THE RELATIONSHIP BETWEEN LATERAL MOVEMENT AND POWER IN FEMALE ADOLESCENT BASKETBALL PLAY

Brian T. McCormick
University of Utah, U.S.A.

Abstract:

Purpose. *Lateral movement is an important quality to performance in basketball. The relationship between lateral movement as measured by a side-step test and power as measured by a lateral hop and vertical jump is largely unstudied.* **Methods.** *Female adolescent basketball players (n = 51) participated in this study. The study used a Pearson's product-moment correlation to measure the relationship between the lateral side-step test (LST), countermovement vertical jump (CMVJ, and lateral hop (LH). Results. There was a moderate relationship between LST and LH (r = .487 to .626, p < .001), and a small relationship between the LST and CMVJ (r = .279, p = .048 to .309, p = .028). There was a moderate significant relationship between CMVJ and LH (r = .370, p = .008 and r = .441, p = .001).* **Conclusions.** *These results suggest that the plane of movement affects the relationship of power and lateral movement in adolescent female basketball players.*

Keywords: *agility, change of direction speed, vertical jump, lateral shuffle*

Contact: brian.mccormick@utah.edu

The relationship between vertical jump (VJ) height and change-of-direction speed (CODS) has been well-studied, and a significant negative relationship between VJ height and CODS time has been established[1,2,3]. An athlete who jumps higher will tend to be faster on a test of CODS. The relationship should be expected, as a negative relationship between VJ and linear speed has been established[4,5], and most tests of CODS have incorporated linear sprinting[6]. Different tests of CODS have been grouped together as one quality regardless of the number or angle of directional changes. However, the percent change between an 8m sprint and an 8m sprint with a 20-degree cut was only 1.8%, whereas the percent change between an 8m sprint with a 40-degree cut and an 8m sprint with a 60-degree cut was 11.3%[7]. Similarly, significant differences were reported between angles of 30, 60, and 90 degrees[8]. These differences suggested that the angle of the cut used in a CODS test changes the movement, and the relationships between these tests and other qualities like speed and power may differ based on the angle of the cut.

Sagittal-plane training has dominated training programs for multi-directional sports performance[9,10,11], and the VJ test has been the primary measure of leg power[12]. Plyometric training (PT) has been a popular training modality[9,10,11], and has been shown to improve VJ and CODS[3,6,9,13,14,15,16,17]. However, the improvements of PT alone on tests of CODS have been small. Multi-direction PT programs have found better practical improvements on CODS performance[13,15,16] compared to studies that trained only in the sagittal plane. Therefore, the relationship between VJ and CODS may be affected by the test and by the specific training stimulus.

Further complicating the relationship between power and CODS, some tests of CODS have incorporated movements other than sprinting and small directional changes. The Edgren Side-Step Test (ESST), T-test of agility, and Lane

Agility Test (LAT) have incorporated lateral shuffling, and the T-test and LAT have incorporated backpedaling. Lateral shuffling and backpedaling are important movements in basketball, and have been found to account for as much as 41% of the movement time in a game of adolescent males[18]. In the T-test, participants sprint forward, shuffle laterally, and sprint backward in the pattern of a T[19], whereas in the LAT, participants sprint forward, shuffle laterally, sprint backward, and shuffle laterally in the shape of a box[20]. In the ESST, participants shuffle side to side[21,22]. Whereas these have been considered tests of CODS, the T-test was found to have a stronger relationship with leg speed than with the Hexagon Agility Test, an established measure of CODS[23], and the T-test was used to establish the reliability and validity of the LAT[20]. Furthermore, no reliability or validity information for the ESST has been established[20].

The number of different procedures for tests of CODS, and the significant differences between different angles of directional changes, has suggested a lack of specificity with CODS[24]. This lack of specificity has complicated the study of the relationship between power and CODS. Since tests such as the ESST, T-test, and LAT differ in execution from tests such as a 20-degree directional change, the relationship with power may differ as well. The purpose of this study was to determine the relationship between sagittal-plane power and frontal-plane power, and between the two measures of power and CODS performance in the frontal plane. A lateral hop (LH) for distance was used as the measure of power in the frontal plane. A countermovement vertical jump (CMVJ) was used as the measure of power in the sagittal plane. A lateral shuffle test (LST) was used as the measure of frontal-plane CODS. The hypothesis were that the LST would be independent of CMVJ, but related to LH, and that there would be a positive relationship between CMVJ and LH.

