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Graduate Studies

THE RELIABILITY AND VALIDITY OF THE LANE AGILITY TEST FOR
COLLEGIATE BASKETBALL PLAYERS

A Manuscript Style Thesis Submitted in Partial Fulfillment of the Requirements for the
Degree of Master of Science in Human Performance

Ashley E. Brown

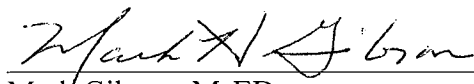College of Science and Health
Human Performance

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THE RELIABILITY AND VALIDITY OF THE LANE AGILITY TEST FOR

COLLEGIATE BASKETBALL PLAYERS

By Ashley E. Brown

We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for the degree of Master of Science in Human Performance

The candidate has completed the oral defense of the thesis.

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ABSTRACT

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Agility is the ability to change body direction, or position in space. The game of basketball requires intermittent starts, stops, changes of direction, etc. Several tests have been developed to measure agility. The purpose of this study was to determine the reliability and validity of the Lane Agility Test (LAT) by comparing this test with the T Test (TT) and Pro Agility Test (PRO). 24 Division III collegiate basketball players performed 3 agility tests on 2 different occasions. The best time recorded for LAT, PRO, and TT were compared. The players' coaches were asked to rank (RANK) each subject on his/her agility in a game. Results were compared with rankings of LAT, TT, and PRO. Reliability of the LAT was assessed using intraclass correlation coefficient and coefficient of variation. To establish validity, rankings of LAT, TT, PRO, and RANK were compared using Spearman-Rho correlation. Intrasession reliability of LAT was very strong for Day 1 and Day 2. Intersession reliability of LAT was also very strong. Very strong Spearman-Rho correlations were found between LAT and TT, LAT and PRO. No significant correlations were found between performance on LAT and RANK. Results support the LAT as a valid and reliability measurement of closed agility.

ACKNOWLEDGEMENTS

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INTRODUCTION

Strength and conditioning coaches, athletic trainers, and other professionals have constantly studied ways to increase human performance. These individuals have traditionally focused on the development of acceleration and speed, primarily in the sagittal plane. However, this philosophy has recently shifted towards the development of sport specific training. Most sports do not rely solely on forward sprinting; these sports require quick changes in direction and bursts of speed in reaction to each unique situation. An individual's success in sports, specifically basketball, relies on the ability to make quick changes in direction followed by acceleration during competition.

Although a standard definition of agility has not been determined, the concept behind this skill is universal (Sheppard & Young, 2006). Agility has been traditionally referred to as the ability to change body direction, or position, in space (Holmberg, 2010; National Basketball Conditioning Coaches Association, 2007; Sheppard & Young, 2006). Recent research, however, has transformed the definition to include changes in direction in response to stimuli (Sheppard & Young, 2006). Sports, such as basketball require intermittent stops, starts, changes of direction, pivots and cuts (National Basketball Conditioning Coaches Association, 2007; Sheppard & Young, 2006). These motor tasks are movements that make agility an imperative skill for basketball athletes.

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The Pro Agility Test (PRO) and T Test (TT) have been commonly used in agility literature, specifically with basketball players (Ben Abdelkrim et al., 2010; Chaouachi et al., 2009; Delextrat & Cohen, 2008; Delextrat & Cohen, 2009; Holmberg, 2010). The National Basketball Association (NBA) has recently utilized an agility test specific to the sport of basketball—the Lane Agility Test (LAT). Each June, the NBA holds a pre-draft camp where they test the potential draft picks on measurements of strength, speed, power, agility, and flexibility (National Basketball Conditioning Coaches Association, 2007). NBA strength and conditioning coaches utilize tests during this camp they claim to be valid and reliable (National Basketball Conditioning Coaches Association, 2007). However, little to no research exists on the validity and reliability of the LAT. Furthermore, the LAT has not been utilized in agility research as a testing measurement. Consequently, the purpose of this study was to establish the validity and reliability of the Lane Agility Test as a measurement of agility for collegiate basketball players.

METHODS

Experimental Approach to the Problem

This study was designed to determine the validity and reliability of the lane agility test (LAT) as a measurement of agility among collegiate basketball players. In order to determine the validity of the LAT, performances on the LAT were compared to performances on two other agility tests: Pro Agility Test (PRO), and the T Test (TT). These results were also compared with a coach's subjective assessment of agility based on the coach's knowledge of their ability to move during a game of basketball. Following completion of the tests, subjects were ranked according to their performance times on each test. These rankings served as a standard comparison between all three agility tests and the coach's rankings; performance results on each test were compared to establish validity of the LAT. To determine the reliability of the LAT, subjects performed three trials of the test on two separate days in a counterbalanced order. Intersession and intra session reliability was then calculated.

Subjects

One week prior to the start of the season, 24 (women = 12, men = 12) Division III Collegiate basketball players voluntarily participated in this study. All subjects read and signed an informed consent form prior to the initiation of testing, in compliance with standards of the Institutional Review Board at the University of Wisconsin-La Crosse. Any lower body injury that prevented the athlete from performing maximally disqualified him/her from the study. Subjects were asked to maintain a normal exercise regimen and

refrain from any abnormal activities between testing sessions. Table 1 shows the anthropometric data for each gender at the time of testing.

