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Original Research

Relationships of Lower-body Power Measures to Sprint and Change of Direction Speed among NCAA Division II Women's Lacrosse Players: An Exploratory Study

EMILY KULAKOWSKI†[1], ROBERT G. LOCKIE‡[2], QUINCY R. JOHNSON†[3], KESTON G. LINDSAY‡[1], and J. JAY DAWES‡[3]

[1]Department of Health and Human Sciences, University of Colorado, Colorado Springs, Colorado Springs, CO, USA. [2]Department of Kinesiology, California State University, Fullerton, Fullerton, CA, USA. [3]School of Kinesiology, Applied Health, and Recreation Oklahoma State University, Stillwater, OK, USA

†Denotes graduate student author, ‡Denotes professional author

ABSTRACT

International Journal of Exercise Science 13(6): 1667-1676, 2020. This study sought to determine if significant relationships exist between lower-body power measures to sprint and change of direction speed (CODS) in Division II collegiate women's lacrosse athletes. Archived data for 17 NCAA Division II female lacrosse athletes was provided to the investigators for analysis. Jumping performance was assessed using a countermovement jump (CMJ), squat jump (SJ), and standing broad jump (SBJ). Sprint speed was measured at 10m and 30m, of a 30m sprint. CODS was evaluated using a T-Test (TT), a modified T-Test (MTT), and the 5-0-5 Agility Test (5-0-5). No significant relationships were found between absolute power measures and any sprint or CODS tests. However, relative power (relative CMJ and SJ) had significant relationships with all CODS and sprints speeds above 10m. Only the CMJ and relative CMJ were related to 10m sprint speed. SBJ distance had significant relationships with all CODS tests and 30m speed, while relative SBJ distance significantly correlated with 5-0-5 speed. Relative lower-body power was significantly related to speed and CODS in Division II female lacrosse athletes. Strength and conditioning professionals should focus on lower-body power development as a key component in preparing female lacrosse athletes for their sport.

KEY WORDS: Female, sex, agility, vertical jump, collegiate, agility

INTRODUCTION

Lacrosse players are required to perform multiple intermittent sprints and changes of direction over the course of a single game (2, 5, 16). These skills are highly reliant on the ability to produce lower-body force rapidly to be successful (1, 8, 10, 12). Currently, little research examining specific performance indicators within this population exist, especially in women's lacrosse at the NCAA Division II level. Several research studies have reported that athletes in field-based sports share similar physical attributes that contribute to success, such as linear sprint speed and change of direction speed (CODS) (3,4,12,17,20). However, these specific relationships have not been explored among women lacrosse athletes. Indeed, this information may be useful to strength and conditioning professionals seeking to enhance performance within this specific population.

The countermovement jump (CMJ), squat jump (SJ) , and standing broad jump (SBJ) are tests commonly used to asses lower-body power across a variety of field-based sports (1,7,9,12,18,19). Several authors have reported significant associations between these tests and measures of sprint and change of direction speed (CODS), such as collegiate soccer and professional rugby players (1,4,9,10,12,17,18). However, the relationships between these lower-body power measures to linear sprint and CODS have not been explored in women's lacrosse. Furthermore, these lower-body power measures have not been fully evaluated in a single study in this population. Indeed, investigating the relationships between these lower-body power assessments may provide greater insights as to which tests would be of most value when attempting to assess athletic potential, especially as they relate to speed and CODS.

The purpose of this study was to determine if significant relationships exist between the selected lower-body power measures to sprint, and CODS in Division II collegiate women's lacrosse athletes. This information could potentially be used by coaches to determine which lower-body power tests should be prioritized when developing an athletic testing battery within this population.

METHODS

Participants

Data from 17 Division II collegiate women's lacrosse players (age: 18 ± 0.7 years; height: 162.4 ± 4.8 cm; body mass: 62.5 ± 8.8 kg), who participated in normal pre-season testing, was analyzed for this study. All participants were required to be a member of the university's team, injury free, over 18 years of age, and fully participating in training at the time of testing. All participants had medical clearance for intercollegiate athletic participation, as well as read and signed consent forms to participate in athletics. The athletic department at the respective university also distributed written consent forms to the athletes at the start of the academic year to obtain permission to use data collected from athletes. As such, the institutional ethics committee approved the use of pre-existing data for analysis. The study conformed to the recommendations of the Declaration of Helsinki. Additionally, this research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science. Each player also completed the university-mandated physical examination and read and signed the university consent and medical forms for participation in collegiate athletics.

