# The Relationship Between Core Stability and Performance in Division I Football Players


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## Abstract

Nesser, TW, Huxel, KC, Tincher, JL, and Okado, T. The relationship between core stability and performance in Division I football players. *J Strength Cond Res* 22(6):1750–1754, 2008–The purpose of this study was to identify relationships between core stability and various strength and power variables in strength and power athletes. National Collegiate Athletic Association Division I football players (height 184.0 ± 7.1 cm, weight 100.5 ± 22.4 kg) completed strength and performance testing before off-season conditioning. Subjects were tested on three strength variables (one-repetition maximum [1RM] bench press, 1RM squat, and 1RM power clean), four performance variables (countermovement vertical jump [CMJ], 20- and 40-yd sprints, and a 10-yd shuttle run), and core stability (back extension, trunk flexion, and left and right bridge). Significant correlations were identified between total core strength and 20-yd sprint ($r = -0.594$), 40-yd sprint ($r = -0.604$), shuttle run ($r = -0.551$), CMJ ($r = 0.591$), power clean/body weight (BW) ($r = 0.622$), 1RM squat ($r = -0.470$), bench press/BW ($r = 0.369$), and combined 1RM/BW ($r = 0.447$); trunk flexion and 20-yd sprint ($r = -0.485$), 40-yd sprint ($r = -0.479$), shuttle run ($r = -0.443$), CMJ ($r = 0.436$), power clean/BW ($r = 0.396$), and 1RM squat ($r = -0.416$); back extension and CMJ ($r = 0.536$), and power clean/BW ($r = 0.449$); right bridge and 20-yd sprint $r = -0.410$) and 40-yd sprint ($r = -0.435$), CMJ ($r = 0.403$), power clean/BW ($r = 0.519$) and bench press/BW ($r = 0.372$) and combined 1RM/BW ($r = 0.406$); and left bridge and 20-yd sprint ($r = -0.376$) and 40-yd sprint ($r = -0.397$), shuttle run ($r = -0.374$), and power clean/BW ($r = 0.460$). The results of this study suggest that core stability is moderately related to strength and performance. Thus, increases in core strength are not going to contribute significantly to strength and power and should not be the focus of strength and conditioning.



**Key Words** core strength, agility, weight lifting, sprint



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## Introduction

It is theorized that a strong core allows an individual the full transfer of forces generated from the ground through the lower extremities, the torso, and finally to the upper extremities and sometimes an implement (1,3,8). A weak core is believed to cause alterations in the transfer of energy, resulting in reduced sport performance and risk of injury to a weak or underdeveloped muscle group. Hence, there is an assumption that an increase in core strength will result in increased sport performance. Henceforth, training the core has become popular among strength coaches and personal trainers as a means to improve performance and reduce the chance for injury.

Research has identified the importance of a strong core in relation to back pain and rehabilitation (2,4,5,10,11,17,18) and has developed tools used for measuring core strength and stability (6,9,12). Although the importance of the core and methods of training and assessing it have been largely publicized, few studies have quantitatively demonstrated core strength's role in strength and performance. Studies that have examined core strength and sport-specific performance were unable to establish a relationship between these variables: Scibek et al. (13) tested swimming performance and core strength in high school–level swimmers, Tse et al. (16) tested rowing performance and core strength in college-aged rowers, and Stanton et al. (14) have reviewed running performance, 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. Explanations for the lack of significant relationships in these studies include inconsistent methods used to measure core strength with the performance variables or the population tested.

According to previous research, relationships between core strength/stability and sport performance have not been established. To date, strength and power athletes have not been tested. Because much of their training incorporates core strength, 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 strength and power athletes.

## METHODS

### Experimental Approach to the Problem

Previous research failed to identify the effects of increases in core strength with improvements in sport performance (13,14,16). The current study attempted to determine whether core strength is related to more specific measurements of strength and power in strength and power athletes. To do so, a multivariate correlation design was used for this study. The independent variables were measurements of the core musculature: back extension, trunk flexion, right side-bridge and left side-bridge. The dependent variables were one-repetition maximum (1RM) bench press, 1RM squat, 1RM power clean, 20-yd sprint, 40-yd sprint, shuttle run, and countermovement vertical jump (CMJ). Each of the 1RM lifts is also used relative to body weight. Height and weight are used for descriptive purposes.

### Subjects

Twenty-nine National Collegiate Athletic Association Division I male strength and power athletes (height 184.0 ± 7.1 cm, weight 100.5 ± 22.4 kg) were tested. All testing was completed as part of the team's off-season strength and performance testing. An 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. Physical characteristics are given in Table 1.