Table 1. Subject Characteristics

	Men	Women
Height (cm)	186.45 ± 9.73	171.89 ± 5.34
Weight (kg)	85.79 ± 9.42	69.18 ± 9.54

Values are expressed as mean ± standard deviation

Agility Testing

Subjects were familiarized by performing each test during pre-season strength and conditioning sessions. Upon arrival at the first testing session, participants were randomly assigned to one of two groups. The group number signified which order the subjects would complete each of the three agility tests; subjects completed all tests in counterbalanced order. At the beginning of each session, subjects completed a 10 minute dynamic warm-up consisting of jogging and dynamic stretching. Subjects performed three trials of PRO and three trials of LAT during one testing session and three trials of TT and LAT during another testing session. Testing sessions were held on separate days, 48 hours apart. Subjects were given 2 minutes rest between each trial to ensure adequate recovery time. The best time of the three trials was recorded and used for data analysis.

Timing of all repetitions was measured by an electronic timing system (Brower Timing Systems; Salt Lake City, UT). The beam was set at a height of 0.5 meters above the start/finish line. Subjects started within one meter behind or next to an electronic gate. Timing started when the subject sprinted through the beam and ended when they crossed the beam at the end of the drill. Performance was determined by finishing time to the nearest hundredth (0.01) of a second.

Lane Agility Test

Participants began in a staggered stance with one foot just behind cone A at the starting line (Figure 1). On his/her own volition, the subject sprinted forward towards cone B starting the timer when crossing the beam. At cone B, the subject side-shuffled to the right towards cone C, then back pedaled to cone D. At cone D, subjects side shuffled to cone A. At cone A, subjects had to ensure their outside foot cleared an extension of the free throw lane line. Without a pause, subjects then reversed their direction and side-shuffled to the right back to cone D. At cone D, participants sprinted forward towards cone C, then side-shuffled towards cone B. Lastly, they finished with a back pedal through the beam at the finish line, stopping the timer. Each subject remained facing the baseline the entire trial.
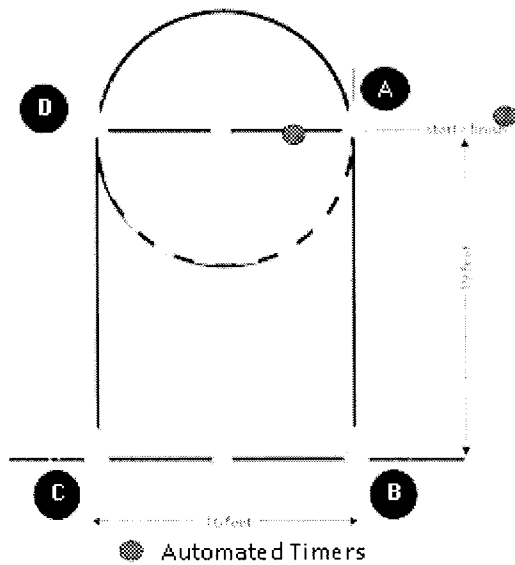
Figure 1. Lane Agility Test (LAT)

Subjects were monitored to ensure each trial was performed properly.

Disqualification of a trial occurred if subjects crossed their feet during any side-shuffle

bout, if their outside foot did not clear the line at cone A when reversing their side-

shuffle, or if a cone was knocked over during the trial.

Pro Agility Test

Subjects began on either the right or left side of the starting line facing forward

(Figure 2); subjects were allowed to choose which side they wanted to start on, but their

initial direction remained constant for each trial. Timing began when the first body part

crossed the electronic beam over the starting line. Directions for this test are given, as if

the subject began on the right side of the line. On their own volition, subjects turned 90

degrees to the left and sprinted towards line A; subjects had to touch their outside (left)

foot completely across line A before pivoting 180 degrees and sprinting towards line B.

At line B, again the subjects outside (right) foot had to touch completely across the line

before they pivoted 180 degrees and sprinted through the finish/start line. Timing ended

as the first body part crossed the beam at the finish line. Disqualifications of a trial were

determined if the subject did not completely cross a line with his/her foot, or if an athlete

pivoted on the wrong foot.
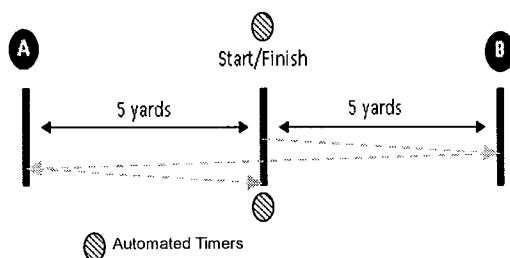
Figure 2. Pro Agility Test (PRO)

T Test

Subjects began in a staggered stance with one foot directly behind the starting line (Figure 3). The timer started when their body crossed the beam above the starting line. On their own volition, subjects sprinted forward towards cone B. At cone B, each athlete was allowed to choose their preference of side-shuffling to the right or left first. Once the decision was made, subjects were required to consistently go the same direction for each trial. The instructions continue, as if a subject chose to go right first. At cone B, the subject side shuffled to the right towards cone D. At cone D, the subject must touch their outside foot completely past the line before changing direction. The subject then side shuffled to the left all the way over to cone C. Again, at cone C, their outside foot must completely touch past the line before changing direction back to cone C. The subject then side shuffled back to the right towards middle cone B. Once the athlete reached cone B, he/she back pedaled all the way back through the finish/start line. Timing ended when the first body part crossed the electronic beam at the finish line. Disqualifications were made if a cone was knocked over, a subject's foot did not completely cross the line, or if a subject crossed his/her feet while side-shuffling (Semenick, 1990).

