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Deception of Resistance and the Effects on Muscular Fitness and Perceived Exertion

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and Perceived Exertion

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ABSTRACT

Resistance training has been a popular tactic that individuals have used to increase muscular fitness for decades. Muscular fitness includes muscular endurance, strength, and power. However, limitations such as self-efficacy and the Central Governor Theory may influence individual maximal performance ability. One training tactic that has been rarely researched is the deception of resistance during exercise, which is assumed to increase performances in all aspects of muscular fitness and improvements in perceived effort. Inconsistent results have been concluded from previous studies that have examined the same topic. Therefore, the purpose of this study was to investigate the effect of resistance deception on muscular fitness and perceived exertion, as well as the impact of self-efficacy. Five college-aged, resistance trained participants completed all four trials of this study. The first trial was the baseline testing which included a one-repetition maximum and repetitions to failure, at 60% one-repetition max, protocols of barbell back squat. The remaining three trials consisted of similar protocols but the resistance was masked. These three trials included: a five percent increase in resistance, a five percent decrease in resistance, and the same resistance lifted at baseline. Perceived exertion, self-efficacy, repetitions, bar velocity, and power output were observed during all trials. No statistically significant results were found among any tested variables. However, trends were shown in the data that are congruent with previous findings.

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INTRODUCTION

For decades, resistance training has been the one of the most popular tactics for individuals to induce muscular adaptations. This type of training has been shown by numerous research studies to improve muscular fitness, which according to the American College of Sports Medicine (ACSM) is an essential aspect of health-related fitness (24). Riebe et al. (24) explains that muscular fitness includes muscular endurance, muscular strength, and muscular power. Although these three components are often grouped together and may seem similar, they differ greatly. It has been concluded that training for muscular strength and muscular endurance simultaneously can hinder the development of strength gains (12). This implied that an individual will not be able to induce significant increases of strength and endurance concurrently. This theory could be explained by the predominance of different muscle fiber types. Muscle fiber types are generally classified as Type I or Type II. Type I, or slow-twitch fibers, are more resistant to fatigue as compared to Type II fibers. In contrast, Type II, or fast-twitch fibers, produce more force than Type I fibers. Powers & Howley (23) claimed that these two types of fibers produce different physiological muscular outputs due to three biomechanical factors: oxidative capacity, myosin isoform, and abundance of contractile protein. During muscular activity, intensity and duration of the activity determine levels of activation of Type I or Type II fibers engaged. In activities that are low intensity and long duration, Type I muscles fibers will become more prevalent for usage. Conversely, in high intense activities that are short in duration the Type II fibers will be used more. Vinogradova et al. (31) showed that during high-intensity resistance training, described as 80-85% of 1 rep maximum (1RM), Type II muscle fibers increased in cross-sectional area significantly compared to Type I fibers. This study also showed that during low-intensity resistance training (50% 1RM), there was a significant increase in Type I fibers compared to Type II. A lesser known, and less studied, tactic for improving muscular performance is deception of external load during exercise. With this method, the instructor misleads the exerciser into believing they are working at a different external load than the actual load being utilized. For example, Stone et al. (29) used nine cyclists to collect baseline time and work from a simulated race against an avatar. On the next trial, the cyclists were informed that they would work at the same rate but they actually increased the load by 2%. Results showed that cyclists improved in time and power output during the deception trial. This showed that deception of exercise can lead to greater increases in both muscular strength and endurance concurrently. While studies like this exist, limited research has been conducted on deception and resistance training. Other studies that have examined these effects found that deception did not increase muscular strength or muscular endurance. Possible conclusions for this are that single-joint exercises were performed, like bicep curls, and also a relatively small sample size of 8 participants (17). It is possible that these limitations were the reason that no significant results were found. Therefore, the purpose of this review was to examine if deception of the amount of resistance had any effects on muscular endurance, muscular strength, or muscular power in the lower body.

REVIEW OF LITERATURE

Muscular Endurance

Muscular endurance can be defined as the ability of a muscle, or group of muscles, to perform repeated actions until fatigue occurs (24). When performing a muscular endurance exercise, the repetitions should be greater than 12 to help ensure that muscular strength or power are not being targeted. Since this volume of repetitions is being performed, the total time of work will typically exceed 30 seconds. Therefore, glycolysis will be the primary energy pathway that is used to enable the muscles to perform the work. As for muscle fiber recruitment, resistance training exercise that targets muscular endurance will predominantly focus on Type II usage.

Assessing Muscular Endurance

Two separate categories of muscular endurance are known: absolute and relative. Absolute muscular endurance is termed as measuring the total number of repetitions performed at a standardized resistance (1). An example of an absolute muscular endurance test is the National Basketball Association (NBA) draft combine's bench press test. The bar is loaded with 185 pounds (83.91 kg) of weight and the athletes must perform as many repetitions as they can until fatigue. This type of muscular endurance test is often done if there is a large group of people causing insufficient time or in attempt to prevent injuries during a one repetition maximum test (1-RM). This type of test is also better used in certain environments that require a person to lift heavy objects repeatedly. An example of this could be a firefighter because of the obligations of their job. No matter the weight, height, or muscular fitness of the person, they must all perform the same tasks. In instances such as that, measuring muscular endurance in absolute terms may be a better assessment than relative. Conversely, relative muscular endurance refers to performing the repetitions at a percentage of an individual's respective 1-RM (1). This is a better way to measure muscular endurance when comparing people of different weight, height, or muscular fitness. Using the relative method, the test and results are more individualized and can often give a better assessment of a person. However, to perform a relative muscular endurance test, the participant must have a 1-RM tested prior. Without knowing the 1-RM, the researcher cannot load the weight to the designated percentage and thus the test could be invalid.

