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Core Stability and Athletic Performance in Male and Female Lacrosse Players

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ABSTRACT

International Journal of Exercise Science 12(4): 1138-1148, 2019. This study determined the relationship of core stability with power production, agility, and dynamic stability of collegiate lacrosse players and whether core stability is more evident in these performance variables in either males or females. Twenty male and female collegiate lacrosse players (20.3 ± 1.0 years, 173.2 ± 11.8 cm, 72.6 ± 13.0 kg) performed the pro-agility shuttle, the countermovement jump (CMJ), the Star Excursion Balance Test (SEBT), and prone, right lateral, and left lateral planks on two sessions- familiarization and testing. Independent T-tests were used to compare sexes. SPSS 24.0 was used; significance was accepted at $p < 0.05$. Pearson correlations were used to compare the relationship of core stability to the performance variables in participants. There was a significant relationship found between the prone plank and pro-agility shuttle in all participants ($r = -0.50$). No significant relationships were found between core stability and performance variables. A significant difference was found in the pro-agility shuttle ($p = 0.001$) and the CMJ ($p = 0.001$) but not in core stability or dynamic stability. Agility, power production, and dynamic stability were not related to core stability in neither male or female lacrosse players. There were no significant differences in core stability and dynamic stability between males and females. A significant difference was found in dynamic stability in the SEBT right leg and left leg composite scores between sexes. From these results, it is suggested that core stability may not directly influence the performance variables in collegiate male and female lacrosse players.

KEY WORDS: Agility, power production, dynamic stability, sexes

INTRODUCTION

Lacrosse is a highly technical and physical game played by both men and women. A strong and stable core is important in agility, power production, and dynamic stability and is highly specific to lacrosse (3, 22). The rules of the game differ between sexes and may reflect anatomical differences of males and females. For example, the men's game has fewer restrictions on physical contact as well as fewer players on the field compared to the women's game as referenced in Randolph (22). In both men and women, the muscles of the core are categorized as 'local' or 'global'. Local muscles are those with attachments to the anatomical core, like the mulitifidus, rotatores, interspinalis, intertransversalis, and transverse abdominis, while global muscles are muscles with attachments to the axial skeleton, hips and pelvis, such as the rectus abdominis, external oblique abdominis, longissimus, spinalis, and iliocastalis (13). Regardless of the style of play, the core muscles appear to be important in the generation of force to execute movement patterns during lacrosse.

Agility, power production, and dynamic stability rely on the smooth transition of energy from the core to the extremities (3, 5). The transfer of energy occurs through the kinetic chain principle and is centered on the local and global muscles working together to produce movement (3, 5, 13). Core stability has been shown to differ between sexes and affect the efficiency of the transfer of energy. Males have higher levels of testosterone leading to greater muscle mass and therefore there tends to be more ability to produce higher power when compared to females. Additionally, females have a wider pelvis, which alters the angulation of core muscle attachments (10), thereby promoting perhaps a weaker core. These differences produce sex-specific movement patterns that may be associated with differences in athletic performance (11).

Agility, which involves the ability to overcome the inertia of the body to change direction, is a vital physical quality in lacrosse as a stable core is necessary for an athlete to change direction, accelerate and decelerate in a fast manner (14). Dynamic stabilization, the ability to maintain a stable center of gravity, requires athletes to possess the ability to control balance and motion during deceleration, thus allowing an efficient generation and transfer of energy through the kinetic chain (4). Power, the amount of work a muscle can produce per unit of time, involves the transfer of energy from the core to the extremities resulting in force production. Power can be optimized with a stable core, as there should be smooth transition of energy from a stored state to the power state (3, 5). Core stability is the ability to control the position and motion of the trunk over the pelvis and it is regarded as being essential in force production, control and transfer in athletic events (16). This is necessary for the transfer of energy in athletic activities (8, 21). While these factors are regarded as being essential to athletics, few studies have investigated these factors within a sport and even fewer have compared sex differences.

