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Original research article

RELIABILITY AND CRITERION VALIDITY OF THE ARROWHEAD CHANGE-OF-DIRECTION SPEED TEST FOR SOCCER

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Robert George Lockie[1], Farzad Jalilvand[2]

[1]California State University, Fullerton, USA
[2]California State University, Northridge, USA

Abstract. *The Arrowhead change-of-direction (COD) speed test was originally designed for soccer, and features three direction changes over a running distance of approximately 37 m. This study aimed to determine the reliability and criterion validity of the Arrowhead test in collegiate soccer players. Twenty Division I female players from the same team completed the Arrowhead test on separate days to assess reliability. Participants also completed tests of linear (30-m sprint; 0-5, 0-10, 0-30 m intervals) and COD (pro-agility and 60-yard shuttle) speed to assess criterion validity. Reliability was determined by intra-class correlation coefficients (ICC) and coefficient of variation (CV). Paired t-tests detected between-session differences in Arrowhead performance. Usefulness was determined by comparing the smallest worthwhile change with a small or moderate effect to the typical error of the Arrowhead test. Correlations were calculated between the Arrowhead test, 30-m sprint intervals, and shuttle tests to assess criterion validity. The ICCs and CVs for both the left- (ICC=0.92; CV=1.01%) and right-turn (ICC=0.93; CV=0.89%) Arrowhead test were acceptable, and the Arrowhead could detect moderate changes in performance. There were no significant between-session differences in Arrowhead times (p=0.87-0.97). Significant relationships were found between the Arrowhead test and the 30-m sprint and 60-yard shuttle (r= 0.55-0.68). Due to relationships with the 30-m sprint and 60-yard shuttle, the Arrowhead test could be utilized to assess a soccer player's ability to complete longer distance sprints that incorporate direction changes, as opposed to being a test of COD speed.*

Key words: *association football, linear speed, maximum velocity, pro-agility shuttle, 60-yard shuttle*

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Corresponding author: Robert George Lockie
California State University, Fullerton Department of Kinesiology 800 N State College Blvd Fullerton, CA 92831 USA
Phone: +1 657-278-4971 • E-mail: rlockie@fullerton.edu

INTRODUCTION

The ability to decelerate, change direction, and accelerate, are common motor tasks performed by many team sport athletes (Andrzejewski, Chmura, Pluta, & Kasprzak, 2012; Dawson, Hopkinson, Appleby, Stewart, & Roberts, 2004; Spencer, Bishop, Dawson, & Goodman, 2005). The ability to change direction is team sports has typically fallen under the term 'agility'. Sheppard & Young (2006) defined agility as the initiation of body movement, change of direction, or rapid acceleration or deceleration, often in response to a stimulus. The inclusion of a decision-making stimulus and cognitive component is what defines an agility-based task. The physical component of agility is change-of-direction (COD) speed, and incorporates factors such as the technique produced during the direction change, linear sprint technique, and the strength and power qualities of the lower-body muscles (Sheppard & Young, 2006). COD speed forms the foundation of agility, and is an essential quality to test and train in athletes (Lockie, Jalilvand, Orjalo, Giuliano, Moreno, & Wright, in press-b; Lockie, Schultz, Callaghan, Jeffriess, & Berry, 2013). This is especially important for soccer players.