### Procedures

A Vertec vertical height-measuring device (MF Athletic Corp, Cranston, Rhode Island) was used to measure the CMJ, a Speedtrap II wireless timing system (Brower Timing Systems, Draper, Utah) was used to measure the 40-yd sprint times, and a handheld stopwatch was used to measure the 20-yd sprint times, shuttle run times, and core muscle endurance times. All strength tests were completed on Samson strength equipment (Las Cruces, NM). Height was measured on a Seca 214 portable stadiometer (Hanover, Md). Weight was measured on a Transcell TI 500E digital scale (Wheeling, Ill).

Subjects reported for four test sessions during a 5-day period, with a minimum of 24 hours between each session. The first test session included study familiarization followed by data collection for the 20- and 40-yd sprint tests. Tests in the second session were the CMJ followed by the power clean. Core tests followed by the back squat were completed during the third session, and the last session included pro agility shuttle run followed by bench press test. Before testing on each day, subjects warmed up as a team by completing a series of dynamic exercises.

**TABLE 1.** Physical characteristics (mean ± *SD*).

| | |
|---|---|
| Height (cm) | 184.0 ± 7.1 |
| Weight (kg) | 100.5 ± 22.4 |

### Measurements

*Countermovement Vertical Jump.* Reach height was measured on all participants before vertical jump testing. Subjects stood flat-footed and reached as high as possible with one arm. The highest point reached on the Vertec was considered reach height. Individuals were allowed one 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. Height for CMJ was calculated as the distance from the highest point reached during the reach height and the highest point reached during the jump. Individuals were only allowed one attempt unless the previous attempt was not performed properly. In that case, 3–5 minutes of rest was allowed between attempts.

*Pro Agility Shuttle Run.* The pro agility shuttle run was used to determined agility performance. A distance of 10 yd was measured with a line in the middle at the 5-yd point. Participants straddled the middle line and ran to their left to the end of the 10-yd marker, then to their right to the opposite 10-yd marks, and back to the middle 5-yd point. Time began with initial movement and ended when the individual crossed the 5-yd point a second time, covering a total distance of 20 yd. Two timers were used, and the average of the two was recorded to the 0.01 second. Individuals were only allowed one attempt unless the previous attempt was not performed properly. In that case, 3–5 minutes of rest was allowed between attempts.

*20- and 40-Yd Sprint.* Sprints of 20 and 40 yd were used to determine quickness. A distance of 40 yd was measured with a marker at the halfway point (20 yd). 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. At the 20-yd distance, a stopwatch was used to measure time. The stopwatch was started on movement of the athlete and stopped when he passed the 20-yd marker. Two timers were used to measure 20-yd sprint time, with the average of the two recorded to the nearest 0.01 second. A speed trap II electronic timer was used to measure time for the 40-yd sprint. Individuals were only allowed one attempt unless the previous attempt was not performed properly. In that case, 3–5 minutes of rest was allowed between attempts.

*One-Repetition Maximum Bench Press, Squat, and Power Clean.* Individuals started each lift with 50% 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 whether it was an acceptable lift (i.e., proper depth, technique, etc.).

#### 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, trunk extensor test, and left and right lateral musculature test. 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 5 minutes of rest between each test.

*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° from the floor. Both knees and hips are flexed 90°, 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.

*Lateral Musculature Test.* The lateral musculature is tested with the person lying in the full side-bridge position (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. Relationships between test variables were determined using multiple bivariate correlations, represented by the Pearson correlation coefficient. Statistical significance was set at $p \leq 0.05$. SPSS 13.0 software (SPSS Inc., Chicago, Ill) was used for all analyses.

## Results

A number of significant correlations were identified between core strength/stability and the strength and performance measures. However, these significant correlations ranged between weak and moderate, and they are not consistent. Core and performance variables are listed in Table 2. Core strength correlations and core strength and performance correlations are given in Tables 3 and 4, respectively.

**Table 2.** Core and performance variables (mean ± *SD*).

| | |
|---|---|
| Trunk flexion (s) | 113.8 ± 51.9 |
| Back extension (s) | 99.6 ± 22.3 |
| Right flexion (s) | 100.8 ± 24.4 |
| Left flexion (s) | 95.9 ± 31.9 |
| 20-m sprint (s) | 2.8 ± 0.3 |
| 40-m sprint (s) | 4.9 ± 0.5 |
| Pro-agility (s) | 4.5 ± 0.3 |
| Vertical jump (in) | 28.8 ± 4.5 |
| Clean (kg) | 120.9 ± 13.3 |
| Clean/BW (kg) | 1.3 ± 0.25 |
| Squat (kg) | 192.1 ± 28.7 |
| Squat/BW (kg) | 2.0 ± 0.37 |
| Bench press (kg) | 128.5 ± 18.9 |
| Bench press per kilogram (kg) | 1.3 ± 0.28 |
| Total lift (kg) | 444.7 ± 52.7 |
| Total lift per kilogram (kg) | 4.6 ± 0.84 |

BW = body weight.

