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Fitness and Training

THE RELATIONSHIP BETWEEN CORE STRENGTH AND PERFORMANCE IN DIVISION I FEMALE SOCCER PLAYERS

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ABSTRACT

Nesser TW, Lee WL. The relationship between core strength and performance in Division I female soccer players. ***JEP****online* 2009; 12(2):21-28. To identify relationships between core stability and various strength and power variables in division I female soccer players. 16 NCAA division I female soccer players (height 163.6 cm ± 5.2 cm, weight 60.7 kg ± 7.5 kg) completed strength and performance testing prior to off-season conditioning. Subjects were tested on two strength variables (1RM bench press, and 1RM squat), three performance variables (countermovement vertical jump, 40 yard sprint, and a 10 yard shuttle run), and core strength (back extension, trunk flexion, and left and right bridge). No significant correlations were identified between core strength and strength and power. The results of this study suggest core strength is not related to strength and power. Core strength does not contribute significantly to strength and power and should not be the focus of any strength and conditioning program with the intent to improve sport performance.

Key Words: Training, Athlete, Core Stability

INTRODUCTION

It is believed that a strong core allows an athlete the full transfer of forces generated with the lower extremities, through the torso, and to the upper extremities and sometimes an implement (1, 3, 8). A weak core is believed to interrupt the transfer of energy, resulting in reduced sport performance and risk of injury to a weak or underdeveloped muscle group. For this reason, there is an assumption that an increase in core strength will result in increased sport performance. Therefore, training the core has become popular among strength coaches and personal trainers as a means to improve performance and reduce the chance for injury despite the lack of research to support such findings.

Researchers have identified the importance of a strong core in relation to back pain and rehabilitation (2, 4, 5, 12, 13, 19, 20), and developed tools used to measure core strength and stability (6, 9, 13). While the importance of the core and methods of training and assessing it have been largely publicized, few studies have been completed which quantitatively demonstrate core strength's role in strength and performance. Scibek et al. (15) tested swimming performance and core strength in high school level swimmers. Tse et al. (18) tested rowing performance and core strength in college aged rowers, and Stanton et al. (16) reviewed running performance and economy, and core strength in high school aged touch football and basketball athletes. Groups from each study completed core training and groups that underwent training experienced improvements in core strength (based on their measurement criteria of core strength) but did not show improvements in swimming, rowing or running performance, respectively. Nesser et al. (10) compared core strength to a number of sport performance variables in division I football players and found weak to moderate correlations. Explanations for the lack of significant relationships in these studies include inconsistent methods used to measure core strength with the performance variables, the population tested, or there is no relationship.

According to previous research, strong relationships between core strength/stability and sport performance have not been established in male athletes. To date, female athletes, specifically Division I soccer players, have not been tested. Since the sport of soccer incorporates the core musculature through running, and kicking, it is hypothesized that relationships exist between core strength/stability and performance in this population. Therefore, the purpose of this study was to identify a relationship between core strength and various performance variables in a group of collegiate soccer players. For this study, core strength is defined as an individual's ability to stabilize the torso from the hips to the shoulders for the purpose of force production, control and transfer to one or more extremities.

METHODS

Subjects

Sixteen NCAA Division I female soccer players (height 163.6 $\pm$ 5.2 cm, weight 60.7 $\pm$ 7.5 kg) completed strength and performance testing prior to the start of off-season conditioning. Any individual that was injured or missed a day of testing was not included in this study. All participants signed an informed consent. This study was approved by the University Institutional Review Board.

Procedures

A Vertec vertical height measuring device (MF Athletic Corp, Cranston, RI) was used to measure the counter movement vertical jump (CMJ), a Speedtrap II wireless timing system (Brower Timing Systems, Draper, UT) was used to measure the 40 yard sprint times, a hand held stopwatch was used to measure the shuttle run and core muscle endurance times. All strength tests were completed on Legend strength equipment (Maynardville, TN). Height was measured on a Seca 214 portable stadiometer (Hanover, MD). Weight was measured on a Transcell TI 500E digital scale (Wheeling, IL).

Subjects reported for two test sessions over a period of two days, with 24 hours rest between the two sessions. The first test session included study familiarization followed by data collection for core strength, 20 yd and 40 yd sprint, shuttle run, and CMJ. The 1RM back squat and 1RM bench press were completed during the second session. Prior to testing on each day, subjects warmed-up as a team by completing a series of dynamic exercises and were allowed time to familiarized themselves with the testing procedures and ask questions. These performance tests, except the core strength tests, were part of the team's regular strength and power testing completed at various points throughout the training year.