Field tests are a type of testing comparable to athletic movements and game-like situations, making the approach useful for the present study. Agility can be measured using the pro-agility shuttle (14). Dynamic stability can be measured using the Star Excursion Balance Test (SEBT) (4). Power can be measured using the countermovement jump (CMJ) (28, 29). Since there is no gold standard to measure core stability, a variety of field tests have been employed in recent research in the assessment of core stability, however plank exercises are currently considered to be an adequate method in the improvement of core stability in athletes (23-25).

The purpose of this study was to determine the relationship of core stability with power production, agility, and dynamic stability of collegiate lacrosse players and whether core stability is more evident in these performance variables in either males or females. It was hypothesized that core stability would be more significantly correlated with power production, agility, and dynamic stability in collegiate male lacrosse players than collegiate female lacrosse players. It was also hypothesized that core stability would be correlated with power production, agility, and dynamic stability in collegiate lacrosse players.

METHODS

Participants

Ten males and ten females between the ages of 18-22 years on the University of New Hampshire's club lacrosse teams were recruited for this study (Table 1). The participants were active members of the club lacrosse teams and were free of upper or lower body orthopedic injuries or limitations. The study was conducted at the University of New Hampshire during the participants' late in-season and off-season from March 2017 to September 2017. The Institutional Board for the Protection of Human Subjects in Research at the University of New Hampshire approved the protocol. This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (18).

Table 1. Means, standard deviations and effect size of age, height, percent body fat, and years of lacrosse played in collegiate male and female lacrosse players.

	Males	Females	P	Cohen's *d*
Age (years)	20.4 ± 1.0	20.1 ± 1.1	0.800	0.29
Height (cm)	182.1 ± 9.3	164.4 ± 5.7	0.001*	2.31
Weight (kg)	81.0 ± 2.9	64.3 ± 9.1	0.001	1.69
% Body Fat	10.5 ± 2.9	21.7 ± 3.1	0.002*	3.74
Years Playing Lacrosse	9.4 ± 23.1	10.1 ± 2.7	0.100	0.29

Values are mean ± standard deviation.

Protocol

Participants visited the laboratory on two different occasions with the first visit serving to collect anthropometric data and familiarize the participants with the field tests and the second visit to complete the field tests. The field tests included the front, right lateral and left lateral plank, the pro-agility shuttle, the CMJ and the SEBT.

On Visit 1 participants read and signed an informed consent, completed a medical questionnaire and had their height, body mass, and percent body fat measured using the 7-site skin fold measurement (2). Leg length on the right and left sides was measured from the anterior superior iliac crest to the ipsilateral medial malleolus while the participant laid in a supine position on a table (20).

The participants then completed a general warm-up consisting of 5-minutes of a running around a gym at a light to moderate pace. They then completed a dynamic warm-up consisting of 20 repetitions of butt kicks and high knees (10 on each side per exercise) and a total of 10 repetitions of reaching hamstring stretch, standing quadriceps stretch, reaching backwards lunge, lateral lunge, standing close the gate, and standing open the gate (5 on each side per exercise). Participants practiced each of the field tests to assess core stability using plank tests, power production using the CMJ, agility using the pro-agility shuttle, and dynamic stability using the SEBT. The methods of those tests are described below.

Visit 2 was completed at least 3 days after Visit 1. At this time, the participants completed the same dynamic warm-up described above and each field test in the following order: pro-agility shuttle, CMJ, SEBT and prone, right lateral and left lateral planks. SEBT was conducted with no rest between each trial. A total of 5-minutes rest was allowed between each performance test.