## Discussion

An underlying belief exists to suggest that optimal core stability is imperative for peak strength and performance in sport. However, relationships between these variables have not been established through research. This study examined whether core stability is related to strength and performance in athletes who train specifically for strength and power. Overall, our results found significant but not strong relationships between core strength and strength and power performance variables. There are two possible reasons for these results: 1) the tests used to measure core strength are not specific to strength and power, and 2) core strength only plays a minor role in strength and power performance.

Our 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

**Table 3.** Core strength correlations.

| | Trunk flexion | Back extension | Right flexion | Left flexion |
|---|---|---|---|---|
| Trunk flexion | 1 | | | |
| Back extension | 0.080 | 1 | | |
| Right flexion | 0.357 | 0.201 | 1 | |
| Left flexion | 0.468* | 0.033 | 0.617** | 1 |

*$p \leq 0.05$.
**$p \leq 0.01$.

**TABLE 4.** Core strength and performance correlations.

| | Total core | Trunk flexion | Back extension | Right flexion | Left flexion |
|---|---|---|---|---|---|
| 20-m sprint | −0.539** | −0.485** | −0.367 | −0.410* | −0.376* |
| 40-m sprint | −0.604** | −0.479** | −0.366 | −0.435* | −0.397* |
| Pro-agility | −0.551** | −0.443* | −0.346 | −0.354 | −0.374* |
| Vertical jump | 0.591** | 0.436* | 0.536** | 0.403* | 0.334 |
| Clean | 0.041 | 0.017 | 0.029 | 0.083 | 0.008 |
| Clean/BW | 0.622** | 0.396* | 0.449* | 0.519** | 0.460* |
| Squat | −0.470* | −0.416* | −0.219 | −0.322 | −0.294 |
| Squat/BW | 0.271 | 0.101 | .256 | 0.248 | 0.258 |
| Bench press | −0.217 | −0.157 | −0.234 | −0.045 | −0.179 |
| Bench press/BW | 0.369* | 0.226 | 0.201 | 0.372* | 0.286 |
| Total lift | −0.317 | −0.274 | −0.193 | −0.167 | −0.217 |
| Total lift/BW | 0.447* | 0.255 | 0.313 | 0.406* | 0.361 |

BW = body weight.
*$p \leq 0.05$.
**$p \leq 0.01$.

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. Because the core strength/stability tests used in the study had reported reliability coefficients of ≥0.98, we believe that McGill's assessment of core strength is accurate (9); however, it may not represent how the muscles operate under functional loads and movements.

Taking into consideration the reliability and validity of McGill's core stability tests, the second possible reason for the weak correlations between core strength and strength and power 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 because the strength and power tests involve primarily fast-twitch muscle fibers, maximum force production, and the adenosine-triphosphate-phosphocreatine system energy system, whereas the core strength/stability tests focus more on slow-twitch muscle fibers, submaximal muscle contractions, and anaerobic glycolysis. Also, results may have been different if athletes were in a state of fatigue before data collection or if athletes were asked to perform the strength and power tests until fatigued. Physiological factors such as these should be considered when developing assessment tests so that the results are representative of variables testing within the body.

Our results were similar to those of Tse et al. (16), who also used McGill's tests to measure core muscle endurance and 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 2000-m time trial on a rowing ergometer. It is interesting to note that even though the 2000-m time trial is a test of muscle endurance and involves the muscles of the torso, the improvement in core strength still had no affect on 2000-m rowing performance. This may be attributable to the specificity of testing and the capacity in which muscles are being used to execute each of the tests; the core strength/stability tests are a measure of static muscle endurance, whereas the 2000-m rowing ergometer trial is a measure of dynamic muscle endurance.

Correlations did improve when the four core strength tests were added together. The individual core strength tests can be used to determine a core muscle imbalance, which may lead to back pain as suggested by McGill (7). Because the core muscles work synergistically during movement, it is difficult to single out one specific aspect of core strength and deem it responsible for any given sporting success or failure. The core works together as a unit and, thus, should be analyzed as a unit.

Although the significant correlations between core strength/stability were weak to moderate, they were still significant. This suggests that core strength does contribute to strength and power performance and should be taken into consideration. However, the challenge of determining the effectiveness of core strength and stability training on sport performance remains. On the basis of the results of this and other studies, measurements of the core and its relationship to sport performance will not come from a general one-test-fits-all measurement. A true measure of improvements in the core may be incorporated when sport-specific improvements (i.e., throwing velocity, club or bat velocity, tennis serve velocity, etc.) in sport performance are found. A good example of this is the study by Thompson et al. (15) who tested older golfers after they had completed 8 weeks of functional training. The effectiveness of the training was gauged by changes in club head speed. The testing of the effectiveness of the functional training program was specific to the sport and was much more meaningful to the participants.

## Practical Applications

It is the authors' opinion that core training is necessary for optimal sport performance and should not be dismissed. 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 core training's role regarding whole-body movements for sport performance requires sport-specific testing.

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