P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (ISRA): 4.69
IJPESH 2016; 3(2): 188-192

www.kheljournal.com
Received: 23-01-2016
Accepted: 25-02-2016

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Agility measures related to strikeouts of NCAA baseball pitchers

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Abstract
Like most kinetic chains in athletic performance, the baseball pitching motion begins with the muscles of the legs and continues progressively through the torso, shoulders, and arms. Similarities are noted between the baseball pitching motion and the kinetic chain employed in agility tests that involve acceleration, deceleration, and change of direction measures of agility.
Purpose: The purpose of this investigation was to determine pre-season agility in NCAA pitchers and to relate these measures to regular season pitching performance.
Methods: NCAA Division II pitchers (n=10, age 20.2±1.9 yrs., weight 83.8±10.3 kg, height 1.85±0.48 m) volunteered as study subjects. A previously described laser-timed 60-yd shuttle run ("JJ Shuttle") provided average speeds for four contiguous agility segments (S1, S2, S3, and S4 of 10, 10, 20, and 20 yds., respectively), as well as Total Shuttle Run (TSR). Statistical measures obtained from regular season games (n=48), including Runs (R), Hits (H), Earned Runs (ER), Base-on-Balls (BB), and Strikeouts (SO), each normalized for innings pitched, provided evidence of game pitching performance. Pearson's Correlation Coefficient determined the relationship of average agility speeds to pitching performance.
Results: Analysis identified significant correlations ($p<.05$) between S1, S2, and TSR and normalized SO (r=0.77, r=0.73, and r=0.87, respectively); S3 and S4 were insignificant (r=0.42 and r=0.59, respectively). Additionally, a significant correlation ($p<.05$) was identified between S3 and BB (r=0.67).
Conclusion: Results of this study suggest that better agility may lead to selected improvements in game performance in NCAA Division II baseball pitchers.

Keywords: baseball, baseball pitchers, strikeouts, agility, speed, training, exercise evaluation

1. Introduction
One of many critical components to NCAA recruitment, roster selections, in-game substitutions, and overall athletic performance is pre-season testing and evaluation procedures. Multiple forms of testing have been created to examine, exemplify, and measure an athlete's potential athletic ability. Strength, or the ability to move substantial amounts of weight from one location to another (i.e. bench press, squat, deadlift), is measured in pounds or kilograms. Dowson *et al.* [1] found significant relations between absolute strength and sprinting velocity at 0-15 m and 30-35 m of rugby players. Power production, work divided by time (power = w/t), measured in watts [2], was utilized within the study conducted by Kasabalis *et al* [3], identifying that peak power production had a significant relationship to the vertical jump height of elite male volleyball players. Rampinini *et al* [4]. found significant correlations between peak running speed and match-related physical performance of elite soccer players. Moreover, agility has shown to be an indicator of playing position among female basketball players [5]. As described, a variety of testing procedures have been noted to exemplify the performance of multiple athletes and athletic sports. Agility testing could be beneficial in describing the potential performance and talents of selected Division II NCAA baseball pitchers.
Like most kinetic chains in athletic performance, the baseball pitching motion begins with the muscles of the legs and continues progressively through the torso, shoulders, and arms. Similarities are noted between the baseball pitching motion and the kinetic chain employed in agility tests which measure acceleration, deceleration, and change of direction. Oliver and Keeley [6] investigated the kinematic relationship between the pelvis, torso, and shoulder during several phases of the pitching motion: stride, arm-cocking, arm-acceleration, and arm-deceleration. They concluded that kinematics of the shoulder during the pitching motion were related to the success of the baseball players. The relationship of the kinetic chain employed

in an agility test and the kinetic chain utilized in the baseball pitching motion remains unclear. Whether or not pre-season measures of agility in NCAA pitchers are related to game performance has not been investigated; therefore, the purpose of this investigation was to determine pre-season agility measures in NCAA pitchers and to relate these measures to pitching performance during the regular season.

2. Methods

2.1 Experimental Approach to the Problem. Segment and total shuttle run (TSR) time were obtained to represent pitchers' agility speeds ($m \cdot s^{-1}$). Normalized statistical measures were obtained from 48 regular season games, providing evidence of game pitching performance. Pearson's Correlation Coefficient determined the relationship of average agility speeds to pitching performance.