Pro-Agility Shuttle: The pro-agility shuttle consisted of a measured distance of 10 yards, with a marked mid-line at 5-yards. The participant started by straddling the 5-yard midline. The researcher said, ‘Ready, set, go’. On the ‘go’, the timing started and the participant ran to their right, touching the marked line with their right hand and right foot and turned to their left. The participant then ran 10-yards, past the 5-yard midline, to the end marker. The participant touched the line with their left foot and left hand and turned to their right, running through the 5-yard midline. Once the participant crossed the 5-yard midline, the researcher stopped the time and that was recorded to the nearest tenth of a second (19). On Visit 1 this was performed for 3 trials and on Visit 2 this was performed twice. The participants rested 2-minutes between each trial. The mean of the two trials from Visit 2 was calculated and used for data analysis.

CMJ: The CMJ was performed using a non-electronic standing scale (Vertec Vertical Jump, Sports Imports Hilliard, OH). The participant walked under the scale, pushing the vanes out of the way with their dominant hand maximally extended to determine standing height. The researcher pushed the vanes back into line via a meter stick. The participant set up underneath the Vertec with their feet shoulder width apart. The participant then performed a CMJ, swinging both arms downwards and then upwards while jumping off both feet, reaching as high as possible with their dominant hand, swatting away the highest reachable vane. The participants performed 3 jumps. The vertical jump was calculated by subtracting the standing reach from the jump reach. Power production was quantified as absolute peak power from vertical jump height and body mass (2).

SEBT: The SEBT measured dynamic stability in the frontal, transverse and sagittal planes (10, 12). The participant was barefoot and stood in the center of the grid with the most distal part of the great toe at the starting line while maintaining a one-leg stance on their right leg with their hands on their hips. They were instructed to reach as far as possible toward the end of the tape measure in the posterolateral direction, touching down lightly to the tape with their great toe and returning to the starting position, with the distance being marked on the tape. This was repeated in the posteromedial and anterior directions. The process was done on the right and left legs and the trial did not count if the participant failed to maintain a one-legged stance, lifted or moved the stance foot from the center of the grid, touched down with the reach foot to maintain balance, or failed to return the reach foot to the starting position (6). Participants performed 6 reaches in each direction. The composite score of each leg for each visit was calculated using the following equation.

$$\boldsymbol{Composite\ Score\ of\ SEBT} = \frac{Best\ Anterior\ Reach(cm) + Best\ Posteromedical\ Reach(cm) + Best\ Posterolateral\ Reach(cm)}{Leg\ Length\ (cm) \times 3} \times 100$$

Core Stability: The participant performed prone, right lateral, and left lateral planks. The participant was positioned in the prone plank with their feet shoulder width apart and their elbows directly under their shoulders flexed at 90°, lifting their trunk off the ground with their shoulders and elbows flexed at 90° (Figure 1). The right lateral and left lateral planks involved lying on the right/left side in a straight line from head to toe with the elbow directly under the shoulder and the feet stacked on top of each other and resting their top arm on their hip (6). The participants held the plank positions while positioned within 2 elastic cords that were positioned 1 cm above their buttocks (prone plank) or above their top hip (lateral planks) and 1 cm below their hips (prone plank) and their lower hip (lateral planks) (Figure 1). The plank position was held for as long as possible and failure was detected when the participant lost form indicated by movement of the elastic cord. Total time to failure was recorded in seconds. Each plank exercise was tested once with 2-minutes of rest between each plank exercise. A composite plank hold was calculated by adding prone, right lateral, and left lateral plank holds together.