Muscular Strength

Muscular strength is defined as the maximal external force that a muscle, or group of muscles, can produce (24). Improvements in muscular strength can arise from either neural or muscular adaptations. Typically, neural adaptations are prominent in the first six to eight weeks of the resistance training program (14). Also, untrained individuals will see greater results due to greater neural improvements than those that are trained. Jones et al. (14) concluded that the first phase of training results in a major improvement in the ability to perform the resistance training exercises. This refers to the learning curve that occurs at the beginning of a training program and shows why untrained individuals will see greater results. The rapid improvements in muscular strength that are shown in the first six to eight weeks of a resistance training program are a result of enhanced neural pathways rather than skeletal muscle adaptations (14). For muscular strength, the primary metabolic pathway that will fuel skeletal muscle is the phosphocreatine (ATP-PCr) system. This energy is readily available and is used for high intensity exercise but only lasts for a few seconds. Since muscular strength is generally only one repetition, this is the most predominant energy pathway. Another factor that determines muscular strength is the amount and size of Type II fibers in the muscle. Netreba et al. (19) examined the effects of various training loads on cross-sectional area of Type II muscle fibers in the vastus lateralis. The training loads used in the protocol were based off of leg press machine 1RM values: low intensity (25%), moderate intensity (65%), and high intensity (85%). This study concluded that there was a relationship between increased load intensity and increased cross-sectional area of Type II fibers. That is, high intensity loads led to greater improvements of Type II fibers than both moderate and low intensity training loads.

Assessing Muscular Strength

The most common and most reliable measurement of muscular strength is the 1-RM test. Furthermore, measuring overall muscular strength of the lower body can be assessed using a back squat 1-RM test. Helms et al. (11) describes a protocol for an individual to use when working up to a maximum strength test. After brief stretching, the individual begins with 50% of predicted 1-RM and completed eight repetitions, followed by three repetitions at 60% of predicted 1-RM, followed by two repetitions at 70% or predicted 1-RM. Finally, the individual will then attempt to perform the predicted 1-RM and will continue to increase in weight until the maximum resistance is reached. A one-minute rest period is implemented between each set. This warm-up protocol is an effective way to reach a true 1-RM, as well as to help prevent injuries. Assessing muscular strength through 1-RM testing is effective and can give baseline data for creating muscular endurance and muscular power assessments.

Muscular Power

Muscular power is defined as the energy output of a muscle, or group of muscles, per unit of time (26). Knowing the difference between muscular strength and muscular power is important. Often times people will use these two interchangeably and that is incorrect. Muscular power is the amount of work that a muscle performs apportioned by the time it took to complete that work. Muscular power output is greater in a shorter amount of time than when exercise is prolonged. This is due to the energy pathway being used between each. In work that occurs in a small amount of time, the phosphocreatine (ATP-PCr) system is the predominant energy system being utilized. In longer durations of power exercises, the ATP-PCr stores become depleted and glycolysis can shift to the primary metabolic pathway that is needed to sustain the work (16).

Assessing Muscular Power

Muscular power is assessed by dividing work by time. Common units used to express power output are joules per second (watts) and foot-pounds per second. Squat jump, vertical jump, and power clean are all examples of tests used to assess muscular power. Also, muscular power can be evaluated as either peak or mean power. Peak power is the highest output measurement that was performed during the test. Mean power is an average of measured output throughout the testing procedure. There are multiple ways that barbell velocity and power can be assessed, such as linear position transducers (LPTs) and inertial measurement units (IMUs). LPTs measure the displacement and velocity on the barbell by using optical encoding technology. Whereas, IMUs measure barbell velocity by using gyroscopes, accelerometers, or magnetometers (2). One particular study that compares LPTs and IMUs was Thompson et al. (30) that explored the reliability and validity of six barbell velocity measuring devices for free-weight back squat and power clean. The devices tested were GymAware, Bar Sensei, PUSHbody, PUSHbar, Beast Sensor, and MyLift. The study involved 10 competitive weightlifters to perform initial 1RM testing for both back squat and power clean followed by three load velocity profiles on four separate occasions. Each device was assessed by data comparison to a 3D motion capture setup that included 12 cameras to measure time displacement. Results of this study showed that the GymAware device was the most reliable and valid in assessing peak and mean barbell velocity for both back squat and power clean. Another study that evaluated the GymAware device was conducted by Orange et al. (21). In this study, it was concluded that this device was a reliable and valid way to measure muscular power. More specifically, they found that it was very effective at measuring the mean velocity of the bar during 40-90% of 1-RM of the back squat. The use of this software removes some human error and also provides an easier method for calculating muscular power.

Perception of Effort

There are many different scales and charts that have been created to describe the perceived effort of an individual exercising. One of the most commonly used is the Borg Rate of Perceived Exertion (RPE) Scale. This scale has been validated as an accurate way to assess an individual's perceived exertion (27). Specifically, the Borg RPE scale has been validated during resistance training in comparison to blood lactic acid concentration, percentage 1RM, and muscle activity (15). Another is the OMNI Perceived Exertion Scale for Resistance Exercise (OMNI-RES). This is used during resistance exercise, such as back squat, and has been shown to be a valid way of assessing perceived exertion (15). The Rating of Fatigue (ROF) Scale as also been widely shown to have both face and convergent validity during exercise. The use of all of these scales to measure the individual's perceived exertion could show to be more precise than using only one. Studies have shown that psychological barriers exist that can affect how effort or intensity of exercise is perceived by an individual. De Bourdeaudhuji et al. (5) examined the effects that mental distraction has on treadmill running time. In this study, 30 obese subjects were split into two groups: distraction and non-distraction. Each group performed a treadmill test to exhaustion on four separate occasions; two sessions were performed on consecutive days and six weeks later the two remaining sessions were completed. The mental distraction group listened to their favorite music while the non-distraction group had no music. The study concluded that the distraction group performed the treadmill run significantly longer than the non-distraction group. This showed that overcoming certain psychological barriers may allow effort to be perceived differently and lead to enhanced muscular performance. Another aspect that comes with perceived exertion is safety. An individual that is trained will know how much force must be exerted to perform the work that is needed at a specific resistance. When a trained individual sees a weight that is well above maximal capacity, then safety and injury concerns can become a factor into the decision to perform the work.

