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Original Research

Relationships between Lower-body Power, Sprint and Change of Direction Speed among Collegiate Basketball Players by Sex

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ABSTRACT

International Journal of Exercise Science 15(6): 974-984, 2022. The purpose of this study was to determine if significant relationships exist between absolute and relative lower-body power and selected measures of speed among male and female collegiate basketball players. Archived performance testing data from 29 (male = 14; female = 15) NCAA division II collegiate basketball players were used for this analysis. These measures included lane agility, 10-yard sprint, and shuttle run time (sec). A Pearson's correlation coefficient was used to determine if significant relationships existed between measures of lower-body power and linear sprint time, change of direction speed (CODS), and shuttle performance. Statistical significance was set *a priori* at $p \leq 0.05$. A significant large correlation was found between absolute power and lane agility ($r = 0.54$, $p = 0.05$) among male players. No significant correlations were found between absolute or relative power for 10-yard sprint times, lane agility, or shuttle run performance ($p > 0.05$). Females showed no significant correlations between relative power and lane agility ($r = -0.25$, $p = 0.37$) or 10-yard sprint ($r = -0.47$, $p = 0.08$), but did show a significant large correlation ($r = -0.64$, $p = 0.01$) between relative power and shuttle run performance. Generating high amounts of relative power is vital in intermittent team sports such as basketball. In particular, this study provided evidence that relative power in female collegiate basketball players is significantly related to shuttle run ability.

KEY WORDS: Agility; vertical jump; shuttle performance; sport performance

INTRODUCTION

To be successful in the sport of basketball, players must possess good multi-directional speed and jumping ability (11, 35). Previous research indicates that these skills are dependent on the ability to produce, reduce and stabilize forces rapidly (37). It has been reported a basketball player performs approximately 1000 short (< 3 sec) explosive movements over the duration of a game (3, 27). Furthermore, forward-backward and lateral movements constitute approximately 40% and 20% of all movements during gameplay, respectively (27). More specifically, Abdelkrim et al., determined that during gameplay basketball athletes may execute approximately 40-60 short sprints, 40 jumps, and 100 high-intensity basketball-specific movements that require multi-directional power, speed and agility (3). For these reasons, exploring the relationships between lower-body power and its potential influence on linear sprint time, change of direction speed (CODS), and shuttle performance to gain a better understanding would be useful when developing strength and conditioning programs to optimize sports performance. Moreover, although these relationships have been investigated in other sports (21, 22, 23, 26, 38), these differences have not been explored in tests specific to the sport of basketball. To gain a greater understanding of how each of these variables may influence the specific demands of this sport, further analysis is warranted.

Several studies have examined the relationships between linear sprint time and measures of lower-body power (20, 34). Wisløff et al. found that vertical jump performance demonstrated strong correlations to 10m and 30m sprint times among soccer athletes (38). These findings are consistent with those discovered by McFarland et al., who found countermovement jump and squat jump were strongly correlated with 30 m speed, pro agility test, and T-test performance in NCAA DII women's soccer players (26). These findings suggest that lower-body power may have a significant impact on an athlete's ability to perform short distance linear- sprints.

While the relationships between absolute and lower-body power have been investigated in previous studies, they have not been fully explored among NCAA DII basketball athletes. Recently, absolute and relative lower-body power were significantly correlated with CODS in NCAA D1 women's basketball players, which is similar to previous research in other sports (2, 9, 23, 24). However, these relationships have not been explored in collegiate male basketball at any level of play (i.e., division 1, 2, or 3). Consequently, it is unclear as to whether there are sex-related differences between these variables as previous research has demonstrated that males and females may utilize different approaches to complete the same tasks (32). Thus, only extrapolations can be made from research performed among athletes belonging to other sports that require multi-directional speed. Furthermore, it is unclear how lower-body power may influence longer duration bouts of sprinting that require multiple changes of direction.

To date, only one study has directly examined the relationship between shuttle performance and anaerobic power in collegiate basketball players (2). Banda and colleagues used the Yo-Yo intermittent recovery level 1 test to assess shuttle performance in NCAA D1 women's basketball players (2). Results from the study found that larger absolute power values resulted in fewer laps completed in the shuttle run (i.e., negatively correlated) (2). This could be explained by larger body masses being more difficult to move quickly despite having greater absolute power values (22). Contrastingly, a larger relative power output (i.e., watts/kg) resulted in more laps completed during the shuttle run (2). Considering this data and previously published data in other team sports, it is plausible to suggest that lower-body power (both absolute and relative) may be indicative longer duration events requiring CODS (2, 23).