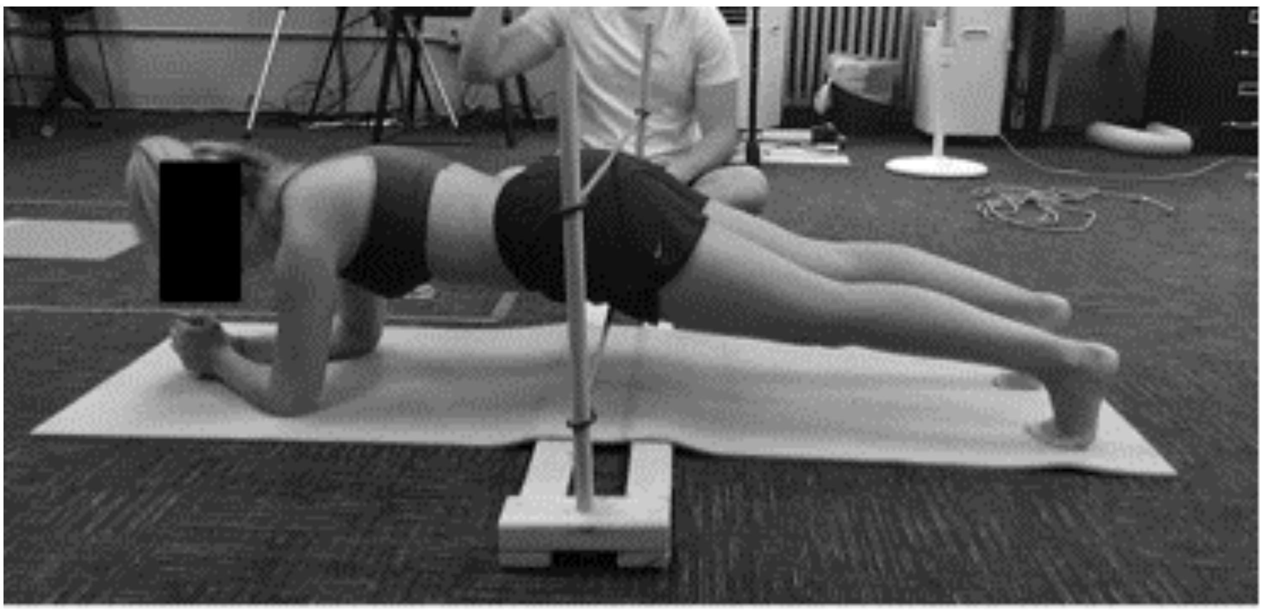

Figure 1. Performance of the prone plank.

Statistical Analysis

Descriptive statistics are presented as mean± standard deviation. Independent T-tests were used to compare males and females. Effect size was assessed with Cohen's d where d = 0.2 is small, d = 0.5 is medium, and d = 0.8 is large (8). Pearson correlations were used to compare the relationship of the composite plank to the pro-agility shuttle run, SEBT, and power in the CMJ in males and females. SPSS 24.0 was used. Significance was accepted at $p < 0.05$.

RESULTS

Males and females were of similar age and years playing lacrosse. Males were significantly taller and had a lower body fat percentage than females (Table 1). Males and females performed similarly in the SEBT right leg (p = 0.702) and left leg composite scores (p = 0.469), prone plank (p = 0.077), right lateral plank (p = 0.395), and left lateral plank (p = 0.518). A significant difference was found in the pro-agility shuttle and the CMJ as males ran 21.2% faster and produced 60.5% more power than the females (Table 2). Prone plank and the pro-agility shuttle were significantly correlated (r = -0.5; Table 3). No other relationships were found between the prone, right lateral, and left lateral planks and the performance tests.

There were no significant relationships in core stability (measured via the composite plank) and the performance tests in the whole sample as well as in male or female lacrosse players (Table 3). No correlation was found between the composite plank and the pro-agility shuttle (r = -0.40; p = 0.08), the CMJ (r = 0.27, p = 0.24), the SEBT right leg (r = 0.14; p = 0.56) and the SEBT left leg (r = 0.02; p = 0.93) composite scores.

Table 2. Means and standard deviations of performance tests in collegiate male and female lacrosse players.