Protocol

Data was collected in the pre-season over two days, with 48-hours between sessions. The only data used were of those athletes that were able to complete all tests relevant to this study. Each session included a ten-minute standardized dynamic warm-up which included; low aerobic intensity jogging, a sport-specific dynamic stretching protocol, and ended with participants performing assessment-specific exercises which included; various bodyweight squats, lunges,, and jumps. Participants were then provided full instruction on how to perform each test and were allowed up to two practice trials for each. The first session included the following lower-body power measurements: SJ, CMJ, and SBJ. Heights from the SJ and CMJ were later used to calculate peak anaerobic power in watts (PAPw). This first session also included height and body mass measurements. The second testing session included COD and linear sprint speed tests performed in the following order: 5-0-5-agility (5-0-5); T-Test (TT); modified T-Test (MTT); 30m sprint recording the 0-10m time (10m and the 30m time.

First, height (cm) and body mass (kg) were measured on a doctor's beam scale (Cardinal; Detecto Scale Co, Webb City, MO, USA) (1,2).

Next, jump height for both the SJ and CMJ was measured using a jump mat (Just Jump, Probotics Inc., Huntsville, Al, USA) (12,13). For both of these tests, athletes were instructed to stand in the center of the jump mat with their hands on their hips. For the SJ, athletes were instructed to squat until they achieved a 90 degree knee angle, pause for approximately 2 seconds, and while keeping the hands on the hips jump as high as possible, before landing back in the center of the mat in an athletic stance (i.e., head up, chest up, and a slight bend in the ankles, knees and hips). (12). For the CMJ, athletes were also instructed to stand in the middle of the mat with hands on the hips, and when ready, jump as high as possible while minimizing the time between the eccentric and concentric muscle actions (12). Each athlete performed SJ and CMJ in a randomized order and were given three attempts for each jump. The best attempt for each jump was recorded. The Sayer's equation (Peak power (Watts) = 60.7 * jump height (cm) + body mass (kg) – 2055) was used to calculate peak absolute power (PAPw) of each jump. PAPw was divided by body mass (kg) to determine relative power (1,19).

Then, SBJ was used as an assessment of lower-body power and participants were allowed three attempts. Participants were instructed to stand at the starting line with their feet shoulder-width apart, bend at the knee and use an arm swing, and jump as far forward as possible. The distance jumped was then measured in centimeters. Relative displacement was assessed by dividing SBJ distance (cm) by body mass (kg) (relative SBJ).

Following that, the 5-0-5 was used to measure agility in the horizontal plane. It required the athlete to accelerate 10m, sprint 5m, plant one foot, change direction, and sprint back 5m towards the direction they began (Figure 1)(18). The athlete was given two trials per plant foot and the best score of each side was recorded.

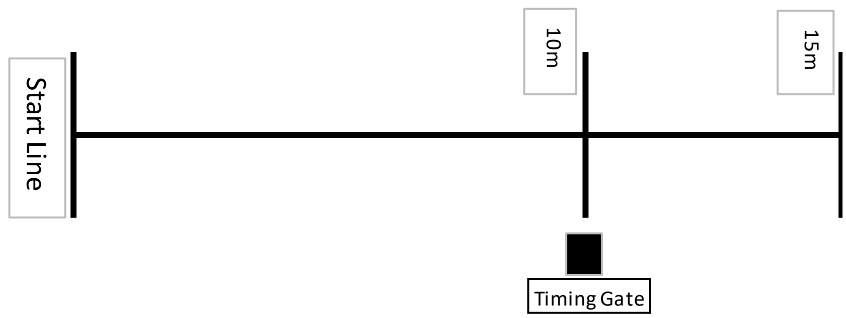

Figure 1. 5-0-5 Agility Test Layout.

Then, then TT is used in many field-based sports to assess CODS by requiring the athlete perform multi-directional movements (i.e., forward sprint, backpedal, and side shuffles) (Figure 2). As described by Stassi et al. (2009), the TT required the participant to sprint forward 10 yds (9.14m) to a center cone and touch said cone with right hand, immediately shuffle to the left 5 yd (4.57m) to touch a cone with their left hand and immediately shuffle to the right 10yds (9.14m) to touch the third cone with their right hand. After the second shuffle, the athlete shuffled left towards the middle cone, touched the cone with their left hand and backpedaled to the same cone she started the test, covering a total of 40 yds (36.56m). Participants were instructed to not cross their feet while shuffling, touch all cones, and face forward for the entirety of the test. If the subject failed to do these actions the test was omitted and repeated after three-minutes.