Deception of Resistance

Along with Stone et al. (29), there have been studies that have shown the benefits of deceiving the participant of the work being performed. More specifically, some studies have shown benefits in resistance training settings. Ness et al. (18) had a total of 48 subjects that lifted for multiple weeks to determine baseline strength. Then, the participants performed three different trials: lifting more resistance than believed, lifting less resistance than believed, and no knowledge of the resistance. The results of the study showed that significantly higher performances of strength occurred in the trial where the resistance was greater than the subject believed. This showed that deceiving the participant of the weight they are lifting can elicit significant increases in their muscular fitness. The theory behind deceiving the participant about the resistance evolves around self-efficacy.

Self-efficacy is a person's belief in their ability to perform a task. Graham et al. (8) conducted a study that looked at the effects of self-efficacy and exercise performance. They found that participants that scored low on self-efficacy questionnaires also had worse performances on exercise testing. This suggested that individuals who suffers from low self-efficacy will not be able to perform to their maximum potential of muscular fitness. Another idea that is considered a form of deception and should be of concern is the effect that having spotters during resistance exercise induces. Sheridan et al. (28) researched this and found that the presence of spotters increased self-efficacy and work performed, as well as decreased the RPE. This indicates that having spotters can have an impact on the resistance lifted because the participant does not have the fear of injury.

However, other studies contradict this finding of lowered RPE. For example, Hampson et al. (9) examined perceived exertion differences in subjects that performed trials of high intensity running bouts. In this study, 40 well-trained subjects were split into four groups; Expected Similar, Expected Increase, Control Similar, and Control Increase. Each group completed three separate running bouts of 1680 meters at 80-86% peak speed. The two “Expected” groups were deceived of the intensities in which they worked during the running bouts and the two “Control” groups were properly informed. Following exercise, each subject gave a rating of perceived effort regarding the entire body. Overall, the results of this study showed no statistically significant differences in RPE between any groups. This led to the conclusion that when participants were working at an increased intensity, they reported similar RPE ratings. One mechanism that could have led to this phenomenon is the Central Governor Theory.

According to Noakes (20), exercise performance can be hindered due to chemical factors in the brain, which leads to central fatigue, or in the muscles, leading to peripheral fatigue. The peripheral fatigue model predicts that the exerciser will be able to perform until all of the motor units in the working muscles have been recruited. The central fatigue model, known as the Central Governor Theory, predicts that performance is subconsciously paced by the brain to allow the exerciser to maintain physiological homeostasis. It also predicts that in most cases, the exerciser finishes with physiological stores which means that they could have went longer or at a more intense pace. A separate study which was conducted by Inzlicht & Marcora (13), suggested that exertion is throttled by some central nervous system mechanism that receives information about energetic bodily needs and motivational drives to regulate exertion and, ultimately, to prevent homeostatic breakdown, chiefly energy depletion. It has been described as the brain's way of controlling exercise so that the body does not reach overexertion to cause detrimental effects. This method of regulation is based on the suggestion that, during exercise, the subconscious brain modulates the number of active motor units based on a pacing strategy that will allow completion of the task in the most efficient. These explanations by Noakes (20) as well as by Inzlicht & Marcora (13) indicated that if the subconscious brain can be deceived, then exercise performance can be improved.

Conclusion

Muscular fitness is an essential component of health-related fitness. Muscular endurance, muscular strength, and muscular power are all important aspects for not just athletes but the general population. Low self-efficacy is a common issue that individuals deal with and can cause less than maximal performances during exercise. Therefore, the tactic of masking the resistance to deceive the individual can be used as a way to limit the detriment of low self-efficacy. With the individual believing that the weight will be easier than in reality, they could possibly perform at their true maximum potential of muscular fitness. Future research needs to continue to examine if deception of weight during resistance exercise can elicit greater muscular fitness. Also, self-efficacy and resistance training should be further examined to see if a correlation exists.

METHODS

Participants

Recruiting participants involved distributing fliers around the university campus, along with the Kinesiology and Health Science instructors informing their students via email and word of mouth. Participants of this experimental study were college aged males and females that had to meet the following requirements: 18 to 26 years of age, no contraindications to exercise or injuries, and a minimum of two months of consistent resistance training experience (advanced training status according to National Strength and Conditioning Association). The Institutional Review Board of Stephen F. Austin State University approved this study and written informed consent was obtained prior to data collection. All procedures and protocols met the ethical principles set forth in the Declaration of Helsinki.

Protocol

For the first day, subjects reported to the testing facility where anthropometric measurements were assessed. Body composition was collected using a dual X-ray absorptiometry (DEXA) machine (General Electric Medical Systems Lunar, Madison, WI). Height was measured using a stadiometer (Detecto, Webb City, MO) and a medical scale (Detecto, Webb City, MO) for weight. Along with anthropometric assessments, a pre-exercise screening questionnaire, and an informed consent were completed on the first day the subject reported to the testing facility before any exercise. The Physical Activity Readiness Questionnaire, or PAR-Q, is the tool that was used to screen participants as it has been shown to be a valid and reliable test (3). Baseline measurements were also completed on the initial day, which included 1RM on back squat and repetitions to failure with 60% 1RM on back squat. The free-weight back squat lift was performed using a barbell (Pro Power Bar, Power Systems; Knoxville, TN) and barbell plates (VTX Grip Plate, TROY Barbell and Fitness; Houston, TX). Before engaging in any exercise, each participant was properly instructed on correct form to minimize the risk of injury. Movement speed of the back squat was assessed using the GymAware software and equipment (Kinetic Performance Technology, Canberra, Australia). Immediately after each bout of exercise, subjects completed a Rating of Fatigue Scale (ROF), a Borg Rating of Perceived Exertion Scale (RPE) and an OMNI-RES scale.