2.2 Subjects. After institutional review board approval, NCAA Division II Baseball Pitchers (N=10) from a university in Texas, volunteered as study subjects. Demographic information for each subject is shown in Table 1. The pitching staff was comprised of ten right-handed pitchers that were thoroughly familiar with test and the testing procedures. All of the pitchers on the squad actively participated in pre-season training associated with their collegiate team protocol. Testing was scheduled and conducted upon completion of the pre-season training.

Table 1. Demographic Information of the Subjects

	X	SD	Max	Min	Median	Mode	Range
Height (in)	72.9	1.93	75.5	70.0	73.0	72.0	5.50
Weight (lbs)	187.1	22.66	225.0	151.0	178.0	171.0	74.0
BMI	24.43	2.62	28.97	21.15	23.67	N/A	7.82

2.3 Procedures. A laser-timed 60-yd shuttle run ("JJ Shuttle") provided average speeds for four contiguous agility segments (S1, S2, S3, and S4 of 10, 10, 20, and 20 yds., respectively), as well as TSR (60 yds.) [7]. Comprehensive details, descriptions, and discussions explaining the validity and reliability of the test are published in pervious articles [8, 9, 7, 10].

Unlike the ordinary T-test and Pro-Agility test [11], the JJ Shuttle Run is a segmented 60-yd agility run that utilized a laser timing device, the Brower Speed-Trap II (Figure 1), to record precise times for each segment.

Fig 1: Equipment includes: laser transmitters and receiver, extendable tripod stands, and handheld remote storage and data recorder device.

The laser timing system placement and beam position is elevated (18 in.) and parallel to a gym floor line representing the starting line, center line, and finish line. A lateral running stance with the subject's lead foot was in direct contact with the center/starting line. This is similar to the stride phase during the pitching delivery [12], and illustrates the correct testing starting position. The test is initiated as the subject interrupts the timing system laser beam and proceeds through the contiguous segments. Center-line intersection and beam interruption signifies the completion of one segment and the beginning of the next. In a similar fashion, the test in concluded upon the interruption of the laser beam, crossing of the center-line, and completion of the final segment of the shuttle run (segment 4). For further clarification of the JJ shuttle, refer to Figure 2 and previous articles discussing testing procedures [8, 9, 7, 10].

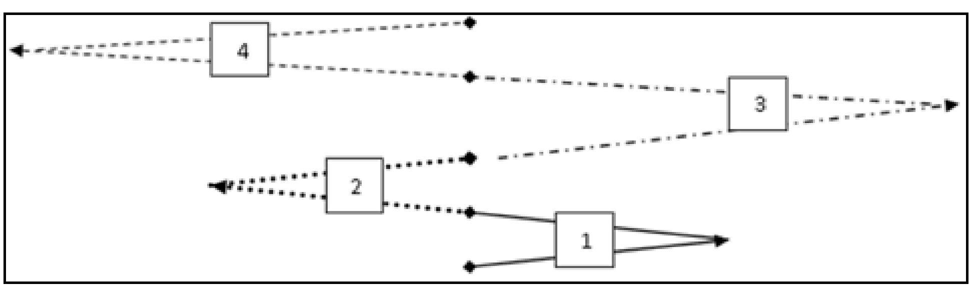

Fig 2: Timed segments of the 60-yd run-shuttle. Arrows indicate direction of movement, position of the 4-in cones, and point of change of direction; ♦ indicates point of laser beam interruption.

Precise measures of time were transmitted to the remote data recorder and storage device as subjects crossed the center-line, signifying segment times and TSR times. Segment times and TSR times were converted to average segment and TSR speeds ($m \cdot s^{-1}$). Subjects performed two shuttle run attempts, striving for quickest TSR time. Due to the anaerobic conditioning demands of the shuttle run, subjects were provided a 5 minute rest period between shuttle runs, allowing for adequate muscle recovery. The subject's fastest TSR time was utilized for statistical correlation process as shown in Table 2.