During an elite soccer match, players can complete over 700 direction changes, turns and swerves at different angles (Bloomfield, Polman, & O'Donoghue, 2007), which places great importance on COD speed (Gil et al., 2014). It would be expected that even at lower levels of play, COD speed would still be important for soccer players. Numerous COD assessments have been used to test this quality in soccer players. Some examples include: the Illinois agility test (Katis & Kellis, 2009); T-test (Sassi et al., 2009; Sporis, Jukic, Milanovic, & Vucetic, 2010); 505 (Lockie et al., 2016a; Lockie et al., 2016b; Tomas, Frantisek, Lucia, & Jaroslav, 2014); shuttle runs over a variety of distances (Boone, Vaeyens, Steyaert, Vanden Bossche, & Bourgois, 2012; Sporis et al., 2010); pro-agility shuttle (Lockie et al., in press-a; Lockie et al., in press-c; Lockie et al., 2016c; Magal, Smith, Dyer, & Hoffman, 2009; Vescovi, Brown, & Murray, 2006);and 60-yard (54.86-meter [m]) shuttle (Lockie et al., in press-a). There is no one, gold-standard test for evaluating COD speed in soccer players. The test that is selected by the coaching staff is dependent on a number of factors. This will include the inherent philosophies of the coaching staff, the availability of appropriate equipment and testing space, the usefulness of the data produced by the selected test, and the reliability and validity of the test. Reliability relates to the consistency or repeatability of a test; validity is the extent to which a test or test item measures what it is supposed to measure. The validity of a field test can be ascertained by comparing it with an established test, and determining whether it assesses components of fitness known to be important for performance (Lockie et al., in press-b; Lockie et al., 2013; Wilkinson, Leedale-Brown, & Winter, 2009). If a coaching staff is considering the use of a novel assessment, it is essential that they know the reliability and validity for that particular test.

The Arrowhead COD speed test was a test that was designed specifically for soccer and was part of the Nike SPARQ testing protocol (SPARQ, 2009). The dimensions can be seen in Figure 1. The test involves the players sprinting 10 m to round a marker to the left or right, 5 m to round another marker at an approximate 45° angle, sprinting approximately 7.1 m to round another marker (the tip of the arrowhead), before rounding the final marker and sprinting back 15 m through the finish line. There has been some research that has utilized the Arrowhead test. Chan, Lee, Fong, Yung, & Chan (2011) analyzed youth and professional male soccer players, and found that the professional players were significantly faster in the Arrowhead test with an initial turn to the left (8.25 ± 0.27 seconds [s]) or right (8.16 ±

0.20 s), when compared to the youth players (left: 8.73 ± 0.64 s; right: 8.46 ± 0.56 s). This provides a measure of discriminant validity for the Arrowhead test. Lockie et al. (in press-c) assessed Division I collegiate women's soccer players in the Arrowhead test and found that it did not differentiate between different positional groups (goalkeepers, defenders, midfielders, and forwards) within the analyzed squad in their study. However, there is no research that has investigated the reliability or criterion validity of this test. This is an issue for soccer coaches who are considering utilizing the Arrowhead test.

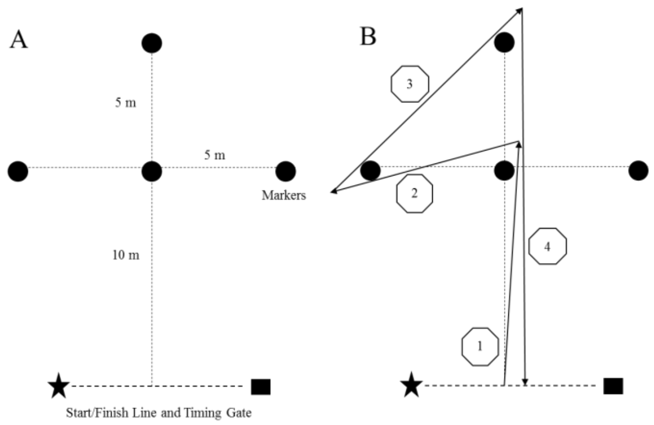

Fig. 1 (A) Dimensions of the Arrowhead COD test, and (B) running path for a test performance with an initial turn to the left

Therefore, the aim of this study was to investigate the relative and absolute reliability, and the usefulness, of the Arrowhead test, while also comparing it to standards for linear speed (30-m sprint; 0-5 m, 0-10 m, and 0-30 m intervals) and change-of-direction speed (pro-agility and 60-yard shuttle). In support of these aims, it was hypothesized that the Arrowhead will be reliable and useful. It was further hypothesized that the Arrowhead would correlate with the linear sprint interval times, and the pro-agility and 60-yard shuttle times, as each of these tests features either linear sprinting or COD actions. This would provide an indication of the criterion validity of the Arrowhead test as an assessment of COD speed.