A standardized dynamic warm-up was prescribed to the participants before each bout of exercise. This consisted of three minutes on a cycle ergometer (Monark Exercise AB, Varberg, Sweden) at 40 rpm, 10 walking knee lifts, 10 walking lunges, 10 bodyweight squats, and 10 barbell back squats with 45 lbs. of resistance, in that order. Then, subjects performed the 1RM testing protocol as described by Haff & Triplett (10) which is accredited by the National

Strength and Conditioning Association. For this protocol, the subject completed 5-10 repetitions of back squats at a light load. One minute of rest was given, then 10-20 percent of the previous resistance was added to the back squat barbell and the subject completed three to five repetitions. Next, following a two-minute rest, 10-20 percent of the previous load was again added and the subject performed two to three repetitions of a near maximal resistance. Next, three minutes of rest was given and load was increased by 10-20 percent for the subject to perform a single time. If this lift was successful and the researcher believed it to be safe, then 5-10 percent was added and the subject attempted another single repetition after a three-minute rest period. This process continued either until the subject failed a lift or the test administrator recommended to stop. Just before performing the 1RM lift, the participant completed a 100 mm visual analog scale (VAS) to assess self-efficacy. To monitor levels of fatigue, ROF, OMNI-RES and RPE scales were completed by the subject immediately following the 1RM testing.

At the conclusion of 1RM testing, the subject was then given a minimum of 30 minutes of rest. As the subject is out of the testing room, the test administrator loaded the bar with 60% of the 1RM that was just assessed. When the rest period was completed, the subject returned and performed the same standardized dynamic warm-up and completed the same self-efficacy VAS scale. Then, the subject completed a reps-to-failure protocol at 60% 1RM, in which they lifted the weight as many times as possible. After completion, the ROF, OMNI-RES, and RPE scales were presented to the subject to assess perceived fatigue.

After completion of the muscular strength and muscular endurance baseline testing (MSB and MEB, respectively), each subject was required to report to the testing facility for three disguised 1RM assessments of back squats. These three disguised trials consisted of: recorded 1RM (MSE: muscular strength even), five percent increase (MSI: muscular strength increase), and five percent decrease (MSD: muscular strength decrease). The order of the trials were counterbalanced. Trials were separated by a minimum of 72 hours. For each trial, the subject completed the same standardized dynamic warm-up and the self-efficacy VAS scale before beginning the protocol. Also, while test administrators were loading the weight, the participant was never in the room and could not be able to see the amount of resistance that they were lifting. The weighted plates that provide resistance for the back squat machine were covered with a plastic sheet so that visual deception for the subject was achieved to the highest degree possible.

The muscular endurance testing was very similar to the muscular strength testing. Using the MSB measurement, subjects performed repetitions to failure at 60% of that resistance to assess muscular endurance baseline (MEB). Like the muscular strength protocol, there were three separate disguised trials for muscular endurance that each participant performed: 60% 1RM (MEE: muscular endurance even), 65% 1RM (MEI: muscular endurance increase), 55% 1RM (MED: muscular endurance decrease). The trials were counterbalanced and the subjects always exited the room while test administrators loaded the weight on the back squat barbell. The weight was masked again with the plastic sheets for visual deception. Participants performed the muscular endurance test a minimum of 30 minutes after the muscular strength protocol was completed.

For assessment of muscular power, the movement speed of the back squat was measured using the GymAware software (Kinetic Performance Technology, Canberra, Australia). This device attached a cable to the barbell and assessed multiple variables during the 1RM and muscular endurance protocols. This included mean and peak velocity, as well as mean and peak power. Velocity was displayed in meters per second (m/s) and power was presented in watts (W). The information was automatically processed by the device and displayed onto a digital screen. These figures were noted by the researcher and used for statistical data processing.

Statistical Analysis

Repeated Measures Analysis of Variance (RMANOVA) was used to compare the means of both within groups and between groups. Post hoc analysis using Tukey’s Test was used to determine the differences between the trials. Variables that were analyzed with RMANOVA for the muscular strength trials were RPE, ROF, OMNI, SES, mean velocity, peak velocity, mean power, and peak power. For muscular endurance trials, the same variable was measured as well as repetitions completed. Statistical significance was set at $p < 0.05$ for all analyses.

RESULTS

Eight university students originally volunteered to participate in this experimental study. Throughout testing protocol, three of the volunteers failed to complete the study for personal reasons. Therefore, five participants (two males and three females) completed all required trials of the study. Descriptive data of the subjects is shown in Table 1. Two of the subjects were unsuccessful in lifting the resistance of the MSI trial. Therefore, some variables were unable to be recorded for these subjects; including mean velocity, peak velocity, mean power, and peak power. RMANOVA showed that there were no significant differences in any of the perceived exertion scales or the self-efficacy scale during the muscular strength trials. RPE (MSB 15.8 ± 1.92, MSI 14.4 ± 3.36, MSD 12.00 ± 1.22, MSE 14.40 ± 2.97; $p = 0.159$), ROF (MSB 4.80 ± 1.92, MSI 5.20 ± 2.28, MSD 4.40 ± 0.89, MSE 5.60 ± 2.61; $p = 0.163$), and OMNI (MSB 8.20 ± 0.84, MSI 7.20 ± 1.92, MSD 5.60 ± 1.67, MSE 6.80 ± 2.17; $p = 0.809$), all shown in Table 2 and Figure 1. This statistical test also showed that no significant differences were found in mean velocity (MSB 0.27 ± 0.05, MSD 0.32 ± 0.08, MSE 0.31 ± 0.08; $p = 0.669$), peak velocity (MSB 0.68 ± 0.08, MSD 0.71 ± 0.12, MSE 0.67 ± 0.07; $p = 0.783$), mean power (MSB 504.80 ± 201.34, MSD 626.69 ± 186.00, MSE 597.46 ± 229.91; $p = 0.569$), or peak power (MSB 1412.11 ± 487.58, MSD