Figure 3. T Test (TT)

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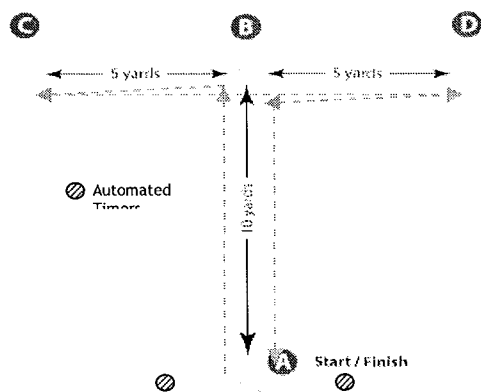
Coaches' Rankings

The men's and women's basketball coaches at the Division III University were asked to rank players of their respective teams against their teammates in terms of their agility. Coaches were given the instructions to "rank their athletes on their ability to move on a basketball court during a game or practice without the consideration of handling the ball." Rankings were used to compare data from each test to the Coach Rank due to the variety in performance times on the three separate agility tests resulting from the different length of each test and the different configurations of movements. These rankings were used to determine if the LAT was a valid measurement of basketball agility in relation to the coaches' subjective rankings.

Data Analysis

The performance times of the all trials of each agility test were recorded to the nearest hundredth (0.01) of a second. To establish intrasession reliability of LAT, each of the three trials were compared separately for Day 1 and Day 2 of testing. The best time from each day of testing the LAT was used to determine intersession reliability. Intraclass correlation coefficient (ICC) and coefficient of variation were used to establish both intra- and inter-session reliability for the LAT test. Hopkins (n.d.) ranked the meaningfulness of correlations as alpha (α) =trivial (0.0), small (0.1), moderate (0.3), strong (0.5), very strong (0.7), nearly perfect (0.9) and perfect (1.0). Coefficient of variance values less than 10% are considered very strong in terms of reliability (Atkinson & Nevill, 1998). The equation used to determine this value is displayed below:

$$\text{Coefficient of Variation} = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100$$

Both inter- and intra-class reliability were analyzed with men and women results together, as well as men only and women only.

The best time for each agility test (i.e. LAT, TT, and PRO) was used to determine player rankings. If two players had the same performance time, the average time of the 3 trials for that test was used to break a tie and rank each player. The player rankings on each of the three agility tests, as well as the coaches' rankings were then used to compare results and establish validity of the LAT. Spearman-Rho Rank Correlation test was used to compare rankings between the three agility tests and the coaches' rankings. The alpha value was set at $p < 0.05$ for all correlation testing. All statistical analyses were performed using SPSS 19.1 (SPSS Inc., Chicago, IL).

RESULTS

Table 2 displays the performance times (mean ± standard deviation) of subjects

for the three agility tests (LAT, TT, and PRO). Due to inherent differences of each

specific test, the performance times on each test could not be compared directly.

Table 2. Performance Time (seconds) on Agility Tests

	All Subjects (n=24)	Men Only (n=12)	Women Only (n=12)
LAT	11.17 ± 0.95	10.38 ± 0.45	11.95 ± 0.58
TT	10.27 ± 0.94	9.43 ± 0.38	11.10 ± 0.42
PRO	5.08 ± 0.29	4.88 ± 0.20	5.29 ± 0.20

LAT=Lane Agility, TT=T Test, PRO=Pro Agility Test; Values are expressed as mean ±
standard deviation

Results of the reliability analysis for the agility tests used in this study can be

found in Table 3. Analysis of intrasession reliability revealed that nearly perfect

intrasession reliability was established for both Day 1 and Day 2 of testing for all

subjects, men only, and women only. Intersession reliability revealed nearly perfect

correlation for all subjects, women only, and men only. All values for coefficient of

variation were considered very strong (below 10%).

Table 3. Intraclass Correlation Coefficient and Coefficient of Variation Values for Inter-
and Intrasession Reliability of the Lane Agility Test

	All Subjects		Men		Women	
	ICC	%CV	ICC	%CV	ICC	%CV
Day 1 Intrasession	0.99	8.80	0.97	5.47	0.94	4.52
Day 2 Intrasession	0.99	8.86	0.96	4.54	0.97	5.61
Intersession	0.98	8.71	0.90	5.00	0.95	4.80

ICC=Intraclass correlation coefficient; %CV=Coefficient of Variance

A Spearman Rho Rank Correlation revealed significant correlations between the LAT and the TT and PRO for men (Table 4) and women (Table 5). Significant correlations were found between TT and PRO, TT and Coach Rank, and PRO and Coach Rank for men (Table 4). Significant correlations were also found between TT and PRO, and PRO and Coach Rank for women (Table 5). All other correlations between the three agility tests and coach's rank were non-significant for men or women (Tables 4 and 5).

Table 4. Spearman Rho Rank Correlation for Men's Performance on Agility Tests

	LAT Rank	TT Rank	PRO Rank
LAT Rank	-------	-------	-------
TT Rank	0.923**	-------	-------
PRO Rank	0.853**	0.874**	-------
Coach Rank	0.510	0.643*	0.797**

LAT=Lane Agility Test, TT=T Test, PRO=Pro Agility Test; **Significant p< 0.01; * Significant at p<0.05

Table 5. Spearman Rho Rank Correlation for Women's Performance on Agility Tests

	LAT Rank	TT Rank	PRO Rank
LAT Rank	-------	-------	-------
TT Rank	0.888**	-------	-------
PRO Rank	0.741**	0.769**	-------
Coach Rank	0.413	0.469	0.713**

LAT=Lane Agility Test, TT=T Test, PRO=Pro Agility Test; **Significant p< 0.01; * Significant at p<0.05

DISCUSSION

The purpose of this study was to determine the reliability and validity of the Lane Agility Test (LAT) as a measurement of agility among collegiate basketball players. The results showed that nearly perfect intrasession reliability of the LAT was observed for both Day 1 and Day 2 of testing for all subjects, and for men and women independently. Nearly perfect intersession reliability was also observed for all subjects and for men and women independently. This is the first study to establish the reliability of this specific test. The ICC values calculated for the LAT in our study were similar to those reported by Pauole et al. (2000) concerning the reliability of the T Test.