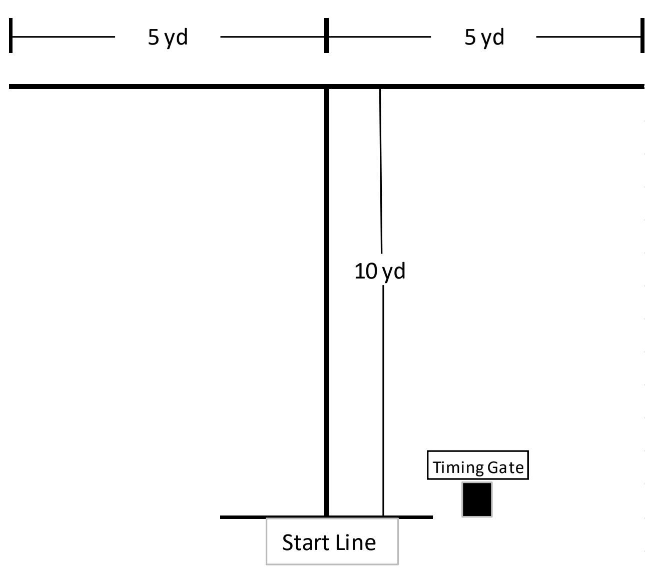

Figure 2. T-Test Layout.

Then, the Modified T-Test (MTT) was performed in the same manner as the T-test but required half of the distances be covered (Figure 3). The MTT required the participant to sprint forward 5 yds (4.57m) to a center cone and touch said cone with right hand, immediately shuffle to the left 2.5 yds (2.28) to touch a cone with their left hand and immediately shuffle to the right 5 yds (4.57m) to touch the third cone with their right hand. After the second shuffle, the athlete shuffled left towards the middle cone, touched the cone with their left hand and backpedaled to the same cone she started the test, covering a total of 20 yds (18.28m). Participants were allowed two attempts for each assessment with the best score being recorded. Previous research suggests the MTT may be more advantageous compared to a TT as the shorter distances better mimic the COD requirements of most field-based sports (9,18). The current researchers choose to implement both tests to determine relationships between longer and shorter CODS tasks (11).

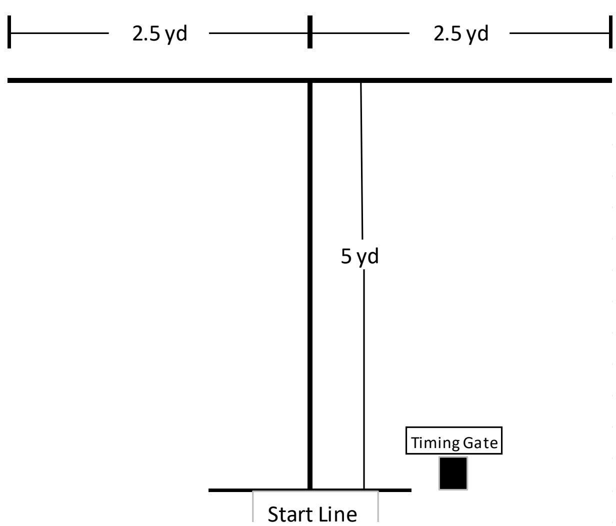

Figure 3. Modified T-Test Layout.

Finally, linear sprint speed was measured over a 30m sprint, recording the first 10m and 30m. Times were recorded using an electronic timing system (TC-System, Brower Timing Systems, Draper, UT, USA) (1). The best of three trials were recorded and rounded to the nearest tenth of a second.

Statistical Analysis

All statistical analyses were computed using JASP (Version 0.9). Descriptive statistics (mean ± standard deviation (SD) were calculated for each variable. A Kolmogorov and Smirnov test was used to check normality of the data prior to further analysis. Pearson's correlation was used to find relationships between lower-body power measurements (CMJ, SJ, SBJ, Relative SBJ, PAPw CMJ, relative CMJ, PAPw SJ, relative SJ), CODS tests (5-0-5, TT, MTT), and linear sprint speed (10m and 30m). Statistical significance was set at $\alpha \leq 0.05$. The strengths of each correlation value were graded as follows: 0 to 0.30, or 0 to -0.30 was considered small; 0.31 to 0.49, or -0.31 to -0.49 was considered moderate; 0.50 to 0.69 or -0.50 to -0.69 was considered large; 0.70 to 0.89 or -0.70 to -0.89 was considered very large; and 0.90 to 1.0 or -0.90 to -1.0 a near perfect correlation (9).

