EFFECTS OF A PILATES EXERCISE PROGRAM ON CORE STRENGTH IN FEMALES

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The purpose of this study was to investigate the effects of a core stability-training program on core strength in females. Core stability is the strength and control of postural muscles of the back, abdomen, and pelvis. Some researchers have suggested that core stability might partially explain why females are more prone to anterior cruciate ligament (ACL) injury than males. We randomly assigned 17 female volunteer participants to an exercise or control group. We measured maximum isometric strength of the hip abductors, abdominals, and back extensors, before and after ten weeks of Pilates exercise. The exercise group met three times weekly for 40 minute supervised exercise sessions. A repeated measures MANOVA revealed no training effect at the end of the intervention ($F = 0.435$, $p = 0.87$)

KEY WORDS: ACL, pilates, core strength.

INTRODUCTION: Female athletes have a greater risk of sustaining an ACL injury than male athletes; various studies place the risk from two to eight times greater than in males (Arendt, 2001; Ireland, 2002; Medvecky, Bosco, & Sherman, 2000). Most ACL injuries are non-contact in nature, and typically occur when landing from a jump, stopping, or changing direction quickly. Some researchers have noted that women tend to perform these activities in a manner that may make them more susceptible to injury (Chappell, Yu, Kirkendall, & Garrett, 2002; Ford, Myer, Toms, & Hewett, 2005; Olsen, Myklebust, Engebretsen, & Bahr, 2004).

While there is substantial documentation concerning risk factors, reconstruction, and rehabilitation, surprisingly little has been published about ACL injury prevention. Recently, however, researchers have published results of injury prevention studies and the trend in research seems to be toward injury prevention. Various protocols have been investigated in an effort to minimize ACL injuries, including proprioceptive training, plyometric training, balance training, neuromuscular training, and general preseason conditioning. While various researchers have applied different terminology to their protocols, all of their protocols involve neuromuscular training of some form.

Neuromuscular training enhances unconscious motor responses by stimulating both afferent signals and proprioceptive skills responsible for dynamic joint and muscle control (Risberg, Mørk, Jenssen, & Holm, 2001). Common in many training regimens is the use of jump, or plyometric, training, with the initial focus on proper form rather than distance or height. By ensuring proper form during the performance of drill jumps, athletes become conditioned to repeat the proper form during game and practice situations. Other elements incorporated into various protocols include stretching, strength training, running and agility drills, and core strength and balance training. While some researchers include core strength and balance (i.e., core stability) training in their neuromuscular training prgrams, we could not find any studies that looked solely at a core stability training program.

Some researchers have suggested that measures of core stability might partially explain the ACL injury gender bias among female athletes (Leetun, Ireland, Willson, Ballantyne, & Davis, 2004). Leetun et al. examined core stability measures over a two-year period and correlated observed ACL injuries with certain measures of core stability. To date, however, there has not been any research into how core stability training programs influence the strength of trunk and hip musculature.

During times of single-leg stance, the pelvis tilts to the unsupported side of the body. Excessive tilting of the pelvis is mitigated by muscle action, particularly the gluteus medius of the stance leg. In the event of gluteus medius weakness or fatigue, the pelvis will drop excessively to the unsupported side, causing excessive stance leg hip adduction and thigh internal rotation, and greater valgus positioning of the knee. Such positioning places greater

tension on the ACL than it bears in a "normal" situation. Women are prone to such loss of pelvis control to a much greater extent than are men (Decker, Torry, Wyland, Sterett, & Steadman, 2003; Hass et al., 2003; Zeller, McCrory, Kibler, & Uhl, 2003).
Core muscles attach to and stabilize the spine and pelvis. Core stability is defined as the strength and control of these stabilizing muscles (Winter, 2004). There is some concern that traditional strength training programs do not properly address the roles of these primarily postural muscles and can lead to imbalances in strength and flexibility (Kloubec & Banks, 2004; LaBrusciano & Lonergan, 1996; Parrott, 1993). One hypothesis is that if core muscles can more effectively stabilize the pelvis, the gluteus medius can work more effectively to control stance leg hip adduction and minimize lateral pelvic tilt. This would, in theory, improve knee stability and relieve valgus stresses on the ACL. Popular methods of improving core stability include yoga, Tai Chi, and Pilates.
The purpose of this study was to determine the effects of a Pilates exercise program on core strength.

