Original Research

The Acute Effect of Pilates Exercise on Lower Extremity Maximal Strength

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ABSTRACT

International Journal of Exercise Science 9(3): 283-290, 2016. In recent years, the effects of chronic core training on athletic performance have been examined with mixed results; however, the acute effects of core training on athletic performance variables have yet to be examined. Therefore, the purpose of this study was to determine the relationship between an acute bout of core training and lower extremity maximal strength. Seventeen healthy males (weight 90.1 ± 17.2 kg; height 176.7 ± 11.2 cm; age 20.9 ± 1.3 years) performed maximal deadlift assessments following 2 testing conditions. A general cardiovascular warm-up was used as the control condition, and a mat-based Pilates warm-up was used as the core training condition. Statistical significance was set at $p < 0.05$. Results from a paired-samples t-test showed that the average maximal strength achieved in the Pilates condition (168.6 ± 33.0kg) was significantly higher compared to the Control condition (161.4 ± 31.9kg). These results indicate that an acute bout of core training does have a significant effect on lower extremity maximal strength. Therefore, it may be beneficial to perform core activation exercises, such as Pilates, as part of a warm-up to activate core muscles directly preceding a lower extremity strength exercise.

KEY WORDS: Core training, core function, trunk muscles, athletic performance, deadlift

INTRODUCTION

Kinesiology professionals describe the anatomic core as a collection of 29 muscles that cross joints within the Lumbo-Pelvic-Hip (LPH) complex of the body and, as such, have an important role in carrying out both simple and complex body movements (1). The term "core function" can be described as the ability of the core to successfully generate, transfer, and control force and motion in the LPH complex and extremities in all three planes of motion according to the demands being placed on the body (26). Due to the widespread acknowledgment of the importance of appropriate core function in maximizing sport performance, exercises designed to increase stability, maintain mobility, and increase core strength are common components of strength and conditioning programs across sports and recreation.

Chronic core training is commonly used to improve core function by improving stability, optimizing mobility, and enhancing force production and transfer during functional movements. Research shows that movement production and control originates in the trunk and progresses to the extremities following specific patterns along the kinetic chain (9, 16, 26). Therefore, dynamic movements rely on the core for a stable foundation to allow effective extremity motion. A chronic effect of core training includes increased core strength, which may improve the ability of the core to generate, transfer and control a maximal force, thereby producing a more powerful and controlled movement in the extremities (16, 22, 23, 25, 26). In addition, increasing core strength may improve the capacity of the core to stabilize the LPH complex and optimize mobility, which is essential in maximizing force production in the extremities (8, 16, 23, 26).

Acute core function relies significantly on the ability of the central nervous system (CNS) to monitor the demands being placed on the body and respond with appropriate force generation in the musculature. Sensory receptors constantly monitor the static and dynamic position of the body and relay the information to the spinal stabilizing system, which determines the amount of force required to adequately stabilize the LPH complex (18). Depending on the requirements, varying levels of muscle activation are necessary to generate and transfer a force to stabilize the trunk and mobilize the extremities (9, 11, 18). Therefore, it is necessary for the CNS to function effectively to optimize core function acutely.

There is little known about the effects of acute core training on core function and performance, however, there is a clear relationship between trunk muscle activity and lower extremity movement (16, 25, 26). Efficient lower extremity movement relies on pre-programmed patterns of muscle activation that originate in the core and can be improved with repetition (9, 26). Evidence suggests that performing exercises with specific motion patterns may improve the ability of the CNS to respond to those patterns, resulting in enhanced muscle activation and higher quality movements (11, 26). In addition, acute core activation has been shown to improve movement control and stability during dynamic kinetic chain activities (11, 12, 16). This suggests that acute core activation has the potential to enhance muscle activation patterns resulting in increased stability and control, thereby improving performance.