1484.35 ± 228.91, MSE 1379.39 ± 443.71; $p = 0.603$) throughout the muscular strength trials, shown in Table 3, Figure 2 and Figure 3. The muscular endurance trials also showed no significant differences in any tested variables via RMANOVA. No significant differences were found between RPE values during muscular endurance trials (MEB 15.8 ± 1.48, MEI 15.40 ± 2.19, MED 14.20 ± 2.77, MEE 13.40 ± 2.07; $p = 0.316$), as described in Table 4 and Figure 4. No significant differences were found between ROF values (MEB 7.20 ± 0.45, MEI 8.00 ± 1.58, MED 7.00 ± 1.58, MEE 6.60 ± 1.34; $p = 0.319$), as seen in Table 4 and Figure 4. Also, no statistically significant differences were revealed between OMNI values (MEB 7.60 ± 0.55, MEI 8.00 ± 1.41, MED 7.00 ± 1.22, MEE 6.60 ± 1.34; $p = 0.285$), shown in Table 4 and Figure 4. Repetitions completed showed no significant differences between trials (MEB 17.8 ± 5.93, MEI 21.2 ± 5.45, MED 26.00 ± 9.30, MEE 22.80 ± 6.53; $p = 0.342$), Table 5 and Figure 7. Mean velocity of the bar also showed no significant differences during muscular endurance tests (MEB 0.49 ± 0.02, MEI 0.48 ± 0.05, MED 0.54 ± 0.04, MEE 0.50 ± 0.02; $p = 0.096$), Table 5 and Figure 5. There were also no significant differences between peak bar velocity (MEB 0.74 ± 0.03, MEI 0.73 ± 0.07, MED 0.79 ± 0.10, MEE 0.75 ± 0.04; $p = 0.479$), Table 5 and Figure 5. Mean power showed no significant differences (MEB 767.20 ± 145.98, MEI 775.30 ± 224.80, MED 799.38 ± 215.32, MEE 777.72 ± 135.30; $p = 0.994$), Table 5 and Figure 6. No significant differences were shown with peak power (MEB 1161.33 ± 299.23, MEI 1234.82 ±

362.91, MED 1247.75 ± 392.51, MEE 1181.07 ± 280.21; $p = 0.972$), Table 5 and Figure 6.

DISCUSSION

The purpose of this study was to examine if deceiving an individual of the amount of resistance has any effects on lower body muscular endurance, muscular strength, muscular power, perceived exertion, or self-efficacy during lower body resistance training. Little research has been conducted in regards to resistance deception, with most of those not regarding weight training. Overall, the results of previous compiled studies have shown to be inconclusive. The current study aimed to see if this resistance deception theory could be a viable training technique for athletes, coaches, and other fitness personnel to use to elicit muscular fitness gains. The present study did not find any statistically significant results across any of the variables that were tested. Limitations from the present study will be discussed in the following paragraphs.

Although there were no statistically significant differences found in the data, trends did appear within the present study. Specifically, mean power trended upward during the MSE trial as compared to the MSB trial, as seen in Table 3 and Figure 3. This implies that subjects were able to produce more power with the same amount of resistance during a masked 1RM lift than an unmasked. Although this result of the current study was not found statistically significant, it does agree with the findings of Ness et al. (18) which concluded that deception of resistance led to increased muscular fitness in that respective study. Mean barbell velocity also showed a trending increase during the MSE trial when compared to the MSB trial, as shown in Table 5 and Figure 5. Although this was not found to be statistically significant, this particular increase in mean barbell velocity has not been shown in prior research. Dickerson, B.L. (6) conducted a similar study with masked trials during bench press and found no significant differences in bar velocity between baseline and even weight masked trials. In fact, bar speed in that particular study slightly decreased in the even weight masked trail as compared to the baseline. While the analyses of the current study did show some increase in the MSE trial, the same result did not translate during the MSI trial. Another noticeable trend that emerged was an increase during the MS trials regarding the SES scale. During all three masked trials, the participants mean SES was greater than that at the unmasked baseline trial, shown in Table 2. This seemed to indicate that participants were more confident in their ability to perform as well or better than their baseline performance. With the little research that has been conducted on resistance deception, no found study have shown significant results regarding self-efficacy and resistance deception in muscular performance. MS perceived exertion seemed to decrease during the masked trials as well. This can be seen from the RPE and OMNI values being lower in all MS masked trials as compared to baseline, shown in Table 2 and Figure 1. Even when the resistance was increased by five percent and participants also made comments such as, “That was easier to squat than on day one,” and “That squat felt much better.” Along with emerging trends within the MS trials, there were also developments that showed from the ME trials. Such as, mean and peak power tended to increase throughout all of the masked trials as compared to baseline, shown in Table 5 and Figure 6. This observation can be interpreted to indicate that even with the same or an increased resistance as baseline, participants were able to produce more power throughout the repetitions completed. Slight increases can be seen in mean and peak bar velocity as well when comparing the MEE trial to baseline, seen in Table 5 and Figure 5. Indicating that bar speed can be increased when the same amount of weight is masked. Rating of perceived exertion also showed a trending decrease in the ME trials as RPE, ROF, and OMNI scales were lower in the MEE trial as compared to baseline, Table 4 and Figure 4. Implying with an equal or increased amount of weight, participants felt that the protocol was easier as compared to baseline. This effect parallels to the findings of De Bourdeaudhuji et al. (5) which stated that mental distraction can lead to participants perceiving their effort as less than not having that distraction. The last trend that can be seen from the results is that the number of repetitions that were completed during masked trials were greater than at baseline, shown in Table 5 and Figure 7. So, even with a five percent increase in resistance, participants were able to complete more repetitions. Again, these are not statistically shown and should be studied deeper before calling this method effective. A possible explanation for these trends found in the current study is the manipulation of the Central Governor Theory. As described previously, this theory is based on the notion that the brain subconsciously paces or cautions the body during resistance exercise. The current study found certain trends that suggest that masking the weight during resistance training can lead to increases in muscular performance. Further research should continue to pursue the idea of resistance deception.

Limitations

Multiple limitations existed within the present study. Sample size is an example as only five participants fully completed the protocol. Due to this limitation, further research should be conducted that includes a sample size significantly larger than in the present study. Another limitation that existed was the effectiveness of resistance deception during the masked trials. For example, participants made comments such as, “I think that I am about to lift more weight than I am being told” and “I think the weight is being hidden because it is different than what you (the researcher) are telling me.” Although the participants did not know whether they were performing their increase, decrease, or even trial, they were still questioning the weight. Future studies should attempt other methods of resistance deception, such as altered weights. Another limitation that exists is that three spotters were not present during every trial. There was two for every trial and a third spotter was only present on occasion, due to scheduling conflicts.

This number of spotters present has been shown by Sheridan et al. (28) to have influences on performance during resistance training. In future research, the number of spotters should be consistent with every trial to minimize any effects on the participant.