Measurements

Counter Movement Vertical Jump

Reach height was measured on all participants prior to vertical jump testing. Subjects stood flatfooted and reached as high as possible with one arm. The highest point reached on the Vertec™ was considered reach height. Individuals were allowed an arm swing down and up while jumping off both feet and reaching as high as possible with one arm to displace the highest possible vane on the Vertec™. CMJ was calculated as the distance from the initial reach and the highest point reached during the jump. Individuals were allowed three attempts with a 3-5 minutes rest between attempts. The best of the three attempts was used for data analysis.

Shuttle run

The shuttle run was used to determined agility performance. A distance of 10 yards was measured with a line at the 5 yard point. Participants straddled the middle line and ran to their left to the end of the 10 yard marker, then to their right to the opposite 10 yard marks, and back to the middle 5 yard point. Time began with initial movement and ended when the individual crossed the 5 yard point a second time covering a total distance of 20 yards. Two timers were used with the average of the two recorded to the 0.01 second. Individuals were allowed three attempts with a 3-5 minutes rest between attempts. The best of the three attempts was used for data analysis.

40 yard sprint

A 40 yard sprint was used to determine quickness. Individuals started in a three point stance with their fingers on a touch and release starter for the electronic timer. As soon as the athlete released pressure from the touch pad, the timer began. A speed trap II electronic timer was used to measure time for the 40 yard sprint to the nearest 0.01 second. Individuals were allowed three attempts with a 3-5 minutes rest between attempts. The best of the three attempts was used for data analysis.

One repetition maximum bench press and squat

Individuals started each lift with 50 percent of their previous 1RM and increased weight by 10-20 kg until their 1RM was determined. All participants attempted to achieve their 1RM within five sets. All lifts were observed by the head strength coach to determine if it was an acceptable lift (i.e. proper depth, technique, etc.). Values are reported as absolute strength and relative to bodyweight (bench/kg and squat/kg).

Core testing

The protocol established by McGill (7) was used to determine muscle endurance of the torso stabilizer muscles. The protocol consists of four tests that measure all aspects of the torso via isometric muscle endurance: trunk flexor test, ICC (3,1) = .98, trunk extensor test, ICC (3,1) = .93, and left and right lateral musculature test, ICC (3,1) = .95(10). Subjects were allowed to practice each position. To prevent fatigue, they were not allowed to hold any one position for more than five seconds. A handheld stopwatch was used to measure the length of time participants were able to hold each isometric position. Individuals were given a minimum of five minutes rest between each test. In relation to movement, all aspects of the core work as a single unit. Thus each of the individual core tests was totaled to produce a single "total core" value.

Trunk flexor test

The flexor endurance test begins with the person in a sit-up position with the back resting against a jig angled at 60 degrees from the floor. Both knees and hips are flexed 90 degrees, the arms are folded across the chest with the hands placed on the opposite shoulder, and the feet are secured. To begin, the jig is pulled back 10 cm and the person holds the isometric posture as long as possible. Failure is determined when any part of the person's back touches the jig.

Trunk extensor test

The back extensors are tested with the upper body cantilevered out over the end of the test bench and with the pelvis, knees, and hips secured. The upper limbs are held across the chest with the hands resting on the opposite shoulders. Failure occurs when the upper body drops below the horizontal position.

Table 1. Physical, Core and Performance Variables

Height (cm)	163.6 ± 5.2
Weight (kg)	60.7 ± 7.5
Trunk Flexion (sec)	216 ± 83.4
Back Extension (sec)	182.0 ± 70.4
Right Flexion (sec)	128.7 ± 56.8
Left Flexion (sec)	122.7 ± 36.2
Total Core (sec)	649.3 ± 150.0
40 m (sec)	5.8 ± 0.4
Shuttle (sec)	5.3 ± 0.3
CMJ (cm)	53.1 ± 9.4
Squat (kg)	75.8 ± 14.0
Squat/kg	1.3 ± 0.2
Bench (kg)	41.5 ± 6.4
Bench/kg	0.7 ± 0.1

Lateral musculature test

The lateral musculature is tested with the person lying in the full side-bridge position (e.g., left and right side individually). Legs are extended, and the top foot is placed in front of the lower foot for support. Subjects support themselves on one elbow and on their feet while lifting their hips off the floor to create a straight line from head to toe. The uninvolved arm is held across the chest with the hand placed on the opposite shoulder. Failure occurs when the person loses the straight-back posture and/or the hip returns to the ground.