Table 2: JJ Shuttle Performance

Subjects	Ht.	Wt.	BMI	Position	T1	S1	T2	S2	T3	S3	T4	S4	T-TSR	S-TSR
1	74	187	24.1	RHP	2.58	3.54	2.24	4.08	3.74	4.89	3.64	5.03	12.2	4.50
2	72	171	23.3	RHP	2.41	3.79	2.09	4.37	3.64	5.03	3.54	5.17	11.68	4.70
3	72	204	27.7	RHP	2.54	3.60	2.19	4.17	3.65	5.01	3.68	4.97	12.06	4.55
4	74.5	210	26.7	RHP	2.42	3.78	2.29	3.99	3.72	4.92	3.75	4.88	12.18	4.50
5	74	225	29.0	RHP	2.62	3.49	2.22	4.12	3.74	4.89	3.77	4.85	12.35	4.44
6	75.5	171	21.1	RHP	2.42	3.78	2.18	4.19	3.75	4.88	3.54	5.17	11.89	4.61
7	70	174	25.0	RHP	2.49	3.67	2.16	4.23	3.7	4.95	3.57	5.13	11.92	4.60
8	70	151	21.7	RHP	2.39	3.82	2.23	4.10	3.7	4.95	3.59	5.10	11.91	4.61
9	74.5	182	23.1	RHP	2.56	3.57	2.23	4.10	3.65	5.01	3.68	4.97	12.12	4.53
10	72	166	22.6	RHP	2.59	3.53	2.36	3.87	3.72	4.92	3.65	5.01	12.32	4.45

*T = shuttle time; S = average running speed; # = segment

The following statistical measures obtained from regular season games (n=48) were compiled upon completion of regular season performance: Runs (R), Hits (H), Earned Runs (ER), Base-on-Balls (BB), and Strikeouts (SO), each normalized for innings pitched, provided evidence of game pitching performance. Refer to Table 3 for a full normalized pitching performance data set.

Table 3: Normalized pitching performance data.

Subjects	H	R	ER	BB	SO
1	2.44	1.71	1.46	0.00	0.49
2	1.56	0.94	0.94	1.25	1.25
3	0.98	0.36	0.33	0.16	0.49
4	1.24	0.52	0.46	0.15	0.78
5	1.20	0.61	0.52	0.31	0.52
6	1.20	0.68	0.52	0.40	0.80
7	0.93	0.45	0.27	0.30	0.87
8	1.25	0.64	0.64	0.29	0.82
9	0.73	0.85	0.61	1.34	0.73
10	1.07	0.50	0.43	0.33	0.40

*H = normalized hits; R = normalized runs; ER = normalized earned runs; BB = normalized base-on-balls; SO = normalized strikeouts

2.4 Statistical Analysis

Shuttle times and pitching performance statistics were imported individually into Microsoft Excel 2010, where segment and TSR times were converted to speed ($m \cdot s^{-1}$). The data was transferred from the Microsoft Excel to IBM SPSS Statistics Tool. To analyze the data, Pearson's Correlation (p<.05) was applied to determine the relationship of average agility speeds to normalized pitcher performance.

3. Results

Analysis identified significant correlations (p<.05) between S1, S2, and TSR and normalized SO (r=0.77, r=0.73, and r=0.87, respectively); S3 and S4 were insignificant (r=0.42 and r=0.59, respectively). Additionally, significant correlation (p<.05) was identified between S3 and BB (r=0.67). No significant correlations were recognized between agility segment speeds and remaining regular season game performance: R, H, and ER. Refer to Table 4 for full correlation data set.

Table 4: Description of Correlation Results, Average Segment Speeds to Game Statistics (n=10)

	R	H	ER	BB	SO
S1 Average Speeds	r = - 0.02	r = - 0.16	r = - 0.07	r = 0.13	r = 0.77*
S2 Average Speeds	r = 0.06	r = 0.09	r = 0.12	r = 0.42	r = 0.73*
S3 Average Speeds	r = - 0.34	r = - 0.16	r = - 0.10	r = 0.67*	r = 0.42
S4 Average Speeds	r = 0.13	r = 0.15	r = 0.17	r = 0.25	r = 0.59
TSR Average Speeds	r = - 0.003	r = - 0.01	r = 0.06	r = 0.42	r = 0.87*

*Indicates significant correlation ($p < 0.05$) between speed and pitching performance.

4. Discussion

The ability to proficiently and rapidly accelerate, decelerate, and change direction throughout agility may contribute to elevated pitching performance. This relationship may be identified due to similar lower extremity, trunk, and torso movement patterns performance throughout agility and the pitching delivery.