Performance times of the LAT have been reported for 24 NCAA Division I Basketball players (male=14; female =10) (National Basketball Conditioning Coaches Association, 2007). Although there were only a small number of participants, the average time was determined for men and women separately (men=10.24 seconds; women=11.62 seconds). In comparison, the average time to complete the LAT by the Division III basketball players in the present study (men=10.38 $\pm$ 0.45, women=11.95 $\pm$ 0.58) was only slightly slower than the Division I athletes reported previously (11) for the LAT. This indicates that the LAT may be able to distinguish between different levels of playing status of collegiate basketball players.

The average time of men (9.43 $\pm$ 0.38 seconds) and women (11.10 $\pm$ 0.42 seconds) for the T Test also compares to previous research data. Pauole et al. (13) established normative data for college-aged men and women with varying levels of sport

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participation. According to the standards established in their study, all of the men in the present study scored in the 70th percentile or higher, with 58 percent of these men scoring in the 90th percentile and above (Pauole et al., 2000). Of the women tested in the present study, 100% scored in the 60th percentile or higher with 25% scoring in the 90th percentile (Pauole et al., 2000). In the study published by Paoule et al. (2000), approximately one third of the participants were competitive intercollegiate athletes in various sports. The authors found that the T Test was an accurate predictor of sport participation; performance times on the T Test allowed the researchers to distinguish between recreational and competitive athletes (Paoule et al., 2000). Therefore, the performance times on the T Test of subjects in the present study were comparable to the competitive athletes in the study by Paoule et al. (2000). In comparison with other studies, T Test times of our men subjects were slightly slower in comparison with Division I male basketball players (Hoffman et al., 1991; Hoffman et al., 1996; Latin et al., 1994) and English national/international players (Delextrat & Cohen, 2008), but faster than members of the members of the Tunisian national team (Chaouachi et al., 2009) and junior Tunisian national team (Ben Abdelkrim et al., 2010). The average performance time during the T Test for the women in the present study was slower compared to competitive level basketball players (Paoule et al., 2000) and English national players (Delextrat & Cohen, 2009).

To establish validity of the LAT, performance rankings were established for each of the three agility tests (LAT, TT, and PRO) and a coach's subjective assessment of agility (Coach Rank) and compared. The validity of the T Test for the measurement of agility was previously established (Paoule et al., 2000). The very strong relationships

between the three agility tests in both men and women suggest the LAT is a valid measurement of agility. A stronger significant relationship was observed between the rankings between the LAT and TT compared to those observed between the LAT and PRO. This is not surprising since the actions during both the LAT and TT include forward sprinting, side-shuffling, and backpedaling are movements and changes in direction similar to movements during a game of basketball. In contrast, the PRO only utilizes forward sprinting during the test with 180° changes of direction. It may be that the key difference between the PAT and the other tests is that the PAT did not include side shuffling movement.

A study by Ben Abdelkrim et al. (2010) observed a significant negative relationship between the amount of time spent side-shuffling during a basketball game and performance times on the TT in junior men basketball players. They also found that during a basketball game, players covered 1,684 m using sideways movements which accounted for 22% of the total distance (7,558 $\pm$ 575m) covered during a game (Ben Abdelkrim et al., 2010). This observation is important to strength and conditioning and basketball coaches because it suggests that side shuffling should be included in performance tests that assess an athlete's agility for basketball. Both the T Test and LAT require a significant amount of maximum speed side-shuffling (National Basketball Conditioning Coaches Association, 2007; Semenick, 1990). The significant correlation seen between T Test performance and the distance covered at high-intensity shuffling during a game provides additional support for the validity of the T Test in basketball (Ben Abdelkrim et al., 2010). Since performance rankings are similar between the LAT

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and T Test, this conclusion could also be applied to the use of the LAT in basketball since a significant correlation was seen between performance on the LAT and T Test.

The PRO is another tool professionals have used to assess agility; it requires forward sprinting with 180° changes in direction. Despite its absence in basketball agility literature, the use of the PRO in previous research studies (Vescovi & McGuigan, 2010; Vescovi & VanHeest, 2008) and as a part of the NFL combine (National Football League, n.d.), demonstrates an understanding by coaches and researchers of its ability to measure agility. Consequently, the very strong correlation observed in the present study between the LAT and PRO further establishes the validity of the LAT as a measurement of agility in collegiate basketball players. An interesting finding utilizing the coaches ranking was that a very strong correlation was observed between the coaches ranking and the PRO. These results were not expected, since movements in basketball are more similar to the TT and LAT. The PRO requires forward sprinting with 180° changes in direction. This very strong relationship was observed with both the men and women subjects and consequently warrants further study.

Our study attempted to validate the LAT by comparing the LAT rankings to the coaches' subjective rankings of agility. We hypothesized that the rankings on the LAT would be related to the subjective rankings of the players' agility on a basketball court by their coach. We seasoned that a significant correlation between these two variables would suggest the LAT as a valid measurement of performance in the game of basketball. However, the results of our study do not support our hypothesis. No significant relationship was observed between LAT and Coach Rank for the men or women. A study by Hoffman et al. (Hoffman et al., 1996) utilized coach's rankings of player

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importance to the team and compared the rankings with the amount of playing time. To our knowledge, however, the idea of using coaches' subjective rankings of agility to assess validity was a novel concept utilized in this study.