Statistical Analyses

Descriptive statistics were performed on all data. After determining normal distribution of the test variables, multiple bivariate correlations represented by the Pearson correlation coefficient were used to identify relationships between test variables. Statistical significance was set at P = 0.05. SPSS 14.0 software (SPSS Inc., Chicago, IL) was used for all analyses.

Table 2. Total core strength and performance correlations(r) and coefficient of determination (r^2)

Test	*Total Core*
20 m (sec)	.326 (.10)
40 m (sec)	-.367 (.13)
Shuttle (sec)	-.424 (.18)
CMJ (cm)	-.276 (.08)
Squat (kg)	-.139 (.02)
Squat/kg	.099 (.01)
Bench (kg)	-.099 (.01)
Bench/kg	.298 (.09)

RESULTS

No significant correlations were identified between core strength/stability and the strength and performance measures. Core and performance variables are listed in Table 1.

Total core strength and performance correlations and coefficients are given in Table 2. To review the functional form of some of the data points, scatterplots between total core and the shuttle run, and 40 yd sprint have been created (Figures 1 and 2, respectively).

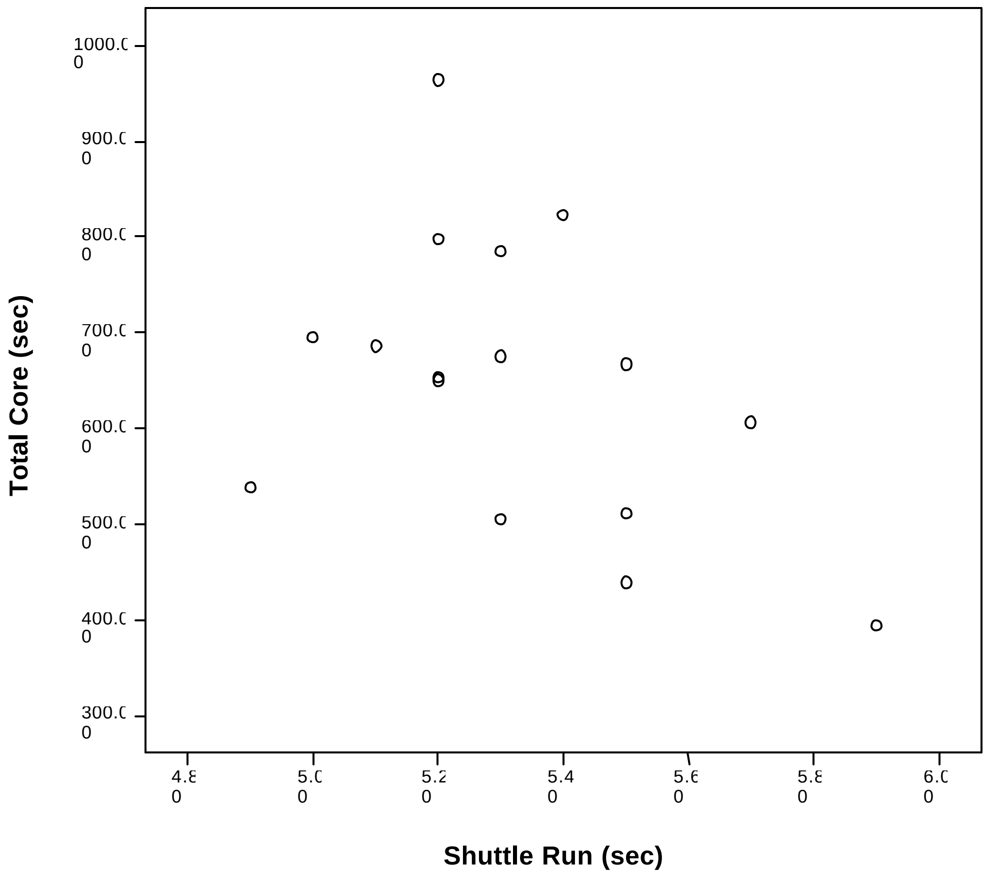

Figure 1. Scatter plot relationship between total core fatigue and the shuttle run.

DISCUSSION

An underlying belief suggests that optimal core strength is imperative for peak strength and performance in sport. However, through research, relationships between these variables are weak to moderate in male athletes and have not been established in female athletes. This study examined whether core stability is related to strength and performance in female athletes that train specifically for strength and athletic performance. Overall, our results found no significant relationships between core strength and strength, and athletic performance variables. There are two possible reasons for these results: 1) The tests used to measure core strength are not specific to strength and athletic performance, and/or 2) Core strength does not play a role in strength and athletic performance.

