	
RPE #8	
RPE #9	
RPE #10 (Walking to IH146)	

POST-EXERCISE BOUT: ***Time Exercise Bout Completed***: ____________AM

Has the following been completed?			
Variables	Yes	No	Notes
IP Saliva Swab			
IP (BD2) – Blood Draw 2			
AD-ACL			
SAI			
EPOC tested			
R30 (BD3) – 30 minutes post exercise			
R60 (BD4) – 60 minutes post exercise			
R60 Saliva Swab			
SAI			
VPMS			

Recovery 24-H (R24)

Please circle one:

NWC	FWC

Has the following been completed?			
Variables	**Yes**	**No**	**Notes**
SAI			
VPMS			
R24 (BD5) – Blood Draw 5			

Vertical Jump Testing	
Attempt	**Vertical Jump Height (in)**
1	
2	
3	
Average:	

Recovery 48-H (R48)

Please circle one:

NWC	FWC

Has the following been completed?			
Variables	**Yes**	**No**	**Notes**
SAI			
VPMS			
R48 (BD6) – Blood Draw 6			

Vertical Jump Testing	
Attempt	**Vertical Jump Height (in)**
1	
2	
3	
Average:	

Recovery 72-H (R72)

Please circle one:

NWC	FWC

Has the following been completed?			
Variables	**Yes**	**No**	**Notes**
SAI			
VPMS			
R72 (BD7) – Blood Draw 7			

Vertical Jump Testing	
Attempt	**Vertical Jump Height (in)**
1	
2	
3	
Average:	

Session II

Please circle one:

NWC	FWC

PRE-EXERCISE BOUT:

Has the following been completed?			
Variables	Yes	No	Notes
AD-ACL			
SAI			
VPMS			
Saliva Swab			
Fitted Bioharness			
Metabolic cart calibration			
EPOC testing			
BD1 (PRE) – Blood draw 1 taken			
Taken to IH146 for DWU			
PRE Saliva Swab			

Did you complete a five-minute treadmill warm-up?	
Yes	No

Set	Repetition	Time to Complete (sec)	Rest
1	1		30 seconds
	2		120 seconds (2 minutes)
2	3		30 seconds
	4		120 seconds (2 minutes)
3	5		30 seconds
	6		120 seconds (2 minutes)
4	7		30 seconds
	8		*120 seconds (2 minutes)*
5	9		30 seconds
	10		Walk Back to IH146

Ratings of Perceived Exertion (RPE)	Score (6-20)
RPE #1	
RPE #2	
RPE #3	
RPE #4	
RPE #5	
RPE #6	
RPE #7	
RPE #8	
RPE #9	
RPE #10 (Walking to IH146)	

POST-EXERCISE BOUT: ***Time Exercise Bout Completed***: ______________AM

Has the following been completed?			
Variables	Yes	No	Notes
IP Saliva Swab			
IP (BD2) – Blood Draw 2			
AD-ACL			
SAI			
EPOC tested			
R30 (BD3) – 30 minutes post exercise			
R60 (BD4) – 60 minutes post exercise			
R60 Saliva Swab			
SAI			
VPMS			

Recovery 24-H (R24)

Please circle one:

NWC	FWC

Has the following been completed?			
Variables	**Yes**	**No**	**Notes**
SAI			
VPMS			
R24 (BD5) – Blood Draw 5			

Vertical Jump Testing	
Attempt	**Vertical Jump Height (in)**
1	
2	
3	
Average:	

Recovery 48-H (R48)

Please circle one:

NWC	FWC

Has the following been completed?			
Variables	**Yes**	**No**	**Notes**
SAI			
VPMS			
R48 (BD6) – Blood Draw 6			

Vertical Jump Testing	
Attempt	**Vertical Jump Height (in)**
1	
2	
3	
Average:	

Recovery 72-H (R72)

Please circle one:

NWC	FWC

Has the following been completed?			
Variables	**Yes**	**No**	**Notes**
SAI			
VPMS			
R72 (BD7) – Blood Draw 7			

Vertical Jump Testing	
Attempt	**Vertical Jump Height (in)**
1	
2	
3	
Average:	

APPENDIX 8

Venipuncture Procedures

Procedure for Blood Collection (Venipuncture):

Decontamination of the Site

Once the site has been selected it will be decontaminated with a sterile swab soaked in 70% percent isopropyl alcohol. The site will be rubbed vigorously with the alcohol sponge in concentric circles working from the inside out. The decontaminated site will be allowed to dry or will be dried with a sterile gauze after site preparation.

Venipuncture Procedures

Once the site has been cleansed, the patient's arm may be held below the site, pulling the skin tightly with the thumb. The Vacutainer assembly that will be used for blood collection will be inspected and prepared for use. A tourniquet will be applied superior to the venipuncture site, so that it is tight, but not painful to the subject. The participant will be asked to clench their fist on the involved side and will be told they will feel a slight "pinch".

The needle will be inserted so that it runs in the same direction as the vein at approximately a 15-degree angle with the skin. The needle will be inserted with the bevel side upward and directly above a prominent vein or slightly below a palpable vein. As the blood begins to flow the participant will be allowed to relax their fist. The tourniquet will be released as the container is filled with blood. After the needed amount of blood is collected, the vacutainer tube will be removed, followed by the needle.

Upon removal of the needle, pressure will be applied to the venipuncture site using a sterile gauze or cotton to control bleeding. The gauze or cotton will be secured using surgical tape or a sterile bandage.

The participants will be given an instruction sheet regarding care of the puncture site(s) following the conclusion of research protocol (see attached).

INSTRUCTIONS FOR CARE FOLLOWING VENIPUNCTURE

- Leave bandage on site where the needle was in your vein (venipuncture site) for at least 2 hours after leaving lab.

- Call one of the laboratory researchers to assess your puncture site if you are experiencing one or more of the following:

  - Pain
  - Redness
  - Feels hot
  - Red streaks going away from the site of the venipuncture
  - Swelling
  - Bleeding
  - Drainage

- If you are experiencing one of the above symptoms and cannot contact one of the laboratory researchers to assess your puncture site, you should call your doctor.

- The laboratory researchers may be reached at the following numbers:

Name	**Office**	**Cell**
Jeb Struder		
Dr. Heather Webb		