The lack of significant correlation between performance on the LAT and Coach Rank (men: $\rho=0.510$, $p<0.05$; women: $\rho=0.413$, $p<0.05$) suggests the LAT may not be a valid measurement of agility during a basketball game, or that other factors besides agility influenced the coach's rankings.

The traditional definition of agility as a change of direction (COD) has transformed to include COD in response to a stimulus (Sheppard & Young, 2006). It may be that, since the game of basketball requires reaction to many different visual stimuli, these tests are not completely sport specific agility tests. All three agility tests utilized in the present study were closed measurements of agility; subjects knew the movement pattern prior to initiating each test. Consequently, open agility tests that require responses to stimuli may better serve as valid predictors of agility during basketball games and may correlate better with coach rankings. Future research for agility testing for basketball, either with the LAT, TT, or PRO, should assess agility that includes reaction(s) to visual stimuli.

In summary, the findings of this study indicate that the LAT is reliable measurement of agility. The very strong correlations observed between the performance rankings on the three agility tests suggest the LAT is a valid measurement of closed agility for basketball athletes. However, the lack of significant correlation between Coach Rank and LAT performance questions the validity of the LAT as a predictor of agility performance in a basketball game. Also, it is possible that the subjective nature of

Coach Rank may not be sensitive to use for the purpose of this study. Consequently,

future research for agility testing for basketball, either with the LAT, TT, or PRO, should

assess agility that includes reaction(s) to visual stimuli.

REFERENCES

1. Atkinson, G. & Nevill, A. (1998). Statistical Methods For Assessing Measurement Error (Reliability) in Variables Relevant to Sports Medicine. *Sports Medicine.* 26(4), 217-238.

2. Ben Abdelkrim, N., Castagna, C., Jabri, I., Battikh, T., El Fazaa, S., & El Ati, J. (2010). Activity profile and physiological requirements of junior elite basketball players in relation to aerobic-anaerobic fitness. *Journal of Strength and Conditioning Research.* 24(9), 2330-2342.

3. Chaouachi, A., Brughelli, M., Chamari, K., Levin, G., Ben Abdelkrim, N., Laurencelle, L., & Castagna, C. (2009). Lower limb maximal dynamic strength and agility determinants in elite basketball players. *Journal of Strength and Conditioning Research.* 23(5), 1570-1577.

4. Delextrat, A., & Cohen, D. (2008). Physiological testing of basketball players: Toward a standard evaluation of anaerobic fitness. *Journal of Strength and Conditioning Research.* 22(4), 1066-1072

5. Delextrat, A., & Cohen, D. (2009). Strength, power, speed, and agility of women basketball players according to playing position. *Journal of Strength and Conditioning Research.* 23(7), 1974-1981.

6. Hoffman, J., Fry, A., Howard, R., Maresh, C., & Kraemer, W. (1991). Strength, spend, and endurance change during the course of a division I basketball season. *Journal of Applied Sport Science Research.* 5(3), 144-149.

7. Hoffman, J., Tenenbaum, G., Maresh, C., & Kraemer, W. (1996). Relationship between athletic performance tests and playing time in elite college basketball players. *Journal of Strength and Conditioning Research.* 10(2), 67-71.

8. Holmberg, P. (2010). Preseason preparatory training for a division III women's college basketball team. *Strength and Conditioning Journal.* 32(6), 42-54.

9. Hopkins, W. A scale of magnitudes for effect statistics. http://www.sportsci.org/resource/stats/index.html. Accessed February 29, 2012.

10. Latin, R., Berg, K., & Baechle, T. (1994). Physical and performance characteristics of NCAA division I male basketball players. *Journal of Strength and Conditioning Research.* 8(4), 214-218.

11. National Basketball Conditioning Coaches Association. (2007). *Complete conditioning for basketball*. Champaign, IL: Human Kinetics, vii-15.

12. National Football League. http://www.nfl.com/combine/workouts. Accessed January 15, 2011.

13. Pauole, K., Madole, K., Garhammer, J., Lacourse, M., & Rozenek, R. (2000). Reliability and validity of the t-test as a measure of agility, leg power, and leg speed in college-aged men and women. *Journal of Strength and Conditioning Research*. 14(4), 443-450.

14. Semenick, D. (1990). The T-test. *NSCA Journal*. 12(1), 36-37.

15. Sheppard, J., & Young, B. (2006). Agility literature review: Classifications, training, and testing. *Journal of Sports Sciences*. 24(9), 919-932.

16. Vescovi, J., & McGuigan, M. (2008). Relationships between sprinting, agility, and jump ability in female athletes. *Journal of Sports Sciences*. 26(1), 97-107.

17. Vescovi, J., & VanHeest, J. (2010). Effects of an anterior cruciate ligament injury prevention program on performance in adolescent female soccer players. *Scandanavian Journal of Medicine and Science in Sport*. 20, 394-402.

APPENDIX A

INFORMED CONSENT

INFORMED CONSENT FORM

University of Wisconsin-La Crosse
La Crosse, WI

I, _____, give my informed consent to participate in this study to determine if the lane agility test is a valid and reliable measurement of agility for college basketball players. I will be required to attend two testing sessions consisting of three trials of two different agility tests. I will meet in the Mitchell Hall Gyms (112, 113, 114) on the University of Wisconsin-La Crosse campus for two separate 2 hour training sessions.