There has been extensive research on what types of exercises are most effective in activating the core muscles. According to a review of the current literature, it is suggested that optimal core activating exercises incorporate complex movements that utilize a large range of muscles (7, 8, 21). Gottschall et al. (7) found that integration exercises that include the proximal trunk muscles (abdomen and lumbar) and distal trunk muscles (deltoid and gluteal) elicited higher core activation compared to isolation exercises that only included the proximal trunk. In addition, multiple studies found that dynamic movements that mimicked sport-related activities activated the core musculature significantly more than simple movements (8, 21, 12). Integration exercises, such as Yoga, Pilates, Tai Chi, Swiss Ball training and other dynamic activities elicit muscular activity from a broad range of core muscles, thereby maximizing core function.

Pilates is an exercise modality commonly associated with an emphasis on improving core function chronically by enhancing core strength, flexibility, muscle control, posture and breathing (24). Pilates incorporates complex exercises that require stabilization of the LPH complex while performing controlled movements of the extremities, which has been shown to elicit high core muscle activity (20). Furthermore, Pilates elicits muscle activity that mimics specific activation patterns along the kinetic chain that are observed in functional movements (4). Research has shown that the chronic effects of Pilates can improve performance of functional movements by strengthening the core and training specific activation patterns (4). Despite extensive research on the chronic effects of Pilates training on core function, there has been little research on the effects of a Pilates warm up on acute sports performance.

Currently, there is a lack of sufficient data to allow strength and conditioning professionals to create evidence-based core function training programs despite their popularity. The effects of chronic core training on athletic performance have been examined with mixed results. However, the acute effects of core training on athletic performance variables have yet to be examined. The purpose of this study is to determine the acute effect of a Pilates exercise intervention on lower extremity maximal strength performance involving the deadlift exercise. We hypothesized that lower extremity maximal strength would be higher following the Pilates condition compared to the Control condition.

METHODS

Participants

Seventeen healthy college males (weight 90.1 ± 17.2 kg; height 176.7 ± 11.2 cm; age 20.9 ± 1.3 years) participated in this study. The participants were informed of the experimental procedures and possible risks involved with the study, and informed consent was obtained. All participants self-reported being recreationally active and incorporating the deadlift exercise into their resistance training program for six-months prior to entering the study and demonstrated proficiency with the deadlift exercise. Participants were free of cardiovascular, metabolic, neuromuscular, and orthopedic pathology as indicated through a self-reported medical history form. The Longwood University Ethics Committee approved this study.

Protocol

Participants met for three sessions with a minimum of 48-hrs between visits. The average time between study sessions was 72 hours. On the first visit, participants reported to the weight room for initial screening including an explanation of the study requirements, obtainment of informed consent, and testing for deadlift proficiency and 1-repetition maximum (1-RM). Following initial screening, participants were randomly assigned to either the Pilates or control testing condition to be completed at the 2nd visit. Random assignments were determined through the use of a random number generator website (www.random.com) whereby an odd number generated resulted in completing the Pilates condition during the session following the initial 1RM test and an even number generated resulted in completing the cycling condition during the session following the initial 1RM test. The testing condition not performed during the 2nd visit was performed during the 3rd visit. Following both testing conditions, the 1-RM assessment was completed. Participants were not informed of the testing loads from visit 1 during visit 2 in an attempt to minimize bias.

Deadlift proficiency was evaluated by having the participant demonstrate proper deadlift exercise technique with a 55lbs. load (standard barbell plus two 5lbs. training plates to raise the bar off the floor) in the presence of an NSCA Certified Strength and Conditioning Specialist without cuing. Proper technique was defined using guidelines for the deadlift exercise published by the National Strength and Conditioning Association including placing the feet either hip or shoulder width apart beneath the barbell, grasping the barbell with a neutral width, overhand grip, and executing the lift such that the hips and shoulders move at the same time (i.e., the hips do not rise higher than the shoulders) (2). After showing proficiency, the maximal strength deadlift was tested by having the participant complete the following protocol: 2 sets of 3 repetitions at an estimated 50% of 1-RM; 2 sets of 3 repetitions at an estimated 75% of 1-RM; then successive sets of 1 repetition with increasing loads (estimated 85% 1-RM, 95% 1-RM, 100% 1-RM, 105% 1-RM) with 3 minutes rest between every set. Maximal strength was determined as the load lifted prior to technique failure. Technique failure was defined as an inability to perform the lift while conforming to the proficiency criteria outlined earlier. This 1RM protocol was also used to assess maximal deadlift strength following both the experimental (Pilates) and control (cycling) warm-up intervention. Sub-maximal loads used by the participants during the 1RM test protocol in both the experimental and control conditions were determined using the 1-RM determined in the first visit.