Little research investigating the relationships between lower-body power and measures of performance among male and female basketball athletes exists. While previous research exists in multi-directional sports, conclusions based on those sports may be ill advised. For example, while soccer is a multi-directional sport, the game demands compared to basketball are quite stark. As such, the purpose of this study was to determine if significant a relationships exists between absolute and relative lower-body power and selected measures of speed among male and female collegiate basketball players. It was hypothesized that greater relative power measured from the countermovement jump would correlate with faster linear sprint time, CODS, and shuttle performance in both male and female collegiate basketball players.

METHODS

Participants

Archived data from 14 male (age: 18 ± 0.7 years; height: 162.4 ± 4.8 cm; body mass: 62.5 ± 8.8 kg) and 15 female (age: 18 ± 0.7 years; height: 162.4 ± 4.8 cm; body mass: 62.5 ± 8.8 kg) NCAA division II collegiate basketball players, who participated in normal pre-season testing, were 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 following the ethical standards of the International Journal of Exercise Science.

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 (e.g., various bodyweight squats, lunges, and jumps). The first session included height and body mass measures, as well as lower-body power measurements during a CMJ. The second testing session included the lane agility test to assess change of direction speed (CODS), the shuttle run to assess shuttle performance, and the 10-yard sprint to assess 10-yard sprint times.

Test Day 1: The subjects' anthropometric measurements (height (cm), body mass (kg)) were measured on a doctor's beam scale (Cardinal; Detecto Scale Co, Webb City, MO, USA). The subjects then completed the ten-minute standardized dynamic warm-up previously mentioned.

Following the dynamic warm-up, an assessment of lower-body power was measured by a counter movement jump (CMJ) performed on a Just Jump Mat (Just Jump, Pro Botics Inc, Huntsville, AL, USA). Compared to vertical jumps measured using a Vertec, the Just Jump Mat system has been shown to be a valid method (r = 0.906) of assessing vertical jump height (18).

The mat was positioned under a basketball goal with athletes performing three distinct countermovement jumps (with arm swing) with 10 s recovery between trials. The only instruction given was to jump from a standing position and reach as high as possible on the backboard. The best score from three trials was retained for analysis and recorded to the nearest 0.01 cm. The best score was then used to estimate absolute power via the Sayer's Equation (PAPw = 60.7 * jump height (cm) + 45.3(body mass (kg) – 2055) (30). Subsequently, absolute power (PAPw) was taken and divided by body mass to achieve relative power, or power:body mass ratio (P:BM).

Test Day 2: The subjects completed the same dynamic warm-up performed on Test Day 1. The lane agility test was used to assess change of direction speed (10). Cones were positioned at all four corners of the free-throw lane on a standard-sized basketball court (Figure 1). From a standing start (cone A), players were instructed to complete a series of forward sprints, lateral shuffles, and backwards sprints until they touched every cone and returned to the beginning. Each attempt time was recorded using a dual-beam electronic laser timing system (TC-System, Brower Timing Systems, Draper, UT, USA). Each subject was allowed 3 efforts with the fastest time being recorded to the nearest 0.01 s. The lane agility test has been shown to be a reliable assessment of change of direction ability in basketball players (ICC = 0.99, CV = 8.71%) (5).