During the delivery process an athlete must travel through multiple planes of movement, sagittal, frontal, and transverse, in order to successfully complete a pitch. Similar movements occur during directional changes of agility drills. Maximal voluntary concentric contraction (MVIC), of gastrocnemius, vastus medialis, rectus femoris, gluteus maximus, and biceps femoris of both the stride and trail leg of pitchers are apparent throughout multiple phases of the throwing motion[12]. Similar musculature contractions have shown to be utilized during sprinting motions [13].

Agility drills, such as the JJ Shuttle, include a deceleration and a change in direction phase that is visually similar to that of the stride phase of the pitching motion. A preload or a windup phase, initiates the movement of the pitching delivery[14]. During the preload phase, muscles are pre-stretched (beginning phase of the stretch shortening cycle), creating an increase potential muscle force production [11]. Similar preloading, pre-stretching and eccentric muscle contraction are prevalent upon foot planting and initiation of change in direct during the JJ Shuttle. Figure 3 exemplify corresponding movement patterns between decelerating phase during agility and wind-up phase during the pitching delivery.

Fig 3: Corresponding movement patterns between the change in direction phase during agility and wind-up phase during pitching.

Progressing to the stride phase of the pitching delivery, a pitcher drives off the trail leg and rotates at the pelvis and trunk advancing the stride foot towards home plate [14]. As an athlete decelerates during agility and accelerates in the opposite direction, the drive of the plant leg, rotation of the pelvis and trunk, and extension of the non-plant leg all contribute to the body moving in that opposite direction. This rotational change in direction during the JJ Shuttle is completed in a similar manner as the stride phase of the pitching motion. Figure 4 illustrates corresponding movement patterns between the acceleration phase during agility and stride phase during the pitching delivery.

Fig 4: Corresponding movement patterns between the acceleration phase during agility and stride phase during pitching.

The similarities of lower extremity, trunk, and torso movement patterns performance throughout agility and the pitching delivery may explain the relationship between agility speeds and SO. However, the researchers are unaware of the potential cause and effect of the significant correlation between S3 and BB (r=0.67*). The relationship of agility to the remaining pitching statistics, R, H, and ER, were not significant.
The results of the research suggests that high agility speeds have a positively relationship to selected NCAA Division II baseball pitching performance. It is a coach's duty and desire to recruit the most effective and athletic players, increase and maximize individual potential through strength and conditioning training programs, and appropriately position and substitute players to increase seasonal wins. By utilizing the results of this study and implementing applicable protocol, baseball coaches could increase accuracy of training, recruiting, player positioning, and theoretically, create a more successful ball team. The conclusion of this study opens numerous alternative potential research topics that need to be exposed. To properly assess these relationships, further kinematic and biomechanical examination would be required to accurately identify similarities in movement patterns.

5. Practical Application

Overall program success requires a collaborative effort among the strength and conditioning trainers, recruiting coordinators, and the sport specific coaches. A lack of quality associated with each or any of these area could jeopardize the overall success of a team. Therefore, innovative enhancement is continuously explored. The current research may provide an innovative impact and improve to each area - training, recruiting, and coaching.

5.1 Training. Typically, during training, recruiting, and/or the position selection process coaches' search for the most athletic individual - speed has repeatedly been utilized to assess athletic ability. Therefore, the result of the study could encourage strength and conditioning coaches and baseball coaches to incorporate the JJ Shuttle into training schemes and player evaluations. The purpose of strength and condition training is maximizing the potential of athletic ability and increasing competitive sports performance by providing athletes with a detailed individualized sports-specific program. Assuming that the previous statement accurately describes the nature of training, the results of this study could potentially aid in designing training programs for pitchers. Agility speeds have a positive relationship to pitching strikeouts; therefore, placing significant emphasis on agility training could theoretically satisfy, justify, and accomplish the purpose of strength and conditioning training.

5.2 Recruiting. Baseball coaches as well as strength and conditioning coaches naturally work cohesively to improve the overall performance and health of the team. By employing the JJ Shuttle within pre-season training, coaches will develop a precise speed description, create a pre- and post-assessment process for agility measures, and consistently track annual agility progress of pitcher. Through this assessment process, coaches could possess the ability to accurately evaluate incoming pitching recruits and base scholarship percentage off of potential athletic abilities; thus, maximizing budgets and recruitment efficiency. In addition, based off the assessment and the results of this study, coaches could possess knowledge of individual pitching performance and develop effective strategies regarding pitching roles. For example, the difficulties associated with the development of appropriate pitcher positioning (starter, reliever, and/or closer), in-game substitutions schemes, and performance predictions could decrease due to knowledge previously attained through the JJ Shuttle test.