METHOD:

Data Collection: Seventeen females volunteered to participate in this study. Participants were informed of the purposes of the research and granted informed consent prior to enrollment in the study. We randomly assigned them to a control or an exercise group. Investigator GC was blinded to group assignment to minimize investigator bias during testing sessions. The other investigators did not participate in the testing sessions; they supervised the conduct of the intervention. Participant anthropometric and demographic data are presented in Table 1.
Participants were pre-screened for exercise history and musculoskeletal injuries. Prior history of hip, knee, or ankle injuries were disqualifying, including but not limited to: ankle sprain (for which participants were symptomatic), knee ligament injury, or congenitally absent ACL or PCL. Additional exclusionary conditions included body mass index (BMI) greater than 27, participation in high school or collegiate athletics or Pilates exercise program within three years, and participation in a regular strength training regimen or class within one year.

Table 1 Participant Characteristics (mean $\pm$ SD)

	Control	**Exercise**	**All**
n	8	9	17
Age	21.5 $\pm$ 1.3	20.1 $\pm$ 1.2	20.8 $\pm$ 1.4
Height (cm)	163.4 $\pm$ 7.1	162.1 $\pm$ 4.7	162.7 $\pm$ 5.8
Mass (kg)	60.0 $\pm$ 7.6	57.2 $\pm$ 5.6	58.5 $\pm$ 6.6

We measured maximum isometric strength of the participants hip abductors, abdominals, and back extensors with a Biodex System 3 isokinetic dynamometer, before and after ten weeks of Pilates exercise. Three trials per muscle group were completed, with a one-minute rest between trials.
Exercise group participants met together three times per week for 40 minutes, led by a certified Pilates instructor; they rested on their non-workout days. Participants were instructed that this exercise program was to be their only strength training during the course of the intervention. Control group participants were instructed to not significantly alter their physical activity routines during the course of the intervention. All participants were encouraged to maintain cardiovascular fitness through activities of their own choosing.

Data Analysis: Between group strength differences of abdominals, back extensors, and dominant and non-dominant hip abductors were evaluated with repeated measures MANOVA; α was set *a priori* at 0.05.

RESULTS: Retention was 100% and exercise group compliance was >90%. A repeated measures MANOVA revealed no strength differences between groups from the start to the end of the intervention ($F = 0.435$, $p = 0.87$, $1-\beta = 0.117$). Both groups showed increases in measured strength over the course of the intervention ($F = 5.041$, $p = 0.017$, $1-\beta = 0.867$).

DISCUSSION: There are several possible reasons why we found no differences. Chief among these reasons are the lack of power to detect between-group differences and a questionable effect size.

We thought that three 40 minute exercise sessions per week for ten weeks would provide sufficient stimulus for strength gains, based on previous similar research (Fitt, Sturman, & McClain-Smith, 1994; Stanforth, Stanforth, Hahn, & Phillips, 1998). Fitt et al showed differences after a seven-week program that included one hour per week of resistance exercise on a Pilates apparatus and daily (~30 minutes, unsupervised) Pilates floor exercises similar to those used in this protocol. Twenty-nine experienced dancers (15 controls, 14 exercisers) completed the training.

Stanforth et al showed differences after a 10-week program of callisthenics on the floor or an exercise ball. Their 55 subjects were divided into three groups. The two exercise groups attended training sessions twice weekly and maintained cardiovascular fitness through a twice-weekly aerobic walking or dance class.

Since both of our groups improved their measured strength, a practice effect may be partially responsible. In addition, the abdominal and back-extension measurement protocols used on the Biodex were not validated prior to use.

Despite the lack of between-group strength differences over the course of the intervention, we believe a training effect did occur. Anecdotal evidence from our participants and observations by investigator JC suggest that our exercise group improved their muscular endurance, which was not tested. This is a potential avenue for further research. In addition to the potential muscular endurance improvement, our exercise group participants reported feeling better physically, mentally, and emotionally. While we did not quantify these measures, we believe they are evidence for a training effect.

CONCLUSION: Several flaws in design contributed to the inability to detect differences; chief among them were a lack of power and a questionable effect size. Despite the shortcomings, we believe this type of training protocol can be effective in improving core strength, based on results from other Pilates' studies and the overall popularity of the Pilates method. Future research should measure muscular endurance and feelings of well-being, as well as muscular strength.

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