The current study incorporated McGill's core stability tests. These tests were designed to measure muscle endurance of the core musculature. Muscles that can sustain prolonged contractions (i.e. muscle endurance) are less likely to fatigue and can thus continue to provide support to the torso over time, reducing the chance of injury or to maintain sport performance. Therefore, greater (i.e. longer) core muscle endurance should correspond with a greater capacity to do work. Since the core strength tests used in the study had reported reliability coefficients of ≥ .97, we believe that McGill's assessment of core strength is accurate (9).

Taking into consideration the reliability and validity of McGill's core stability tests, one possible reason for the weak correlations between core strength, and strength and athletic performance is the specificity of the tests. All of the performance measures in this study were one repetition, quick, explosive movements lasting less than 10 seconds. As previously mentioned, McGill's measurement of the core musculature is an isometric muscle contraction and a test of muscle endurance. An accurate comparison of these two tests cannot be made since the strength and power tests involve primarily fast twitch muscle fibers, maximum force production, and the ATP-PC energy system, while the core strength/stability tests focus more on slow twitch muscle fibers, submaximal muscle contractions, and anaerobic glycolysis.

The second possible explanation is core strength does not significantly contribute to strength and athletic performance. Our results were similar to Tse et al. (18), who also used McGill's tests to measure core muscle endurance and, then, compared core strength with performance variables in rowers. As previously mentioned, subjects who completed core training and showed improvements in core muscle endurance (McGill's test) did not show improvements in their performance variables, which included one-time measurements of power and a 2000m time trial on a rowing ergometer. It is interesting to note that despite the improved performance on the core tests, there were no improvements on the 2000m time trial which involves the muscle of the torso and is a test of muscle endurance. The one difference is that the core tests are static muscle endurance while the 2000m rowing ergometer trial is a measure of dynamic muscle endurance.

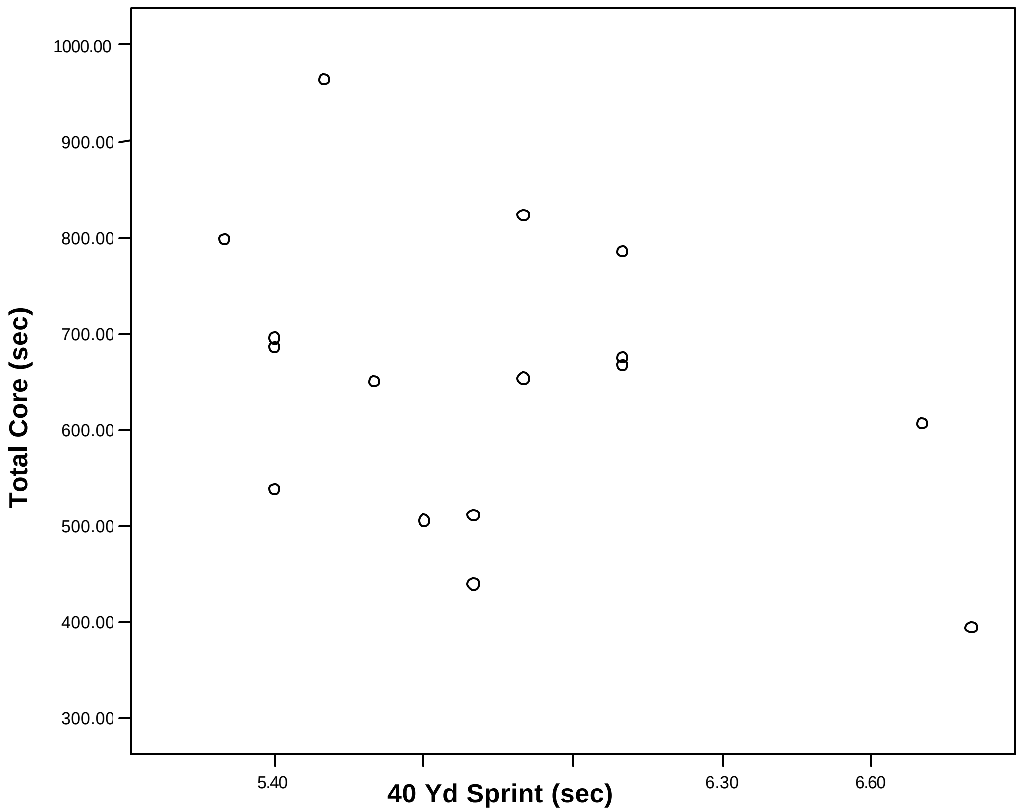

Figure 2. Scatter plot relationship between Total Core fatigue and 40 Yard Sprint.