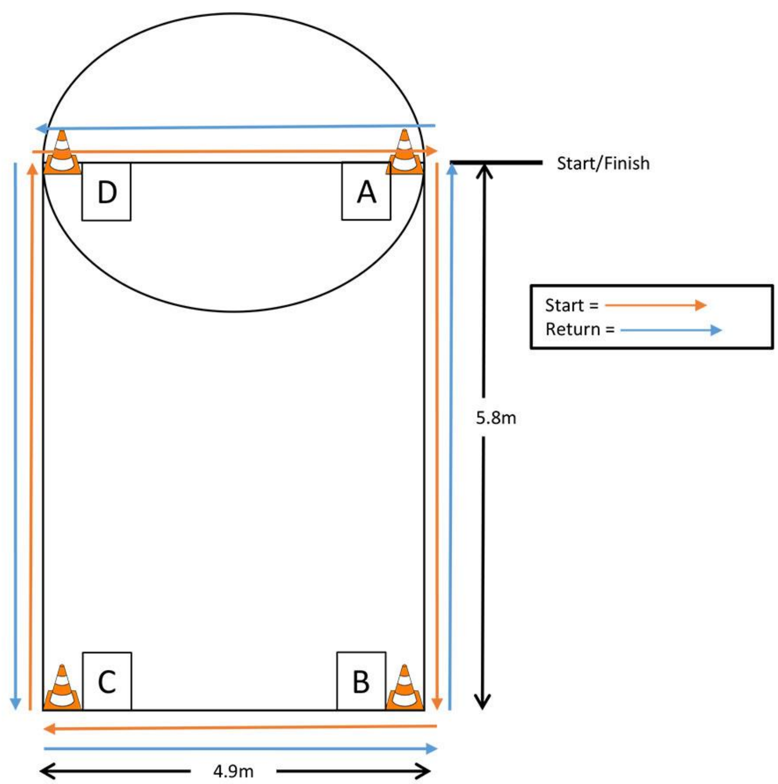

Figure 1. Basketball Lane Agility test

Shuttle performance was assessed using a shuttle run test, commonly referred to as "suicides". Each player started standing behind the baseline, sprinting to the nearest free-throw line (5.8m) and back to the starting position. After reaching the baseline, players changed direction sprinting towards the halfway point of the court (14.3m) and back to the baseline. Players finished this sequence by reaching the opposite free throw line (22.9m) and finally the opposite baseline (28.7m). The total distance covered was 143.4-meters (9). All athletes only performed this test once, with time recorded to the nearest 0.01 s using a hand-held stopwatch (Figure 2).

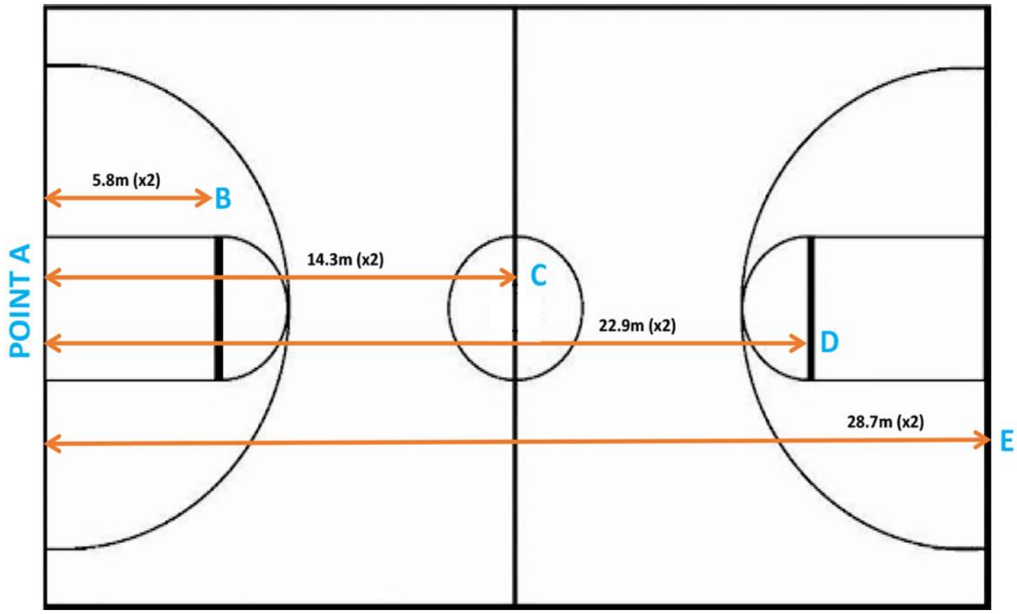

Figure 2. All athletes started behind the baseline (point A), sprinting to the nearest free throw line (point B), halfway point of the court (point C), the opposite free-throw line (point D), and the opposite baseline (point E), each time returning to the baseline (point A).

Finally, linear sprint time was measured over a 10-yard sprint. Times were recorded using a dual-beam electronic laser timing system (TC-System, Brower Timing Systems, Draper, UT, USA). The best of three trials was recorded and rounded to the nearest tenth of a second.

Statistical Analysis

All data were analyzed using a free open-source statistical software package (JASP, Version 0.11.1, Amsterdam, NL USA). A power analysis indicated that 111 participants were required to achieve an alpha of 0.05 (G*Power 3.1). While this recommendation is statistically appropriate, it is impractical given that this exceeds the total number of individuals for each team. Descriptive statistics (mean ± standard deviation (SD)) were calculated for each variable. Pearson's correlation coefficients were used to find relationships between absolute and relative lower-body power, 10-yard sprint time, CODS tests (lane agility), and shuttle performance by sex. Power to body mass ratio (P:BM) is calculated by the following: P:BM = PAPw/BM (kgs). Statistical significance was set at $p \leq 0.05$. 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 (14).