Methods. Participants

The participants were 51 female high-school varsity basketball players from the western United States. The participant characteristics were: age 15.86 +/- 1.15, height 171.47 +/- 7.34 cm, mass 61.29 +/- 7.93 kg. The participants were recruited by contacting their high school and club coaches. The participants had varied training histories, but all were involved in an off-season strength training program with their team. None of the participants had sustained a significant ankle, knee, hip, or back injury in the prior 6 months. The study was approved by the University Institutional Review Board, and written parental and participant consent was completed prior to the data collection.

Study Design

The study used a within-groups repeated measures design. Each participant completed 5 tests: CMVJ, LST (dominant and non-dominant), and LH (dominant and non-dominant). The participants were given a demonstration of each test and completed several sub-maximal and one maximal practice trial to familiarize themselves with the different tests. After the familiarization period, the participants completed three test trials of the CMVJ and LH, and one test trial of the LST. Participants were given 60-90 seconds to recover between trials[25]. The tests were completed in a randomized order in a single session, and the best performance of each test was used for analysis.

Procedures

Participants reported to their high-school gymnasium for testing during a normally scheduled basketball practice in the off-season, approximately one month after the final game of their season. Upon arrival, the participants presented signed permission forms, and were asked for their height, weight, and age. After a 10-minute, standardized warm-up (Table 1), the tests were explained and demonstrated to the participants, and the participants had time to familiarize themselves with the testing procedures. The testing took place on a wood floor in the high school gymnasium.

Table 1. Standardized warm-up exercises

Unless otherwise noted, do the exercise from one sideline to the other.
Jog
Backpedal
Quick skip
Quick skip (thigh parallel to the ground)
Skip (knee above hip)
High skip (reach as high as possible)
Monkey shuffle (lateral shuffle with arm swing)
Carioca
Sumo squat x10 (stationary)
Hip turn and walkover
High knees
Butt kicks
Walking lunge (elbow to instep)
3/4 speed sprint
Backpedal
Stork stretch
Knee hug
3/4 speed sprint
Backpedal

Countermovement vertical jump (CMVJ). A Vertec device (Jumpusa, Sunnyvale, CA) was used to measure the height of the jumps to the nearest half inch (1.27 cm). To prepare the Vertec, the participants stood under the Vertec and reached with one arm in order to measure their standing reach. The participants were instructed to use a no-step, countermovement jump. The participants were allowed to swing their arms, and were instructed to jump as high as possible and reach for the vanes. To begin the test, the participants stood in an upright standing position. When ready, the participants flexed at the ankles, knees, and hips to make a preliminary downward movement, then extended their ankles, knees, and hips to jump vertically. At the top of their jump, the participants hit the vanes. Their vertical jump was measured as the difference between the highest vane hit on their jump and their standing reach. Participants completed 3 jumps, and the best jump was used for analysis.

Lateral hop (LH). The participants started in a standing position with the medial border of their shoe behind a line taped on the gym floor. When ready, they raised their other leg off of the ground and flexed at the ankles, knees, and hips on their stance leg to make a preliminary downward movement. They extended their ankles, knees, and hips to hop medially in the frontal plane. Participants landed on the same leg to reduce the effects of leg length on the distance measurements. The distance of the LH was measured with a tape measure to the nearest millimeter from the starting line at take-off to the point nearest the starting line at landing. The participants completed 3 trials on their right foot and 3 trials on their left foot. The best performance for each foot was used for analysis. The trials were recorded for the right and left leg, and transformed to dominant (LH-D) and non-dominant (LH-ND) legs. Previous studies have identified a dominant and non-dominant leg for power exertion and for functional exertion[26]. The dominant leg was determined to be the leg that produced the greatest distance on the LH, which represented the dominant leg for power exertion.