With sport movement, the entire core is functioning as a unit so it was expected correlations would have been identified as seen by Nesser et al. (10). However, this was not the case. A limitation to this study was the small N. Had a greater number of subjects been available for testing, significant correlations may have been found, yet, even so, the correlations likely would have been weak.

Despite the fact significant correlations were not identified between core strength and athletic performance, it does not warrant neglect of the core. At the same time, it appears the core is no more important than any other body part.

CONCLUSIONS

Based on the results of the current and previous research, it is believed core training is necessary for optimal sport performance and should not be dismissed. However, it should not be the emphasis of any resistance training program. The core is one part of the body thus it is should not be the focus of any training program taking time away from other body parts which may lead to a muscle imbalance and possible injury.

Determination of the role of core strength/stability requires additional research and sport specific means of determining its effectiveness. One general test may be sufficient to determine an individual's base core stability/strength values, but a true understanding of the core's role to whole body movements for sport performance is yet to be determined and likely requires sport specific testing.

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REFERENCES

1. Behm DG, Leonard AM, Young WB, Bonsey WAC, Mackinnon SN. Trunk muscle electromyographic activity with unstable and unilateral exercises. ***J Strength Cond Res*** 2005; 19:193-201.

2. Cholewicki J, McGill SM. Mechanical stability of the in vivo lumbar spine: Implications for injury and chronic low back pain. ***Clin Biomech*** 1996; 11:1-15.

3. Cissik JM. Programming abdominal training, part one. ***Strength Cond J*** 2002; 24(1):9-15.

4. Duncan RA, McNair PJ. Factors contribution to low back pain in rowers. ***Br J Sports Med*** 2000; 34:321-322.

5. Hodges PW, Richardson CA. Inefficient muscular stabilization of the lumbar spine associated with low back pain: A motor control evaluation of transversus abdominis. ***Spine*** 1996; 21:2640-2650.

6. Liemohn WP, Baumgartner TA, Gagnon LH. Measuring core stability. ***J Strength Cond Res*** 2005; 19(3):583-586.

7. McGill, SM. ***Low Back Disorders. Evidence-Based Prevention and Rehabilitation.*** Champaign, IL: Human Kinetics. 2002.

8. McGill SM, ***Ultimate Back Fitness and Performance.*** Ontario, Canada: Wabuno, 2004.

9. McGill SM, Childs A, Liebenson C. Endurance times for low back stabilization exercises: Clinical targets for testing and training from a normal database. ***Arch Phys Med Rehabil*** 1999; 80:941-944.

10. Nesser TW, Huxel KC, Tincher JL, Okada T. The relationship between core stability and performance in Division I football players. ***J Strength Cond Res*** 2008; 22(6):1750-1754.

11. Portney LG , Watkins MP. **Foundations of Clinical Research Applications to Practice.** Upper Saddle River, NJ: Prentice Hall Inc. 2000.

12. O'Sullivan PB, Twomey LT, Allison GT. Evaluation of specific stabilizing exercises in the treatment of chronic low back pain with radiologic diagnosis of spondylolysis or spondylolisthesis. ***Spine*** 1997; 22:2959-2967.

13. Richardson CA, Snijders C, Hides JA, Damen L, Pas MS, Storm J. The relation between the transversus abdominis muscles, sacroiliac joint mechanics, and low back pain, ***Spine*** 2002; 27:399-405.

14. Sahrmann S. **Treatment and Diagnosis of Movement Impairment Syndromes**. St. Louis, MO. Mosby. 2002.

15. Scibek JS, Guskiewicz KM, Prentice WE, Mays S, Davis JM. **The effect of core stabilization training on functional performance in swimming.** Master's Thesis, University of North Carolina, Chapel Hill, 2001.

16. Stanton R. Reaburn PR, Humphries B. The effect of short-term Swiss ball training on core stability and running economy. ***J Strength Cond Res*** 2004; 18(3):522-528.

17. Thompson CJ, Myers Cobb K, Blackwell J. Functional training improves club head speed and functional fitness in older golfers. ***J Strength Cond Res*** 2007; 21(1):131-137.

18. Tse MA, McManus AM, Masters RSW. Development and validation of a core endurance intervention program: Implications for performance in college-age rowers. ***J Strength Cond Res*** 2005; 19(3):547-552.

19. Whitaker J. Abdominal ultrasound imaging of pelvic floor muscle function in individuals with low back pain. ***J Man Manipulative Ther*** 2004; 12:44-49.

20. Wilson JD, Dougherty CP, Ireland ML, Davis IM. Core stability and its relationship to lower extremity function and injury. ***J Am Acad Orthop Surg*** 2005; 13:316-325.