Conclusion

The present study showed that improvements in bar velocity, power output, repetitions, perceived exertion, and self-efficacy can be elicited by using resistance deception techniques. Although no statistically significant results were found in the present study, the outcomes that were found do agree with similar previous studies. These conclusions indicate that individuals can produce greater muscular performance when they are deceived to believe that the weight being lifted is less than the actual amount. For practical use, this training tactic could be used by athletes, coaches, and trainers to increase performance for muscular strength, endurance, and power. Users might consider less than a five percent increase on the muscular strength (1RM) regimen, as the current study had individuals that could not lift their respective amount of weight. Once more, the present study did not find statistically significant results. Conclusions therein are based on trends seen within the data that were shown to agree with previous studies. Future research should continue to explore this area of training, while bearing in mind the limitations and outcomes of the present study.

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Table 1. Descriptive data of participants

Descriptive	Women (n = 3)	Men (n = 2)	Total (n = 5)
Age (years)	21.5 ± 1.26	22.38 ± 0.06	21.85 ± 1.01
Weight (kg)	71.21 ± 6.71	90.95 ± 8.02	79.11 ± 12.47
Height (cm)	165.52 ± 5.59	175.13 ± 3.78	169.36 ± 6.85
Body Fat (%)	29.13 ± 3.00	22.80 ± 4.95	26.60 ± 4.76
1RM (kg)	106.59 ± 21.63	158.76 ± 9.62	127.46 ± 32.76

All values represent mean ± SD. 1RM = one-repetition maximum.

Table 2. Perceived exertion and self-efficacy scales from MS trials

Variables	MSB	MSI	MSD	MSE
ROF	4.80 ± 1.92	5.20 ± 2.28	4.40 ± 0.89	5.60 ± 2.61
RPE	15.80 ± 1.92	14.40 ± 3.36	12.00 ± 1.22	14.40 ± 2.97
OMNI	8.20 ± 0.84	7.20 ± 1.92	5.60 ± 1.67	6.80 ± 2.17
SES (mm)	36.20 ± 27.91	55.20 ± 35.05	67.80 ± 20.56	61.00 ± 25.15

All values represent mean ± SD. MSB = muscular strength baseline. MSI = muscular strength increase. MSD = muscular strength decrease. MSE= muscular strength even. SES = self-efficacy scale. *denotes significant difference from baseline.

Table 3. Bar velocity and power output during MS trials

Variables	MSB	MSI	MSD	MSE
Mean Velocity (m/s)	0.27 ± 0.05	NA	0.32 ± 0.08	0.31 ± 0.08
Peak Velocity (m/s)	0.68 ± 0.08	NA	0.71 ± 0.12	0.67 ± 0.07
Mean Power (W)	504.8 ± 201.34	NA	626.69 ± 186.00	597.46 ± 229.91
Peak Power (W)	1412.11 ± 487.58	NA	1484.35 ± 228.91	1379.39 ± 443.71

All values represent mean ± SD. MSB = muscular strength baseline. MSI = muscular strength increase. MSD = muscular strength decrease. MSE= muscular strength even. *denotes significant difference from baseline.

Table 4. Perceived exertion and self-efficacy scales from ME trials

Variables	MEB	MEI	MED	MEE
ROF	7.20 ± 0.45	8.00 ± 1.58	7.00 ± 1.58	6.60 ± 1.14
RPE	15.80 ± 1.48	15.40 ± 2.19	14.20 ± 2.77	13.40 ± 2.07
OMNI	7.60 ± 0.55	8.00 ± 1.41	7.00 ± 1.22	6.60 ± 1.34
SES (mm)	NA	69.60 ± 5.37	61.60 ± 15.82	69.80 ± 17.53

All values represent mean ± SD. MEB = muscular endurance baseline. MEI = muscular endurance increase. MED = muscular endurance decrease. MEE= muscular endurance even. SES = self-efficacy scale. *denotes significant difference from baseline.

Table 5. Repetitions, bar velocity, and power output from ME trials

Variables	MEB	MEI	MED	MEE
Repetitions	17.80 ± 5.93	21.20 ± 5.45	26.00 ± 9.30	22.80 ± 6.53
Mean Velocity (m/s)	0.49 ± 0.02	0.48 ± 0.05	0.54 ± 0.04	0.50 ± 0.02
Peak Velocity (m/s)	0.74 ± 0.03	0.73 ± 0.07	0.79 ± 0.10	0.75 ± 0.04
Mean Power (W)	767.20 ± 145.98	775.30 ± 224.80	779.38 ± 215.32	777.72 ± 135.30
Peak Power (W)	1161.33 ± 299.23	1234.82 ± 362.91	1247.75 ± 392.51	1181.07 ± 280.21

All values represent mean ± SD. MEB = muscular endurance baseline. MEI = muscular endurance increase. MED = muscular endurance decrease. MEE= muscular endurance even. *denotes significant difference from baseline.

Figure 1.

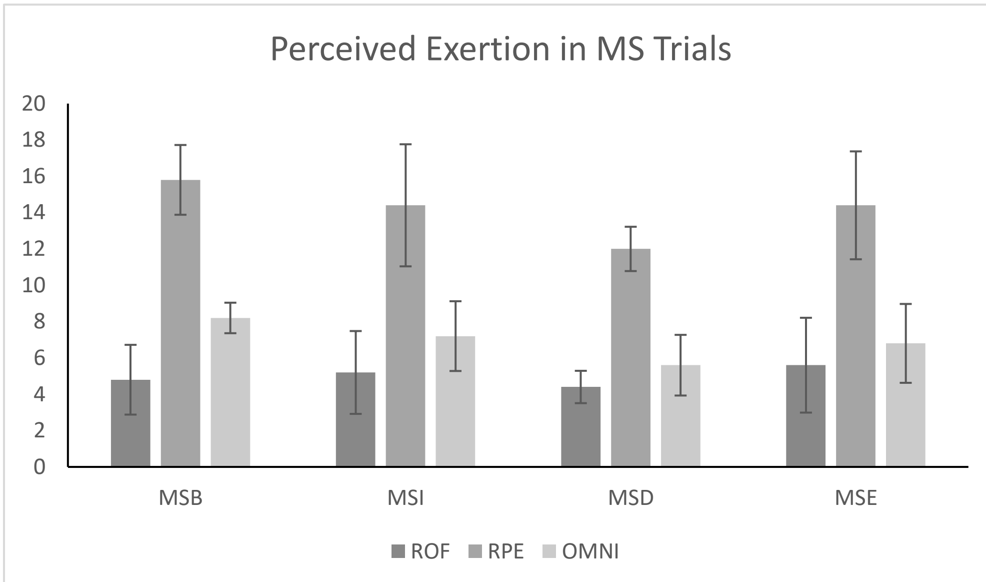

Perceived Exertion in MS Trials
20
18
16
14
12
10
8
6
4
2
0
MSB
MSI
MSD
MSE
ROF
RPE
OMNI

Figure 2.