The Pilates testing condition involved participants completing a Pilates training video program (*Pilates-Beginning Mat Workout*, Gaiam, Inc., 2002) to ensure standardization of exercise cuing and technique across participants. This program included approximately 12-minutes of a series of mat-based, beginner level Pilates exercises targeting the muscles of the LPH complex.

The control testing condition involved participants performing 12 minutes of sub-maximal cycling on a cycle ergometer at a self-selected cadence and intensity considered to be moderate (defined as a self-report of a Ratings of Perceived Exertion (RPE) of 10-11 on a 6-20 scale). The duration of the control warm-up was selected to match the duration of the experimental warm-up (12 min) and the intensity and cadence of the control warm-up were selected to mimic recommendations that general warm-ups should consist of 5-10min of light to moderate cardiorespiratory exercise (20).

Statistical Analysis

The maximum loads lifted prior to technique failure during both visits were used for statistical analysis. The data was statistically analyzed using a paired samples t-test with mixed-modeling procedures in the SPSS 19.0 software (IBM, Armonk, NY, USA). The level of statistical significance was set at $p < 0.05$. The Effect size along with the 95% Confidence Interval between the two conditions were also calculated and effect sizes were classified using the equation and classifications established by Cohen (3).

RESULTS

Maximal deadlift strength following a pre-test Pilates exercise intervention was significantly higher ($t = -7.23$, $p < 0.001$) compared to following a pre-test cycle ergometer intervention. Individual subject 1RM's for each condition are plotted in Figure 1. Average maximal strength achieved in the Pilates condition was 168.6 ± 33.0kg while in the Cycle Ergometer condition was 161.4 ± 31.9kg yielding an effect size of 0.22 (95% CI: -0.46 – 0.89).

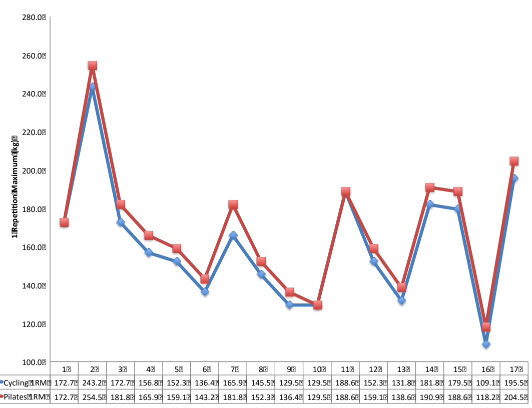

Figure 1. Mean deadlift 1RM values following the bike and the Pilates interventions for all 17 subjects.

DISCUSSION

A substantial portion of athletic performance relies on the ability of the body to appropriately generate, control, and transfer movement in all three planes of motion according to the demands being placed on the body. The core muscles are responsible for providing a stable LPH complex to optimize extremity movement and force transfer during sport performance. Nesser et al. have reported a significant positive correlation between measures of core stability and measures of maximal strength in collegiate football athletes (15). Additionally, chronic training sessions designed to improve core function have been shown to elicit improvements in maximal strength (5, 13). To the authors' knowledge, this is the first study to examine the acute response to a collection of integrated core exercises performed as a warm-up with regards to lower extremity maximal strength performance. Our results indicate a statistically significant improvement in maximal deadlift strength in response to a Pilates exercise warm up compared to a general cardiovascular warm up.