I have been informed that participation in this study may results in possible muscle soreness, muscle strains, or ligament sprains. These risks will be minimized by participating in a warm-up (5 minute jog and dynamic movement preparation), and a cool-down following the testing session. There will be a minimum of 48 hours between testing sessions to further minimize potential risks.

My participation in the research of the validity and reliability of the lane agility test will help to determine if this test should be used as a measurement of agility among basketball players. I have been informed that the researchers intend to present and/or publish this data in a scientific research journal.

All personal information related to this study will only be accessible to the researcher. No names will be disclosed and all personal information will be kept confidential. Any information that is obtained in connection with this study and that can be identified with me will remain confidential and will be disclosed only with my permission.

I have been informed that participation is this study is strictly voluntary. There is no charge to me to participate in this study. I have been informed that I am free to withdraw myself fro this study at anytime without penalty or loss of benefits.

Questions regarding the protection of human subjects may be addressed to irb@uwlax.edu. Questions regarding study procedures may be directed to Ashley Brown (brown.ashl@uwlax.edu) or Mark Gibson (mgibson@uwlax.edu).

I have read and been informed of the procedures involved in this study. I have been made fully aware of the nature of the tests and potential risks involved, of which I assume voluntarily. I have been informed that I may withdraw my participation at any time and for any reason without penalty.

_____   _____   _____   _____
Subject   Date   Investigator   Date

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APPENDIX B

REVIEW OF RELATED LITERATURE

REVIEW OF RELATED LITERATURE

Introduction

Strength and conditioning coaches, athletic trainers, and other allied health care professionals have constantly studied ways to increase athletic performance. Traditionally, these individuals have focused on the development of acceleration and speed, primarily in the sagittal plane. More recently, however, this philosophy has shifted towards the development of sport specific training, involving multi-directional movements. Most field and court sports do not rely solely on forward sprinting; rather, these sports require quick changes of direction and bursts of speed. An individual's success in sports, specifically basketball, depends on an ability to react and change direction quickly in each unique situation.

Although a standard definition of agility has not been established, the concept behind the skill is universal (Sheppard & Young, 2006). Authors have defined agility traditionally as the ability to change direction or position in space (Holmberg, 2010; National Basketball Conditioning Coaches Association, 2007; Sheppard & Young, 2006). More recently, this definition has transformed to include changes in direction in response to a stimulus (Sheppard & Young, 2006). Furthermore, authors have established agility is a trainable motor skill that can be improved through proper practice (Holmberg, 2010). Agility performance is determined by the speed in changing direction and is influenced by a combination of explosive strength, balance, muscular coordination, and flexibility (Chaouachi et al., 2009; Sheppard & Young, 2006).

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Sports such as basketball require intermittent stops, starts, changes of direction, pivots and cuts (National Basketball Conditioning Coaches Association, 2007; Sheppard & Young, 2006). These motor tasks are imperative to success in the game of basketball, and therefore make agility an important skill among elite basketball players. Research has established characteristics such as strength, power, agility, and speed as important for elite basketball players (Chaouachi et al., 2009; Delextrat & Cohen, 2008; Ziv & Lidor, 2009). Furthermore, research has shown that basketball is characterized by short bouts of high intensity (Holmberg, 2010). Consequently, players must rely highly on anaerobic metabolism to handle the physiological demands of the game of basketball (Delextrat & Cohen, 2008). Although, aerobic capacity is also necessary for basketball players to recover from repeated high intensity actions, the game of basketball predominantly relies on anaerobic power (Delextrat & Cohen, 2008). Therefore, the ability to quickly and repeatedly accelerate, change direction, and decelerate can distinguish elite basketball players from average players (Delextrat & Cohen, 2008; Hoare, 2000). Consequently, strength and conditioning coaches have established methods to test agility among basketball players. If performance on agility tests can pre-determine playing abilities, agility testing would be a valuable tool to help basketball and strength and conditioning coaches separate average and elite basketball players.

Development of Agility

Authors have established agility is a trainable motor skill that can be improved through proper practice (Holmberg, 2010). Research has shown that agility training needs to be specific to see improvements in agility performance (Little & Williams, 2005; Sheppard & Young, 2006; Young et al., 2001). Previous research has examined the

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relationship between straight sprinting speed and agility training (Young et al., 2001; Little & Williams, 2005). Results from these studies have shown that straight speed and agility training programs are specific and produce minimal transfer to each other (Little & Williams, 2005; Young et al., 2001). Furthermore acceleration, maximum speed, and agility are distinct qualities that need to be trained individually (Little & Williams, 2005; Young et al., 2001). Consequently, strength and conditioning coaches should consider specificity of the programs that have been developed to improve agility.

When athletes are performing agility movements during training, it is important to teach proper technique. A forward lean and low center of gravity is imperative to allow for quick and efficient changes of direction (Sheppard & Young, 2006; Young & Farrow, 2006). This "athletic position" allows for quick changes of speed and increases stability as athletes change movements (Sheppard & Young, 2006). Shorter stride lengths may also help athletes to make quicker changes of directions (Sheppard & Young, 2006). Therefore, it is important that proper instructions and supervision are given when teaching athletes agility drills and movements.