Lateral shuffle test (LST). The LST was chosen as the test of CODS because other tests of CODS have been shown to have a stronger relationship with straight-ahead speed than another test of CODS[23]. The LST was devised because there is no single ESST[21,22]. Pilot testing found an 8-foot distance to be superior to a 12-foot distance as a measure of

CODS, and no difference was found between a 6-second and a 10-second time frame. Therefore, this study used the 8-foot distance and 6-second time frame.

The test was marked with white athletic tape on the hardwood floor. A distance of 8 feet was marked with lines marked every 2 feet. The participant's score was the number of lines crossed during the duration of the test. A video camera (Flip Mino HD, Cisco Systems, Irvine, CA) was used to capture the trials, and the scores were counted and confirmed via video analysis. The time started on the participants' first visible movement. The participants started in an upright standing position straddling the center line. On the researcher's verbal signal, participants side-stepped from side to side continuously for 6 seconds. Participants were instructed not to cross their feet during the duration of the test, and a trial was discarded if a participant crossed her feet. The outside leg had to cross the outside line before changing directions. Each participant completed one test trial starting with her dominant foot (LST-D) as her push-off or trail foot and one with her non-dominant foot (LST-ND) as her push-off or trail foot.

Statistical Analysis

SPSS (version 20.0, Chicago, IL) was used to analyze the data. A Pearson's product-moment correlation was used to determine if any of the personal characteristics had a significant relationship with the five tests. A Pearson's product moment correlation was used to determine the relationship between the five tests. Statistical significance was set at $p < 0.05$.

Results

The means and standard deviations for the five tests are shown in Table 2. The LST is reported as the number of lines crossed within the 6-second period. The LH and CMVJ are reported in cm.

Table 2 Means and standard deviations for the tests of CODS and power (n = 51)

	Mean	Std. Deviation
CMVJ (cm)	45.82	5.93
LH-D (cm)	140.31	13.37
LH-ND (cm)	133.40	12.67
LST-D	22.71	2.14
LST-ND	22.65	2.23

Note: CMVJ = countermovement jump; LH = lateral hop; LST = lateral shuffle test; D = dominant; ND = non-dominant. LST is measured as the number of lines crossed.

Height and weight had a strong positive relationship, r = .521, p < .001, but there were no significant relationships between the personal characteristics and the tests. The inter-correlations for the 5 tests are shown in Table 3.

Table 3. Correlations for the tests of CODS and power (n = 51)

	LH-D	LH-ND	LST-D	LST-ND
CMVJ	.441**	.370**	.309*	.279*
	0.001	0.008	0.028	0.048
LH-D		.904**	.626**	.487**
		0.000	0.000	0.000
LH-ND			.609**	.488**
			0.000	0.000
LST-D				.853**
				0.000

** Statistical significance (*p*<.01), * Statistical significance (*p*< .05)

Note: CMVJ = countermovement vertical jump; LH = lateral hop; LST = lateral shuffle test; D = dominant leg; ND = non-dominant leg

Discussion

Power and CODS have been shown to be different, but related physical qualities in tests incorporating primarily sagittal-plane movements. This study incorporated movements in the frontal plane. The results did not confirm the first hypothesis, as there was a small, but statistically significant relationship between the CMVJ and LST. The results confirmed the second hypothesis, as there was a moderate relationship between the CMVJ and LH.

The results suggest that the plane of movement has a small effect on the relationship of power and CODS in female adolescent basketball players. There was a strong relationship between the LST and LH compared to the small relationship between CMVJ and LST. Vertical ground reaction force (VGRF) has been found to account for much of the total force in a COD task[1], and greater VGRF has been found to correlate with better performance in a lateral movement test similar to the LST[27]. Regardless of the direction, movement requires VGRF, as shown by the relationship between the CMVJ and LST. Despite the importance of VGRF to CODS tasks, this study found a stronger relationship between the LST and LH than the relationship between the CMVJ and LST, attesting to the specificity of movement. This movement specificity suggests a need to diversify common sagittal-plane dominated training programs for multi-direction sports[9,10,11].