5.3 Coaching. At the collegiate level, baseball coaches are constantly searching for innovative information, strategies, and techniques to implement for the overall improvement of their teams. By applying the current research to off-season training programs and pre-season evaluation processes, coaches could add an additional unique element to their training arsenal. With appropriately programmed off-season training, constructed from the results of the research, athletes could return prepared for pre-season training with increased assessment scores. These improved pre-season agility evaluation results could potentially aid in selecting the appropriate pitcher for starter roles, closer roles, and in-game situational substitutions. The agility shuttle results possess more than baseline athleticism data, they may provide purpose to testing procedures due to the significant relationship to sport - in this case baseball. Through efficient networking and proper implementation, the JJ-Shuttle could aid in a pitcher's growth and success.

6. References

1. Dowson MN, Nevill ME, Lakomy KA, Mevill AM, Hazeldine RJ. Modelling the relationship between isokinetic muscle strength and sprint running performance. Journal of Sports Sciences. 1998; 16(3):257-265. http://www.tandfonline.com/doi/pdf/10.1080/026404198366786
2. Powers SK, Howley ET. Exercise physiology: Theory and application to fitness and performance (7th ed.). New York, NY: The McGraw-Hill Companies, 2009.
3. Kasabalis A, Douba H, Tokmakidis SP. Relationship between anaerobic power and jumping of selected male volleyball players of different ages. Perceptual & Motor Skills. 2005; 100(3):607-614. http://www.amsciepub.com/doi/abs/10.2466/pms.100.3.60

7-614
4. Rampinini E, Bishop D, Marcora SM, Ferrari Bravo D, Sassi R, Impellizzeri FM. Validity of simple field tests as indicators of match-related physical performance in top-level professional soccer players. International Journal of Sports Medicine. 2007; 28:228-235. http://www.researchgate.net/publication/6769681_Validity_of_simple_field_tests_as_indicators_of_match-related_physical_performance_in_top-level_professional_soccer_players
5. Delextrat A, Cohen D. Strength, power, speed, and agility of women basketball players according to playing position. Journal of Strength & Conditioning Research. 2009; 23(7):1974-1981. http://journals.lww.com/nsca-jscr/Abstract/2009/10000/Strength,_Power,_Speed,_and_Agility_of_Women.9.aspx
6. Oliver GD, Keeley DW. Pelvis and torso kinematics and their relationship to shoulder kinematics in high-school baseball pitchers. Journal of Strength & Conditioning Research. 2010; 24(12):3241-3246.
7. Priest JW, Jones JN, Conger B, Marble DK. Performance measures of NCAA baseball tryouts obtained from the new 60-yd run-shuttle. The Journal of Strength and Conditioning Research. 2011; 25(10):2872-2878.
8. Jones JN, Priest JW, Marble DK. Kinetic energy factors in evaluation of athletes. The Journal of Strength and Conditioning Research. 2008; 22(6):2050-2055.
9. McCulloch A. Speed, agility, and the playing position of elite male NCAA Division II basketball players (Master Thesis). Retrieved from Pro Quest, 2015, (1589554)
10. Wolfe A. Relationship of kinetic energy factors to the athletic performance of selected NCAA Division II baseball pitchers (Master Thesis). Retrieved from ProQuest, 2014. (1564554)
11. Baechle TR, Earle RW. Essentials of strength training and conditioning, (3rd ed.). Champaign, IL: National Strength and Conditioning Association, 2008.
12. Campbell BM, Stodden DF, Nixon MK. Lower extremity muscle activation during baseball pitching. The Journal of Strength and Conditioning Research. 2010; 24(4):964-971.
13. Jonhagen S, Ericson M, Nemeth G, Eriksson E. Amplitude and timing of electromyographic activity during sprinting. Scandinavian Journal of Medicine and Science in Sports. 1996; 6:15-21. http://onlinelibrary.wiley.com/doi/10.1111/j.1600-0838.1996.tb00064.x/pdf
14. Fleisig G. The biomechanics of throwing. American Sports Medicine Institute. 2001; 1(1):91-94. https://ojs.ub.uni-konstanz.de/cpa/article/view/3826/3545