Agility Testing

As the concept of agility has emerged in the literature, several tests have been established to measure agility, each with its own unique procedure. Two tests have emerged as popular tests among athletes to measure agility—the T Test and Pro Agility Test. Among the recent agility literature, the T test is the most commonly used test to measure agility among basketball players (Ben Abdelkrim et al., 2010; Chaouachi et al., 2009; Delextrat & Cohen, 2008; Delextrat & Cohen, 2009; Hoffman et al., 1991; Hoffman et al., 1996; Latin et al., 1994). The Pro Agility test has only been used in one

paper examining agility in female basketball players (Holmberg, 2010); however, it is a test used by the National Football league (NFL) during their combine testing to assess agility (National Football League, n.d.) and has been used in research with non basketball athletes (Vescovi & McGuigan, 2010; Vescovi & VanHeest, 2008).

T Test

The T test was developed as a measure of four-directional agility; it measures a subject's ability to change direction rapidly while maintaining balance without loss of speed (Semenick, 1990). Semenick (1990) published a standard protocol for this test to allow consistent testing amongst professionals. After the introduction of the T Test, its popularity increased. The minimal equipment and preparation required to administer the test made it a popular choice for agility testing among professionals (Pauole et al., 2000). In a study conducted by Pauole, Madole, Garhammer, Lacourse, and Rozenek (2000), the validity and reliability of the T test as a measurement of agility, leg power, and leg speed in college-aged men and women was established; it was the first to establish the validity of the T test as a measurement of leg speed, leg power, and agility.

A secondary purpose the study conducted by Pauole et al. (2000) was to establish normative values of the T test for college-aged men and women. Subjects used in this study ranged in levels of sport participation from recreational intercollegiate participation in a variety of sports (Pauole et al., 2000). This normative data has given professionals baseline measurement to serve as comparisons for their own athlete's performance on the T test.

In an article by Holmberg (2010), he suggests agility training should involve movements characteristic to basketball—sprinting, lateral shuffling, and backpedaling.

These sport-specific actions to the game of basketball are all utilized during the T test (Ben Abdelkrim et al., 2010; Delextrat & Cohen, 2009). Consequently the T test has emerged as a popular test to assess basketball players' agility. Evidence of this comes from a study completed by Simenz, Dugan, and Ebben (2005), who analyzed the practices of the strength and conditioning coaches employed by the National Basketball Association. The authors surveyed 29 strength and conditioning coaches and 21% coaches indicated they utilized the T test as a measurement of agility (Simenz et al., 2005). Other measurements of agility included "lane box test", "lane agility", "slides", and "court testing" (Simenz et al., 2005). Furthermore, many authors have utilized this test as a measurement of agility in their studies of basketball players (Ben Abdelkrim et al., 2010; Chaouachi et al., 2009; Delextrat & Cohen, 2008; Delextrat & Cohen, 2009; Hoffman et al., 1991; Hoffman et al., 1996; Latin et al., 1994).

Subjects in these studies ranged from high school elite basketball players to professional players in a variety of countries. Each study had is own objective, however, the commonality between these studies was their use of the T Test to assess agility. The T Test was found as a consistent correlator with playing time among division I college basketball players (Hoffman et al., 1991). Results from several studies also revealed a significant difference in performance times on the T Test between different playing positions in the game of basketball; guards performed significantly better on the T Test than forwards and centers (Delextrat & Cohen, 2009; Hoare, 2000). The test was also able to distinguish elite basketball players from average basketball players; elite players were defined by players on the University's First team, whereas average players were on the second team at the university. Elite players performed significantly better on the T

test than those of average ability (Delextrat & Cohen, 2008). Furthermore, another study (Ben Abdelkrim et al., 2010) found a significant negative correlation between the amount of high intensity side shuffling during a basketball game and T Test performance. These results suggested the importance and validity of the T test as measurement of agility for basketball athletes, since side shuffling is an important movement in the game of basketball (Ben Abdelkrim et al., 2010). Each study demonstrates the importance of the T Test in profiling basketball players. If this test can distinguish between playing positions, amount of playing time, level of playing ability, and amount of side shuffling completed during a game of basketball, it is an appropriate test for professionals to utilize in testing basketball athletes.

The T test has also been used in research literature to establish the validity of agility tests. In a study completed by Sassi, Dardouri, Yahmed, Gmada, Mahfoudhi, and Gharbi, (2009) the authors utilized the traditional T Test to establish reliability of a new Modified Agility T Test. The main difference between the Modified Agility T Test and the traditional T test was the amount of distance covered during the test; the authors of the study reduced the distance for the Modified Agility T Test. However, the movement pattern did not change from the original T Test protocol (Semenick, 1990).

Pro Agility Test

The pro agility test, another popular measurement of agility is used during the combine testing of the NFL (National Football League, n.d.). Strength and conditioning professionals in the NFL use this test to help distinguish each prospective player in terms of their agility; it helps these professionals to separate and predict potential successful NFL players. This test has also been referenced in agility literature and has been used as

an alternative measurement of agility. This test has only been mentioned in one article concerning basketball players and agility to our knowledge (Holmberg, 2010). Despite its minimal use among agility testing in basketball research, the pro agility test has been used to measure agility in other research studies with a variety of athletes.

In a study by Vescovi and VanHeest (2010), the authors used the Pro Agility Test as a measurement of improvements in agility following an anterior cruciate ligament (ACL) injury prevention program. Female adolescent soccer players performed the Pro Agility test prior to initiation of the program, 6 weeks into the program, and again at completion of the program (12 weeks). Results showed there was no improvement in agility following completion of the ACL Injury prevention program (Vescovi & VanHeest, 2010). In another study by Vescovi and McGuigan (2008), the authors aimed to assess relationships between a variety of field tests among athletes. To measure agility, these authors also used the Pro-Agility Test. Results of the study showed significant correlations between the Pro Agility Test and linear sprint times. Conclusions from this study included that measurements of linear sprinting, agility, and linear sprinting should be included in a fitness assessment protocol among female college and high school athletes (Vescovi & McGuigan, 2008).