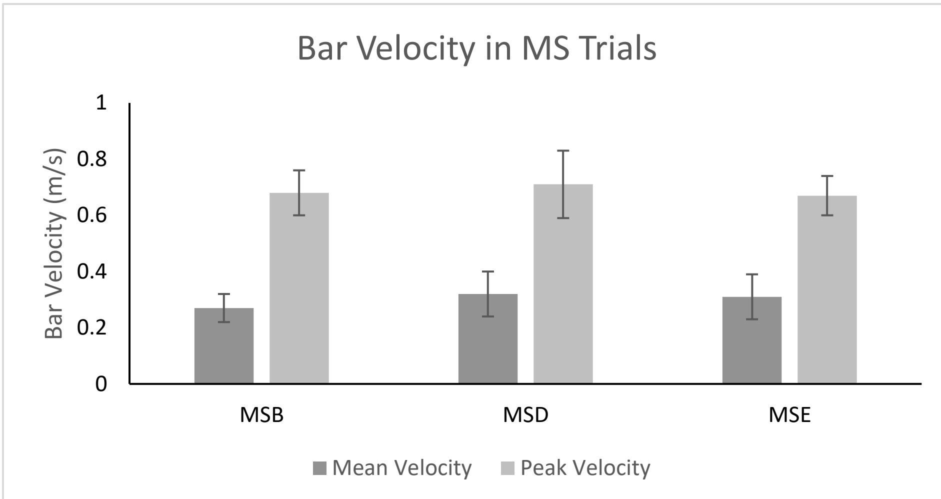
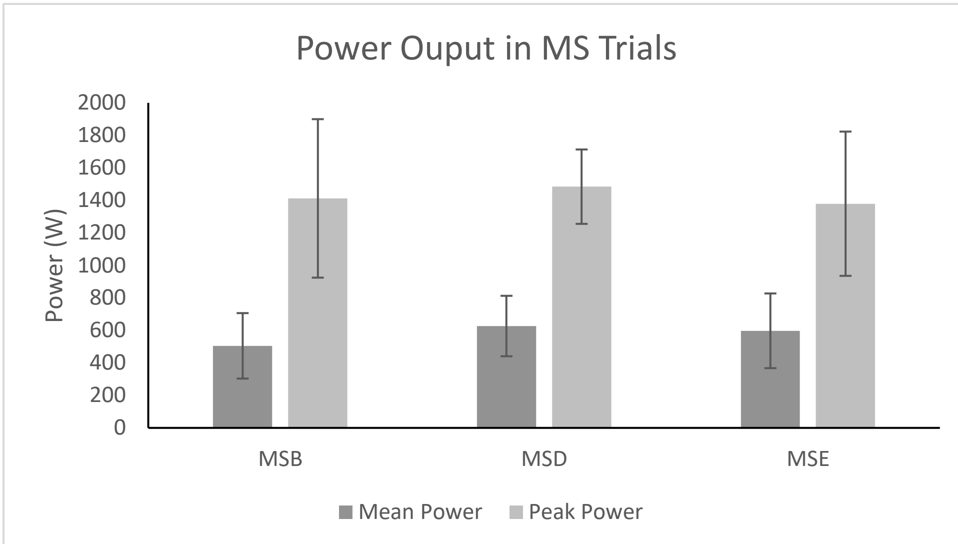
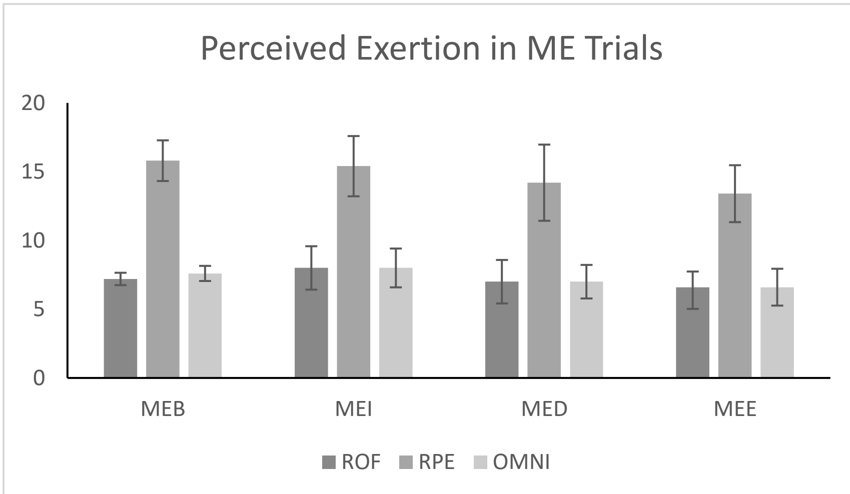

Bar Velocity in MS Trials
Bar Velocity (m/s)
1
0.8
0.6
0.4
0.2
0
MSB
MSD
MSE
Mean Velocity
Peak Velocity

Figure 3.