RESULTS

The descriptive statistics of all assessments can be seen in Table 1. Correlation data for absolute and relative power measurements in relation to 10-yard sprint time, CODs, and shuttle performance for males and females are displayed in Tables 2 and 3, respectively. Statistical analysis revealed large, significant relationships for between absolute power and lane agility (r = 0.54, p = 0.05) among male players. For the male data, no statistically significant correlations were found between absolute or relative power for 10-yard sprint times, lane agility, or shuttle run performance (p > 0.05). Females showed no statistically significant correlations between relative power and lane agility (r = -0.25, p = 0.37) or 10-yard sprint (r = -0.47, p = 0.08), but did show and a significant large correlation (r = -0.64, p = 0.01) between relative power and shuttle run performance. No other relationships between lower-body power measures or 10-yard sprint time were observed.

Table 1. Descriptive Statistics for sample (male = 14; female = 15). All data presented as mean ± standard deviation (SD). PAPw = peak anaerobic power output; P:BM = power: body mass ratio; CMJ = countermovement jump; LAT = lane agility test; 10yd = 10-yard sprint time.

	Male	Female
Age (yrs)	20.1 ± 1.9	19.5 ± 1.5
Ht (cm)	189.1 ± 11.1	170.0 ± 5.9
Wt (kg)	89.3 ± 11.7	72.1 ± 9.7
PAP(w)	6574.2 ± 733.8	4239.9 ± 436.6
P:BM (w/kg)	74.1 ± 6.8	59.2 ± 5.6
CMJ (cm)	75.6 ± 8.0	49.9 ± 5.4
LAT (s)	10.7 ± 0.6	11.9 ± 0.6
10yd (s)	1.7 ± 0.1	1.9 ± 0.1
Shuttle(s)	55.9 ± 2.6	65.7 ± 3.6

Table 2. Correlations (with 95% confidence intervals) between measures of absolute and relative power to CODS, 10-yard sprint time, and shuttle performance in males. PAPw = peak anaerobic power output; P:BM = power:body mass ratio; LAT = lane agility test; 10yd = 10-yard sprint time.

Variable	Statistic	LAT(s)	10yd(s)	Shuttle(s)
PAP(w)	r	0.542	0.172	0.266
	Sig.	0.05* 95% CI [0.01, 0.83]	0.56 95% CI [-0.39, 0.64]	0.36 95% CI [-0.31 0.70]
P:BM(w/kg)	r	-0.521	-0.356	-0.341
	Sig.	0.056 95% CI [-0.82, 0.01]	0.21 95% CI [-0.75, 0.21]	0.23 95% CI [-0.74, 0.23]

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

Table 3. Correlations (with 95% confidence intervals) between measures of absolute and relative power to CODS, 10-yard sprint time, and shuttle performance in females. PAPw = peak anaerobic power output; P:BM = power:body mass ratio; LAT = lane agility test; 10yd = 10-yard sprint time.

Variable	Statistic	LAT(s)	10yd(s)	Shuttle(s)
PAP(w)	*r*	-0.087	-0.035	0.180
	Sig.	0.76 95% CI [-0.57, 0.45]	0.9 95% CI [-0.54, 0.49]	0.52 95% CI [-0.63, 0.37]
P:BM(w/kg)	*r*	-0.251	-0.473	-0.643
	Sig.	0.37 95% CI [-0.67, 0.30]	0.08 95% CI [-0.79, 0.05]	0.01** 95% CI [-0.87, -0.20]

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 primary purpose of this study was to determine if significant relationships exist between absolute and relative power and linear sprint time, change of direction speed (CODS), and shuttle performance in collegiate basketball players. When comparing by sex, no significant correlations were found between absolute lower-body power and any measures of performance for females. For males, a significant large correlation was found between absolute power and lane agility with no significant correlations discovered between absolute or relative power for any of the other speed measures. A significant large positive correlation was discovered between relative power and shuttle performance among female players, however no other relationships between absolute and relative power and any other speed measure were observed. While these results suggest that absolute and relative power may not impact speed and shuttle run performance within this population, lower-body power is still an essential attribute for improving other aspects of performance in this sport, such as jumping. The authors would posit that although lower-body power is an important, other factors (i.e., running form and technique, body composition, etc.) should also be addressed to enhance performance among collegiate basketball athletes.