	Males	Females	*p*	Cohen's *d*
Pro-Agility Shuttle (s)	5.2 ± 0.3	6.3 ± 0.4	0.001*	3.40
CMJ (W)	5209 ± 513	3246 ± 708	0.001*	3.18
SEBT Composite Right Leg (%)	61 ± 13	53 ± 4	0.702	0.17
SEBT Composite Left Leg (%)	59 ± 14	52 ± 5.8	0.469	0.33
Composite Plank (s)	236 ± 94	184 ± 69	0.177	0.63
Right Lateral Plank (s)	61 ± 25	53 ± 17	0.395	0.39
Left Lateral Plank (s)	59 ± 26	52 ± 20	0.518	0.30
Prone Plank (s)	115 ± 50	79 ± 37	0.077	0.84

CMJ: Countermovement Jump, SEBT: Star Excursion Balance Test
* Statistically significant (p < 0.05)

Table 3. Pearson correlation values for performance tests and core stability measurements in collegiate male and female lacrosse players.

		Agility	CMJ	SEBT Right Leg Composite	SEBT Left Leg Composite
Composite Plank	Sample	-0.40	0.27	0.14	0.02
	Males	-0.40	0.10	0.08	-0.96
	Females	-0.15	-0.08	0.30	0.17
Right Lateral Plank (s)	Sample	-0.27	0.27	-0.09	-0.21
	Males	-0.20	0.30	-0.21	-0.35
	Females	-0.23	0.09	0.29	0.06
Left Lateral Plank (s)	Sample	-0.21	0.25	-0.12	-0.24
	Males	-0.33	0.42	-0.22	-0.36
	Females	-0.001	0.04	0.18	-0.02
Prone Plank (s)	Sample	-0.50*	0.30	0.53	0.25
	Males	-0.44	-0.11	0.38	0.18
	Females	-0.18	-0.13	0.33	0.31

CMJ: Countermovement Jump, SEBT: Star Excursion Balance Test
* Statistically significant (p < 0.05)