RESULTS

The descriptive statistics and data for all assessments can be seen in Table 1. Correlation data for all power measurements in relation to COD and linear speeds displayed in Table 2. Statistical analysis revealed significant relationships for both SJ and CMJ with most tests. SJ height showed large to very large negative correlations with all tests except 10m sprint, 95% CI [-0.93, 0.99]. CMJ height showed large to very large negative correlations with all tests, 95% CI [-0.92, 0.99]. Relative SJ revealed large negative correlations with all sprint speeds over 10m and all COD tests. Relative CMJ revealed moderate to large negative correlations with all sprint and CODS, 95% CI [-0.91, -0.01]. In short, greater jump height related to faster linear sprint and CODS. In contrast, PAPw for both SJ and CMJ revealed no significant relationships with any tests, 95% CI [-0.78, 0.70]. SBJ distance demonstrated small positive correlations with all CODS tests and 30m speed, 95% CI [-0.88, -0.06]. However, Relative SBJ only had small positive correlations with the 5-0-5, 95% CI [-0.83, -0.06]. In short, greater jump distance related to faster maximal linear sprint speed and CODS.

Table 1. Descriptive Statistics for sample (n = 17).

	Minimum	Maximum	Mean ± SD
Age (yrs)	17	20	18.2 ± 0.8
Ht (cm)	154.5	170.5	162.4 ± 4.8
Wt (kg)	47.5	81.4	62.5 ± 9.1
CMJ (cm)	27.7	51.3	39.30± 5.8
SJ (cm)	27.7	51.6	41.0 ± 5.5
SBJ (cm)	44.00	69.0	59.4 ± 6.0
PAPw CMJ	2537.2	4066.4	3160.7 ± 413.9
PAPw SJ	2506.4	3958.4	3261.3 ± 387.0
Relative CMJ	40.7	64.8	51.0 ± 5.8
Relative SJ	40.7	65.1	52.6 ± 5.7
Relative SBJ	0.5	1.3	1.0 ± 0.2
5-0-5 R (s)	2.3	2.9	2.6 ± 0.2
5-0-5 L (s)	2.3	2.9	2.5 ± 0.2
TT (s)	10.8	13.3	12.0 ± 0.6
MTT (s)	6.1	7.6	6.8 ± 0.4
10m (s)	1.7	2.3	1.9 ± 0.1
30m (s)	4.5	5.7	5.0 ± 0.3

Table 2. Correlations between measures of power to linear and change of direction speed.

Variable	Statistics	5-0-5 R (s)	5-0-5 L (s)	TT (s)	MTT (s)	10m (s)	30m (s)
CMJ (cm)	r	-.527*	-.785***	-.645**	-.703**	-.506*	-.668**
	Sig.	0.03	< 0.001	0.01	< 0.001	0.04	<0.001
SJ (cm)	r	-.641**	-.810***	-.652**	-.593**	-.438	-.709**
	Sig.	0.01	< 0.001	0.01	0.01	0.08	< 0.001
SBJ (cm)	r	-.601**	-.684**	-.642**	-.594**	-.471	-.528*
	Sig.	0.01	< 0.001	0.01	0.01	0.06	.03
PAPw CMJ	r	-.101	-.262	-.310	-.47	-.281	-.198
	Sig.	0.70	0.31	0.23	0.06	0.28	0.45
PAPw SJ	r	-.19	-.270	-.312	-.381	-.221	-.220
	Sig.	0.48	0.29	0.22	0.13	0.40	0.40
Relative CMJ	r	-.532*	-.770***	-.620**	-.652**	-.491*	-.629**
	Sig.	0.03	< .001	0.01	0.01	0.05	0.01
Relative SJ	r	-.619**	-.771***	-.599**	-.523*	-.418	-.657**
	Sig.	0.01	< 0.001	0.01	0.03	0.10	< 0.001
Relative SBJ	r	-.523*	-.579*	-.435	-.340	-.305	-.657**
	Sig.	0.03	0.02	0.08	0.18	0.23	< 0.001

Note. * Significant relationship ($p \leq .05$) between the two variables; ** Significant relationship ($p \leq .01$) between the two variables; *** Significant relationship ($p \leq .001$) between the two variables.