The specificity of the LST and LH movements may have been the angles created by the leg to initiate the movements. Young et al.[7] identified foot placement, body lean, and posture as factors that affected COD technique, and Wilson et al.[11] has found the posture of movements to affect the transference of strength. The foot placement, body lean, and posture between the LH and LST may have been similar and strengthened the relationship between the two tests compared to the CMVJ, which utilized a different foot placement, body lean, and posture. The specificity between the LST and LH also may have been the unilateral nature of the tests compared to the bilateral CMVJ. A uniltateral squat compared to a bilateral squat was found to have a greater relationship with CODS[28]. The author speculated that an unilateral squat compared to a bilateral squat demands greater balance, stability, and coordination similar to CODS tasks[28], which have been considered relatively complex[14]. This complexity may weaken the relationship between CMVJ and CODS[14,29]. However, the LH compared to the CMVJ may have been similarly complex and demanding in terms of balance, stability, and coordination, and therefore shared a stronger relationship with the LST.

The asymmetries between the dominant and non-dominant legs in this study fall within the differences reported elsewhere. An asymmetry between 10 and 15% has been described as typical and acceptable in non-injured populations[30,31,32], and significant differences between dominant and non-dominant legs have been identified in unilateral vertical jumps[30] and a horizontal hopping test[33]. However, this is the first known study to identify asymmetries in a lateral-hop test.

The primary limitation to this study is a lack of validity information available for the LST and other similar shuffling tests. Also, whereas the study used high-school athletes, this population of female high-school basketball players may have lacked the strength and power to generalize these results beyond female high-school basketball players. College women's basketball players and male high-school basketball players would be expected, on average, to have a higher VJ[34], which could affect the relationship to the CODS test.

To maintain consistency, and exclude a potential confounding variable, the VJ test could be performed as a unilateral test to match the LH and LST. Similarly, a CODS test with a greater sagittal-plane element, a cut with a smaller degree, could be used to compare the relationships and exclude the choice of test as another factor.

This study examined the relationship between power and CODS specific to a CODS test in the frontal plane. Based on the results from this study and a study that found approximately 41% of a basketball game to be spent in movements similar to those used in the LST[18], adolescent female basketball players should train to improve frontal-plane performance in order to improve CODS in basketball-specific tasks.

References:

1. Barnes JL, Schilling BK, Falvo MJ, Weiss LW, Creasy AK, Fry AC. Relationship of jumping and agility performance in female volleyball players. J Strength Cond Res. 2007;21:1192-1196.

2. Castillo-Rodriguez A, Fernandez-Garcia JC, Chinchilla-Minguet JL, Carnero EA. Relationship between muscular strength and sprints with change of direction. J Strength Cond Res.2012;26:725-732.

3. Markovic, G. Poor relationship between strength and power qualities and agility performance. J Sports Med Phys Fitness. 2007;47:276-83.

4. Cronin JB, Hansen KT. Strength and power predictors of sports speed. J Strength Cond Res. 2005;19:349-357.

5. Vescovi JD, McGuigan MR. Relationships between sprinting, agility, and jump ability in female athletes. J Sports Sci., 2008;26:97-107.

6. Brughelli M, Cronin J, Levin G, Chaouachi A. Understanding change of direction ability in sport. Sport Med. 2008;38:1045-1063.

7. Young WB, James R, Montgomery I. Is muscle power related to running speed with changes of direction? J Sports Med Phys Fitness. 2002;42:282-288.

8. Suzuki Y, Enomoto Y, Ae M. A biomechanical analysis of cut-

ting movement while running with change in directions. In Kwon YH, Shim J, Shim JK, Shin IS, eds. Proceedings of International Conference on Biomechanics in Sports. Seoul, Korea; 2008: 681-684.

9. King JA, Cipriani DJ. Comparing pre-season frontal and sagittal plane plyometric programs on vertical jump height in high-school basketball players. J Strength Cond Res. 2010;24:2109-2114.

10. Simenz CJ, Dugan CA, Ebben WP. Strength and conditioning practices of National Basketball Association strength and conditioning coaches. J Strength Cond Res. 2005;19:495-504.

11. Wilson GJ, Murphy AJ, Walshe A. The specificity of strength training: The effect of posture. Eur J Appl Physiol. 1996;73:346-352.

12. Patterson DD, Peterson DF. (2004). Vertical jump and leg power norms for young adults. Meas Phys Educ Exerc Sci. 2004;8:33-41.