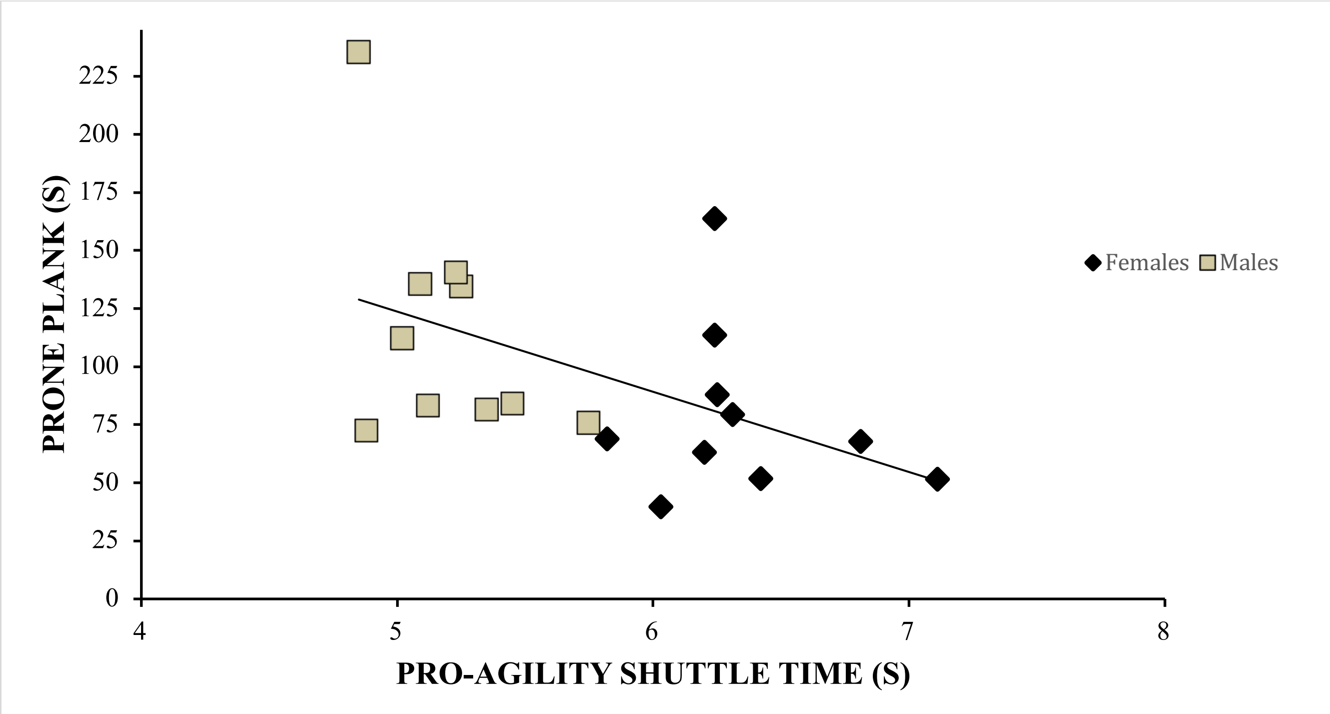

Figure 2. Relationship between pro-agility shuttle time and prone plank time in male and female lacrosse players. Males are displayed as tan boxes and females are displayed as black diamonds. The correlation value of the entire sample is $r = 0.5$; $p = 0.03$.

DISCUSSION

This study was conducted to determine the differences in core stability measurements in power production, agility, and dynamic stability in collegiate male and female lacrosse players as well as to assess the relationship of core stability to measures of athletic performance. The primary results indicate that there were no relationships between core stability and the performance tests in collegiate male and female lacrosse players. Males completed the pro-agility shuttle significantly faster and produced significantly more power in the CMJ than females. A relationship was found between agility measurements and the prone plank hold in the participants as a group and not specific to sex.

Core Stability and Performance Variables in All Participants: It was hypothesized that there would be a correlation between core stability and agility, power production, and dynamic stability in collegiate male and female lacrosse players, but this was not found in the present study using the composite plank to quantify core stability. The only relationship found was between the prone plank hold and the pro-agility shuttle in the participants as a group. Nesser et al (19) investigated the relationship between core stability and performance variables in Division I football players. Core stability was determined through a composite score of trunk flexion, back extension endurance, and left lateral and right lateral planks and was compared to bench press, squat, power clean, 20- and 40-yard sprints, and 10-yard shuttle run. There were significant correlations that ranged from -0.604 to 0.622 between total core stability and the 20-yard sprint, 40-yard sprint, 10-yard shuttle run, bench press, squat, and power clean. A significant correlation was found between core stability measurements and the 10-yard shuttle run, p = -0.550 (19). The muscles active in the prone plank are not exclusively responsible for the multi-faceted stages of the agility shuttle, but rather a combination of muscles that make up the kinetic chain, allowing energy to be transferred and produced during the movements associated with agility including deceleration, change of direction, and acceleration (16). In the present study, the moderate correlation identified between the prone plank and the pro-agility shuttle gives evidence that the muscles active in the prone plank may have a heavier impact on both a male and female's ability to quickly and efficiently change direction compared to the other muscles active during movements associated with agility (27).

No relationship was found between core stability and power production measurements in either male or female lacrosse players. This was not expected, as the core is the central focal point in which energy is transferred through during power production in lacrosse players. Nesser & Lee (20) studied the relationship between core stability and performance in Division I female soccer players. They completed a one-repetition maximum (1 RM) bench press and 1RM squat, CMJ, 40-yard sprint, 10-yard shuttle run and core stability measurements including trunk flexion, back extension as well as left lateral and right lateral planks. There were no significant relationships between core stability, 1RM testing, power production, and agility tests in collegiate female soccer players. Similar results were reflected in the present study regarding the lack of a relationship between core stability and power production in collegiate lacrosse players (20). This may be due to the concept that core stability encompasses core strength and endurance whereas power production is related to purely peak strength. Also, the method of testing of core stability in the present study was not specific to stability and athletic performance. The planking exercises involved isometric contractions that measured the endurance of the core, recruiting slow-twitch fibers to sustain the isometric contraction to maintain constant force for an extended period of time, therefore not producing a significant amount of force. Fast twitch fibers were recruited in the CMJ due to the explosive nature of the movement. The difference in demand utilized the readily available energy of the triphosphate phosphocreatine (ATP-PCr) system, allowing for the muscle contraction to take a shorter amount of time and producing more force (2, 20).