DISCUSSION

The current study investigated the relationships between lower-body power, linear sprint speed, and CODS among Division II women's lacrosse players. The primary findings of this research identified significant, negative correlations between jump height and relative lower-body power with sprint and CODS. No significant relationships were found between absolute power measures and any sprint or CODS tests. Thus, the results of this study suggest that emphasizing the development of relative lower-body power within the collegiate female lacrosse population may improve both sprint and CODS within this population. Additionally, these findings may be beneficial for strength and conditioning professionals working to determine which lower-body power tests should be prioritized when developing an athletic testing battery within this population.

The relationships between measures of lower-body power to linear sprint speed have been investigated in previous studies (1,9,12). The results of this study revealed large to very large negative relationships between SJ and CMJ, as well as relative measures calculated from these tests. Furthermore, a moderate negative relationship was discovered between 10m sprint speed and the CMJ (r = -.506, p = 0.04) but did not relate to any other measures of power investigated. These findings are similar to those of McFarland et al. (12) who found moderate-to-strong negative correlations between 30 m sprint time (r = −0.502 to −0.751), and SJ (r = − 0.502 to − 0.681) among a group of NCAA Division II women's soccer players. In contrast, this study did find a significant relationship between 10m time and CMJ height. However, McFarland et al (12) reported moderate negative correlations between 10m and 30m sprint times to the CMJ (r = −0.476 and −0.570) and SJ (r = −0.443 and −0.553, respectively) among males at the same playing level. A moderate negative relationship was discovered between the SBJ and relative SBJ and 30m time (r = -0.528 and -0.657, respectively), with no significant relationships discovered between these variables and 10 m time. These results suggest that the CMJ and/or the SJ may be better tests to include in a testing battery compare to the SBJ as they are more closely related other skills required to be successful in lacrosse, specifically sprint speed.

The relationships between lower-body power tests to CODS have also been the focus of several studies (1,9,10,12). Significant moderate to large negative correlations were found between the CMJ (r = -.527 to -0.785) and SJ (r = -0.593 to -0.810) and all measures of CODS. Significant moderate negative relationships (r = -0.471 to -0.684) between SBJ and all measures of CODS. These results suggest, that in general, vertical jump height as measured by the CMJ and SJ relate better to CODS tests than the SBJ. When looking at the jump measures in relation to their body mass, it seems that relative CMJ and relative SJ demonstrated moderate to strong negative relationships (r = -0.523 to -0.771) between all measures of CODS. In contrast, significant moderate negative relationships were discovered between (r = -0.523 to -0.579) relative SBJ and the 5-0-5 test only. These findings suggest that measures of power using the CMJ and SJ may more closely relate to measures of CODS than the SBJ. Based on the relationships between the measures of power related to the CMJ and SJ to linear and CODS, these tests would appear to have greater value when attempting to profile athletes that may have greater success in the sport of women's lacrosse.

This study has limitations that should be noted. The data set only included one team at one point in time. Additionally, the sample size was relatively small as it only included those athletes that were available and capable of performing all tests in this study. The average age of this sample size was 18 years old, and thus it could be considered a young collegiate team. A young training age may have influenced the athletes' mechanical efficiencies in tasks such as CODS, sprinting, and jumping that may not be observed in more experienced athletes. The current research also did not have access to any information on the athlete's competitive and training experience. Future researchers may consider collecting this data annually to evaluate the effects of these variables on performance tests. Finally, do the the large number of correlations performed it is possible that some spurious correlations may have occurred. However, upon review it does appear that the data does trend in a general direction and the correlations observed do not simply appear to be random chance.

In conclusion, this study adds to the sparse research in women's collegiate lacrosse, contributing to the data available on female athletes participating in this sport (2). In particular, this study provided evidence that relative lower-body power correlated with linear speed capability and CODS. These results suggest that strength and conditioning professionals should prioritize developing relative lower-body power when working with collegiate Division II female lacrosse athletes. Additionally, the findings from this study also provides strength and conditioning professionals with valuable information to improve and prioritize assessments during an athletic testing battery. Future research may include larger sample sizes as well as athletes from different teams and universities, as they will have been exposed to different training protocols. This may also further contribute to the needs analysis of the sport of lacrosse.

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