Lane Agility Test (LAT)

The National Basketball Association (NBA) has recently utilized an agility test specific to the sport of basketball—the Lane Agility Test (LAT). Each June, the NBA holds a pre-draft camp where they test the potential draft picks on measurements of strength, speed, power, agility, and flexibility (National Basketball Conditioning Coaches Association, 2007). NBA strength and conditioning coaches utilize tests during this

camp they claim to be valid and reliable (National Basketball Conditioning Coaches Association, 2007). However, no research exists on the validity and reliability of the Lane Agility Test. Furthermore, to our knowledge, the Lane Agility test has not been utilized in agility research as a testing measurement. In a book published by the National Basketball Conditioning Coaches Association (2007), the authors published instructions for this test and performance results for high school, college, and professional male and female basketball players. These results are based on a very limited number of high school and college basketball athletes, however. Consequently, research needs to be conducted first concerning the validity and reliability of the Lane Agility Test as a measurement of agility.

REFERENCES

1. Ben Abdelkrim, N., Castagna, C., Jabri, I., Battikh, T., El Fazaa, S., & El Ati, J. (2010). Activity profile and physiological requirements of junior elite basketball players in relation to aerobic-anaerobic fitness. *Journal of Strength and Conditioning Research.* 24(9), 2330-2342.

2. Chaouachi, A., Brughelli, M., Chamari, K., Levin, G., Ben Abdelkrim, N., Laurencelle, L., & Castagna, C. (2009). Lower limb maximal dynamic strength and agility determinants in elite basketball players. *Journal of Strength and Conditioning Research.* 23(5), 1570-1577.

3. Delextrat, A., & Cohen, D. (2008). Physiological testing of basketball players: Toward a standard evaluation of anaerobic fitness. *Journal of Strength and Conditioning Research.* 22(4), 1066-1072

4. Delextrat, A., & Cohen, D. (2009). Strength, power, speed, and agility of women basketball players according to playing position. *Journal of Strength and Conditioning Research.* 23(7), 1974-1981.

5. Hoare, D. (2000). Predicting success in junior elite basketball players: The contribution of anthropometric and physiological attributes. *Journal of Science and Medicine in Sport.* 3(4), 391-405.

6. Hoffman, J., Fry, A., Howard, R., Maresh, C., & Kraemer, W. (1991). Strength, speed, and endurance change during the course of a division I basketball season. *Journal of Applied Sport Science Research.* 5(3), 144-149.

7. Hoffman, J., Tenenbaum, G., Maresh, C., & Kraemer, W. (1996). Relationship between athletic performance tests and playing time in elite college basketball players. *Journal of Strength and Conditioning Research.* 10(2), 67-71.

8. Holmberg, P. (2010). Preseason preparatory training for a division III women's college basketball team. *Strength and Conditioning Journal.* 32(6), 42-54.

9. Latin, R., Berg, K., & Baechle, T. (1994). Physical and performance characteristics of NCAA division I male basketball players. *Journal of Strength and Conditioning Research.* 8(4), 214-218.

10. Little, T. & Williams, A. (2005). Specificity of acceleration, maximum speed, and agility in professional soccer players. *Journal of Strength and Conditioning Research.* 19(1), 76-78.

11. National Basketball Conditioning Coaches Association. (2007). *Complete conditioning for basketball.* Champaign, IL: Human Kinetics, vii-15.

12. National Football League. http://www.nfl.com/combine/workouts. Accessed January 15, 2011.

13. Pauole, K., Madole, K., Garhammer, J., Lacourse, M., & Rozenek, R. (2000). Reliability and validity of the t-test as a measure of agility, leg power, and leg speed in college-aged men and women. *Journal of Strength and Conditioning Research.* 14(4), 443-450.

14. Sassi, R., Dardouri, W., Yahmed, M., Gmada, N., Mahfoudhi, M., & Gharbi, Z. (2009). Relative and absolute reliability of a modified agility T-test and its relationship with vertical jump and straight sprint. *Journal of Strength and Conditioning Research.* 23(6), 1644-1651.

15. Semenick, D. (1990). The T-test. *NSCA Journal.* 12(1), 36-37.

16. Sheppard, J., & Young, B. (2006). Agility literature review: Classifications, training, and testing. *Journal of Sports Sciences.* 24(9), 919-932.

17. Simenz, C., Dugan, C., & Ebben, W. (2005). Strength and conditioning practices of nation basketball association strength and conditioning coaches. *Journal of Strength and Conditioning Research.* 9(3), 495-504.

18. Vescovi, J., & McGuigan, M. (2008). Relationships between sprinting, agility, and jump ability in female athletes. *Journal of Sports Sciences.* 26(1), 97-107.

19. Vescovi, J., & VanHeest, J. (2010). Effects of an anterior cruciate ligament injury prevention program on performance in adolescent female soccer players. *Scandanavian Journal of Medicine and Science in Sport.* 20, 394-402.

20. Young, W. & Farrow, D. (2006). A review of agility: Practical applications for strength and conditioning. *Strength and Conditioning Journal.* 28 (5), 24-29.

21. Young, W., McDowell, M., & Scarlett, B. (2001). Specificity of sprint and agility training methods. *Journal of Strength and Conditioning Research.* 15(3), 315-319.

22. Ziv, G., & Lidor, R. (2009). Physical attributes, physiological characteristics, on-court performances, and nutritional strategies of female and male basketball players. *Sports Medicine.* 39(7), 547-568.