Little research investigating the relationships between absolute lower-body power and measures of speed among male and female collegiate basketball athletes currently exists. Overall, no statistically significant relationships between absolute power and linear sprint time or shuttle performance were observed for either male or female collegiate basketball athletes participating in this investigation. No significant relationships were identified between absolute power and selected measures of linear sprint time, CODS, and shuttle performance for female collegiate basketball athletes. However, statistically significant, moderately positive relationships were identified between absolute power and CODS performance for male collegiate athletes in this investigation (i.e., slower CODS). These findings are similar to previous research conducted by Banda et al. who reported that absolute power was significantly related to the pro-agility shuttle (r = 0.745) in female basketball players (2). While larger athletes may produce higher amounts of absolute power, they also have larger body mass which is more difficult to move quickly (2, 22). In this case, the evidence from this investigation suggests the proposed strategy of increasing power output relative to body mass. Results from the current study showed near significant correlation between relative power and lane agility (p = 0.056). While this is strictly above the statistical significance threshold of 0.05, a larger sample size may have shown statistical significance between the variables.

In regard to relative power's influence on selected measures of CODS, linear speed, and shuttle performance, no statistically significant relationships were identified for CODS or linear sprint time performance for either male or female collegiate basketball athletes participating in this investigation. Although, it should be noted there was a non-significant trend (p = .056) between relative power and CODS among males. Consequently, the investigators would posit that while statistical significance was not reached, most likely due to the small sample size, these findings have practical relevance when seeking to enhance CODS performance within these populations. Statistically significant moderate relationships were identified between relative power and shuttle performance for female collegiate athletes. These findings differ from previous research conducted with NCAA Division I female basketball players where relative power was positively correlated with measures of shuttle performance (r = 0.622)(2). While speculative, this may be explained by differences in body mass, as the athletes in the study conducted by Banda et al (2) were larger than the athletes in this investigation. However, other factors such as technique, body composition, and training focus may also impact shuttle run performance. For these reasons, the authors would suggest addressing each of these areas in a strength and conditioning program to afford athletes the best opportunity for success.

Interesting differences were observed between sexes in terms of CODS and shuttle performance. In contrast to the females in this study, male athletes demonstrated a significant relationship between lane agility performance and absolute power. Although not examined in the current study, these differences may be explained by the difference in body composition between males and females. In short, females carry greater fat mass relative to body weight and while they may produce higher amounts of absolute power, there is more lean muscle mass contributing to force output in males (4). Future investigations should seek to investigate the impact of body composition on predictors of performance in these populations.

There are several limitations to this study that should be addressed. Although the sample sizes included within the study are realistic in regard to basketball team size, it may be beneficial to include larger sample sizes in order to better represent the collegiate basketball athlete population. Furthermore, in regard to sample characteristics it may be beneficial to conduct multiple assessments longitudinally and monitor fluctuations in performance as well as parse data out based on identifiable characteristics (i.e., age, training age, grade classification, role on team or minutes played, etc.). In the future, this may enhance the interpretation of the results and the recommendations researchers are able to provide. In regard to assessment selection, assessing power via the utilization of horizontal power expression, loaded vertical or horizontal power expression (e.g., trap bar vertical jumps, loaded trap bar vertical jumps, etc.), and/or Olympic lifting patterns (e.g. hang jump shrugs, hang high pull, hang clean, etc.) may provide insight on key determinants of power production within the basketball athlete population.

Finally, individual participants have unique characteristics that likely contributed to their performance. For the male athlete, including anthropometric measurements such as limb length and circumference as well as body composition may provide a better understanding and thus a better interpretation of their performance.

In conclusion, the ability to generate high amounts of power relative to body mass is vital in high-intensity, intermittent team sports such as basketball. In particular, this study provided evidence that relative power in female collegiate basketball players is significantly related to intermittent repeat sprint ability, which is a unique characteristic of the sport of basketball. Additionally, this study also provides evidence that absolute power in male collegiate basketball players seems to be significantly related to slower CODS in male basketball players. Thus, it should be noted that generating high amounts of absolute power may not be a sole predictor of performance and coaches should take into account power output relative to body mass. For example, although not statistically significant, it may be advantageous to optimize relative power over absolute power when attempting to improve lane agility in male basketball athletes. For females, it seems higher relative power improves shuttle run performance. Therefore, based on the findings of this study, it may be beneficial to implement sex specific training strategies when working with basketball athletes.

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