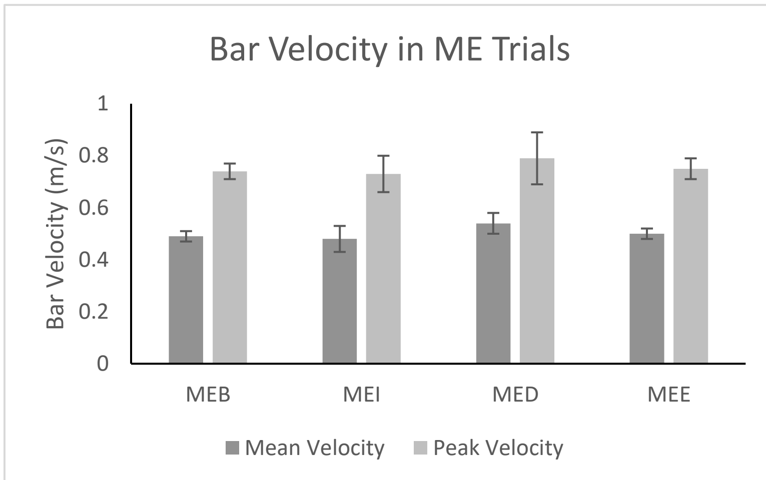
Power Ouput in MS Trials
Power (W)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
MSB
MSD
MSE
Mean Power
Peak Power

Figure 4.



Perceived Exertion in ME Trials
20
15
10
5
0
MEB
MEI
MED
MEE
ROF
RPE
OMNI

Figure 5.



Bar Velocity in ME Trials
Bar Velocity (m/s)
1
0.8
0.6
0.4
0.2
0
MEB
MEI
MED
MEE
Mean Velocity
Peak Velocity

Figure 6.

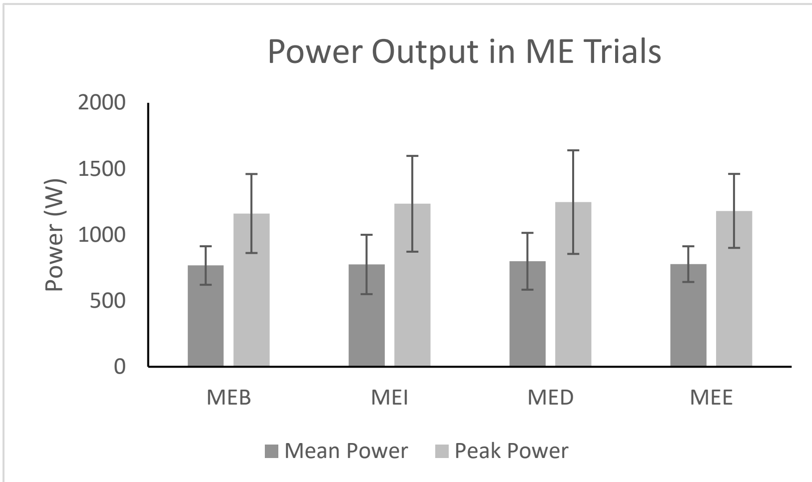

Power Output in ME Trials
Power (W)
2000
1500
1000
500
0
MEB
MEI
MED
MEE
Mean Power
Peak Power

Figure 7.

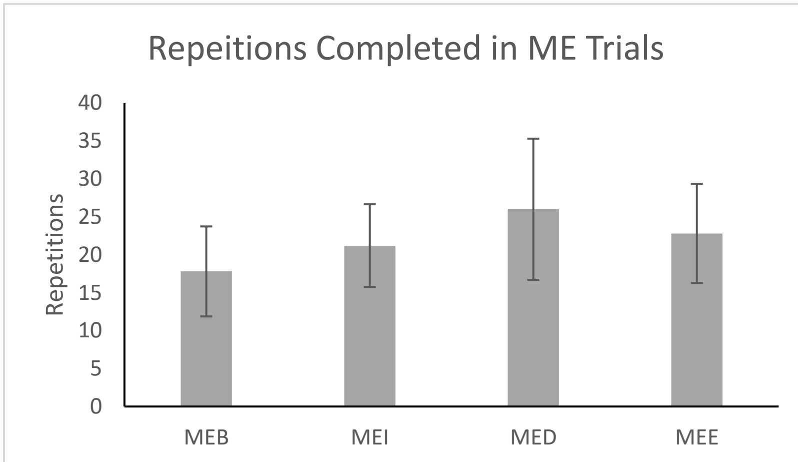

Repeitions Completed in ME Trials
40
35
30
25
20
15
10
5
0
Repetitions
MEB
MEI
MED
MEE

Figure 1. RPE, ROF, and OMNI reported in baseline and masked MS trials. No significant difference between RPE, ROF, and OMNI comparing all MS trials. Set at $p \leq 0.05$.

Figure 2. Mean and peak bar velocity (m/s) in MS trials. MSI trial not shown, due to failure to complete repetition. No significant differences in bar velocity comparing all MS trials. Set at $p \leq 0.05$.

Figure 3. Mean and peak power output (W) reported in baseline and masked MS trials. MSI trial not shown, due to failure to complete repetition. No significant differences in power output comparing all MS trials. Set at $p \leq 0.05$.

Figure 4. RPE, ROF, and OMNI during ME at baseline and masked trials. No significant difference between RPE, ROF, and OMNI comparing all ME trials. Set at $p \leq 0.05$.

Figure 5. Mean and peak bar velocity (m/s) during ME baseline and masked trials. No significant differences found in bar velocity comparing all ME trials. Set at $p \leq 0.05$.

Figure 6. Mean and peak power output (W) performed during ME baseline and masked trials. No significant differences in power output comparing all ME trials. Set at $p \leq 0.05$.

Figure 7. Repetitions completed during ME baseline and masked trials. No significant differences found between baseline and masked ME trials. Set at $p \leq 0.05$.

VITA

After graduating from Central High School (Pollok, Texas) in 2014, William Tyler McHenry enrolled into Angelina College in Lufkin, Texas. After preliminary classes, he transferred to Stephen F. Austin State University in Nacogdoches, Texas in the spring semester of 2016. In May of 2019, he received his Bachelor of Science in Kinesiology with an emphasis in fitness and human performance. Following graduation, he enrolled in the Graduate School of Stephen F. Austin Statue University in the Kinesiology and Health Science Department. Along with enrollment, he also accepted the position as a graduate teaching/research assistant in the same department. He was the instructor of record for two lecture courses as well as several different activity and laboratory courses.

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