13. Malisoux L, Francaux M, Nielens H, Theisen D. Stretch-shortening cycle exercises: an effective training paradigm to enhance power output of human single muscle fibers. J Appl Physiol. 2006;100:771-779.

14. Markovic G, Mikulic P. Neuro-musculoskeletal and performance adaptations to lower extremity plyometric training. Sports Medicine. 2010;40:859-895.

15. Miller MG, Herniman JJ, Ricard MD, Cheatham CC, Michael TJ. The effects of a 6 week plyometric training program on agility. J Sports Sci Med. 2006;5:459-465.

16. Salonikidis K, Zafeiridis A. The effects of plyometric, tennis drills, and combined training on reaction, lateral and linear speed, power, and strength in novice tennis players. J Strength Cond Res. 2008;22:182-91.

17. Thomas K, French D, Hayes PR. The effect of two plyometric training techniques on muscular power and agility in youth soccer players. J Strength Cond Res. 2009;23:332-335.

18. Abdelkrim NB, El Fazaa S, El Ati J. Time-motion analysis and physiological data of elite under-19-year-old basketball players during competition. Br J Sports Med. 2007;41:69-75.

19. Semenick D. (1990). Tests and measurements: The T-test. Natl Str Cond Assoc J. 1990;12:36-37.

20. Brown AE. The reliability and validity of the lane agility test for collegiate basketball players [thesis]. La-Crosse, WI: University of Wisconsin, La-Crosse; 2012.

21. Harman E, Garhammer J, Pandorf C. Administration, scoring, and interpretation of selected tests. In Baechle TR, Earle RW, eds. Essentials of strength training and conditioning (2nd ed.). Champaign, IL: Human Kinetics. 2000;287-317.

22. Edgren HD. An experiment in the testing of ability and progress in basketball. Res Q. 1932;3:159-171.

23. Pauole K, Madole K, Garhammer J, Lacourse M, Rozenek R. Reliability and validity of the T- test as a measure of agility, leg power, and leg speed in college-aged men and women. J Strength Cond Res. 2000;14:443—450.

24. Jeffreys I. The nature of agility. Strength Cond J. 2011;33(4):52-59.

25. Farlinger CM, Kruisselbrink LD, Fowles JR. Relationships to skating performance in competitive hockey players. J Strength Cond Res. 2007;21:915-922.

26. Demura S, Goshi F, Yamaji S, Nagasawa Y. Lateral dominance of legs in maximal power, muscular endurance, and grading ability. Percept Mot Skills. 2001;93:11-23.

27. Shimokochi Y, Ide D, Kokubu M, Nakaoji T. Relationships among performance of lateral cutting maneuver from lateral sliding and hip extension and abduction motions, ground reaction force, and body center of mass height. J Strength Cond Res. 2013;27(7):1851-1860.

28. Brorsson S, Olsson CM, Bengtsson O, Petersson J. Maximal strength in one leg squat correlates with acceleration capacity and agility. Conference paper presented at The Interdisciplinary Perspectives on Health, Participation and Effects of Sport and Exercise. 2010; Odense, Denmark.

29. Tricoli VA, Lamas L, Carnevale R, Ugrinowitsch C. Short-term effects on lower-body functional power development: Weightlifting vs vertical jump training programs. J Strength Cond Res. 2005;19:433-437.

30. Hoffman JR, Ratamess NA, Klatt M, Faigenbaum AD,

Kang J. Do bilateral power deficits influence direction-specific movement patterns. Res Sports Med. 2007;15:125-132.

31. McElveen M, Riemann B, Davies G. Bilateral comparison of propulsion mechanics during single-leg vertical jumping. J Strength Cond Res. 2010;24:375-382.

32. Paterno M, Ford K, Myer G, Heyl R, Hewett T. Limb asymmetries in landing and jumping 2 years following anterior cruciate ligament reconstruction. Clin. J. Sports Med. 2007;17:258-262.

33. Newton RU, Gerber A, Nimphius S, Shim JK, Doan BK, Robertson M, Pearson DR, Craig BW, Hakkinen K, Kraemer WK. Determination of functional strength imbalance of the lower extremities. J Strength Cond Res. 2006;20;971—977.

34. Hoffman, J. Norms for fitness, performance, and health. Champaign, IL: Human Kinetics; 2006.