No relationship was found between core stability measurements and dynamic stability in either male or female lacrosse players. Ambegaonkar et al (4) observed the relationship between core stability, hip strength, and dynamic stability (SEBT test scores) in forty collegiate female athletes. Core stability was measured using prone, right and left lateral planks and dynamic stability was measured using the SEBT. Similar to our study, it was found that core stability measurements were not related to SEBT scores. Similar core musculature is active during the core stability measurements in the present study and the SEBT, as each exercise requires core stabilization to preserve the position of the trunk due to the "SAID" principle; specific adaptations to imposed demands. This principle allows the body to adapt to different demands and improve its ability to withstand that specific form of stress in the future (15). However, the different modes of testing may utilize additional musculature in the body, which may have altered the results suggesting core stability may not be the only predictor in dynamic stability in lacrosse (4). Dynamic stability is also governed by multiple systems working together including the central and peripheral nervous systems and visual systems, all of which may have also influenced the scores (21, 27).

Core Stability and Performance Measurements: Males vs. Females: It was hypothesized that core stability would be more significantly correlated with power production, agility and dynamic stability in collegiate male lacrosse players than in collegiate female lacrosse players. The results were similar between sexes in core stability and dynamic stability. Significant differences were observed in the pro-agility shuttle as well as in the CMJ, in which male participants completed the pro-agility shuttle significantly faster and produced significantly more power in the CMJ than female participants.

In the present study, it was found that males completed the pro-agility shuttle significantly faster than females. Spiteri et al (26) found that males had greater lower body strength and vertical braking force. This may have contributed to a faster pro-agility time as it may have allowed males to run faster and change direction at a more efficient rate compared to females. Ferber et al (9) also found that females exhibited significantly different hip and knee kinematic and kinetic gait patterns compared to males that may have also contributed to the significant difference between sexes as well.

Males may have produced more power in the CMJ due to an increased rate of force development during the eccentric contraction phase of the jump. McMahan et al (17) found that males may jump with increased leg stiffness during the movement of the CMJ. By using a stiffer leg strategy, males may have exhibited shorter movement times resulting in an increase in power production. A higher amount of muscle mass may have also allowed males a greater ability to utilize contractile mechanisms of the muscle, maximal force capacity, and rate of force development compared to females (7).

Despite physiological and structural differences between males and females, there were no significant differences in core stability measurements and the SEBT. The variation in muscle mass between sexes could have affected the results, with males having a higher ratio of skeletal mass to fat free mass compared to females. The weaker core strength present in the female participants could have caused them to respond differently than their male counterparts to a constant load due to less muscle being present, resulting in females working harder to complete the same task due to the difference in ratios between the two masses (1). However, in contradiction to these differences, the results of the present study imply that sex does not play a role in dynamic stability or core stability measurements in collegiate lacrosse players.

Core stability, as determined by the composite plank score, did not produce a relationship with agility, power production, or dynamic stability in neither collegiate male nor female lacrosse players. There were no significant differences in core stability or dynamic stability between collegiate male and female lacrosse players. A significant difference was observed in agility and power production between sexes. From these results it is suggested that core stability may not directly influence the performance variables in collegiate male and female lacrosse players. Since prior research (5, 16, 21, 24) indicates core stability is an important component in sport-specific movements and that increased core stability is associated with athletic success, strength and conditioning professionals should take into consideration the contradicting results of this study present when developing a lacrosse-specific training program.

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