It is believed that the completion of a warm-up improves performance by preparing the athlete physically and mentally for exercise or competition (2). General cardiovascular exercises, such as jogging or cycling, are among the most commonly used warm-ups. These exercises increase core temperature and muscle blood flow, which has been shown to improve strength performance (6, 17). With increasing research, it has become more evident that warm-ups activating the musculature in a pattern similar to a specific exercise have the potential to enhance movement control and stability during acute performance of the mimicked exercise (9). The Pilates program used in this study incorporated integration movements that follow an activation pattern that is similar to the deadlift exercise. In healthy individuals, Pilates and the deadlift have a pattern that starts with force generation in the core muscles, which provides stability and control of the LPH complex for the duration of the movement (8, 20). The force is then transferred from the proximal trunk muscles through the distal trunk muscles and into the limb muscles, resulting in extremity movement. Adequate stabilization of the core throughout the entirety of a movement has been shown to be crucial in maximizing force generation in the extremities (26).

As a result of the available evidence suggesting that integration core exercises elicit a greater activation of the core musculature and the positive relationship between core stability and maximal strength assessments, we believe that the Pilates intervention created a facilitation of the LPH musculature that provided participants an increased activation of these muscles and thereby increased the stiffness of the trunk during the execution of the maximal deadlift attempts. McGill, et al, has described a stiffened torso as providing a strong base that may allow joints distal to the trunk with insufficient strength to support external loads during complex motor tasks to be buttressed and thereby improve performance of the task (12). Therefore, performing a Pilates warm-up may improve core stabilization and movement control, thereby maximizing force generation during a subsequent deadlift.

Potential limitations in the current study include the lack of a standardized cadence and wattage prescription during the general cycling warm-up, lack of blinding of the investigator to the warm-up condition prior to the 1RM deadlift assessment, and lack of a familiarization trial with the Pilates intervention exercises. A general cardiovascular warm-up was included based on evidence that this mode of exercise can elicit a positive strength response. Another common mode of exercise included within a warm up is static stretching. Static stretching was not included as an intervention in this study due to the evidence suggesting a decrease in muscular strength secondary to an increased compliance to musculotendinous tissue following static stretching (6, 10, 14, 17). In addition, neither measures of muscle activation nor stiffness were obtained nor were quantitative measures of joint motion during the maximal deadlift attempts thereby limiting the ability to directly relate the outcome of this investigation (maximal strength) with the factors that may have influenced it (muscle activation, trunk stiffness, and movement quality). As with any health-related research, statistical significance does not necessarily imply clinical meaningfulness, and in the current study, while the mean 1RM deadlift result following the Pilates intervention was 7.2kg higher than following the cycling warm-up, the effect size was low and the 95% Confidence Interval crossed 0 indicating that the Pilates intervention used in this study may not generate a positive strength response in all who complete it. While the effect size was influenced by the small sample size and wide range of maximal strength capacities within our subjects that led to broad standard deviations within treatment conditions, it should be noted that no subject generated a lower 1RM deadlift effort with the Pilates warm-up compared to the cycling warm-up. In addition, the 7.2kg average increase in 1RM can be viewed as an acute 4.5% improvement in maximum deadlift strength that was generated solely by manipulating the warm-up protocol and successive positive training responses typically lead to greater adaptations.

Performance that relies on optimal core function may significantly benefit from movement-specific core activation directly prior to the activity. Currently, muscle activation via a single bout of core training is overlooked as a way to improve acute strength performance. According to the results of this study, it would be advantageous to perform integration exercises, such as Pilates, to activate core muscles directly preceding a lower extremity strength exercise. Athletes and strength and conditioning professionals may use this information to help guide the selection of exercises to be included in a warm-up when the main body of a resistance training session will include near-maximal or maximal loads being used. Future studies may add to these results by seeking to clarify the mechanisms responsible for a potential increase in lower extremity maximal strength secondary to the completion of integrated core exercises. In addition, future studies could examine the effects of a combined general and specific warm-up including integrated core exercises on expression of maximal strength, determining if a dose-response relationship exists between integrated core exercise and measures of maximal strength, or determining if integrated core exercises have effects on other biomotor abilities relevant to athletic performance including, but not limited to, speed, agility, power, and local muscular endurance.

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