METHODS

Participants

Twenty female soccer players (age = 20.10 ± 1.20 years; height = 1.67 ± 0.07 m; body mass = 61.45 ± 7.73 kg) were recruited from the same Division I women's collegiate soccer team. For inclusion, participants were required to be a member of the playing squad, over 18 years of age, and injury-free at the time of testing. G*Power software (v3.1.9.2, Universität Kiel, Germany) was used to confirm that the sample size of 20 was sufficient for a bivariate normal model correlation analysis, and ensured the data could be interpreted with a moderate effect level of 0.60 and power level of 0.90 when significance was set at 0.05 (Faul, Erdfelder, Lang, & Buchner, 2007).The data used in this study arose as a condition of monitoring in which player activities were measured over the course of the pre-season (Lockie et al., 2016a; Lockie et al., 2016b; Lockie et al., in press-a; Winter & Maughan, 2009). As a result, the institutional ethics committee approved the use of pre-existing data. The study still conformed to the recommendations of the Declaration of Helsinki, and all participants received a clear explanation of the study, including the risks and benefits of participation. Each player had also completed the university-mandated physical examination, and read and signed the university consent and medical forms for participation in collegiate athletics.

Procedures

The procedures for the assessments in this study have been detailed in the literature (Lockie et al., 2016a; Lockie et al., 2016b; Lockie et al., in press-a; Lockie et al., in press-c). However, they are reported here for the convenience of the reader. Testing was incorporated at the start of the squad's field training sessions across four weeks during the pre-season in the non-competition months of February and March. Testing was conducted in this manner at the request of the team's head coach and training staff. Four field testing sessions were completed, separated by at least 48 hours, and the assessments within each session were completed after the team's usual warm-up and prior to their field training. The four sessions involved: 1) pro-agility and 60-yard shuttle; 2) 30-m sprint; 3) Arrowhead test first session; and 4) Arrowhead test second session. A familiarization session for the Arrowhead test was conducted after the 30-m sprint testing session (Lockie et al., 2013; Sheppard, Young, Doyle, Sheppard, & Newton, 2006), which was incorporated into the training session for the team. Each testing session lasted for approximately 20-30 minutes in duration, was conducted on a natural grass outdoor soccer pitch, and participants wore their own cleats.

Prior to data collection in the first session, each participant's age, height, and body mass were recorded. Height was measured barefoot using a standard stadiometer (seca, Hamburg, Germany). Body mass was recorded using a standard electronic digital scale (Tanita Corporation, Tokyo, Japan). Participants also completed a standardized warm-up before each session that was designed by the team's coaching staff, which consisted of 10 minutes of jogging, 10 minutes of dynamic stretching of the lower limbs, and linear and lateral runs over 20-30 m that progressively increased in intensity. Participants completed testing in the order stated in this section, and rotated alphabetically by surname for each test. This provided sufficient recovery periods (i.e. greater than 3 minutes) between efforts (Lockie et al., 2016a; Lockie et al., 2016b; Lockie et al., in press-a; Lockie et al., in press-c), and also ensured that the same testing order was utilized for the two Arrowhead testing sessions. A standard metric tape measure was used to determine all distances. Time for each test was recorded to the nearest 0.001 s, and the averages were used for analysis.

Pro-agility shuttle

The pro-agility shuttle and running path is shown in Figure 2. This test has been used to assess COD speed in female soccer players (Lockie et al., in press-a; Lockie et al., in press-c; Vescovi et al., 2006), as thus was adopted for this study. One timing gate (TC Timing System, Brower Timing, Utah) was used, set at a height of approximately 1 m and width of 1.5 m. Participants straddled the middle line in a three-point stance in between the timing gate. As per the timing system set-up, a TC motion start was utilized where once the participant was stable in their stance they began the test. Timing was initiated by the first movement of the hand. The participant turned and sprinted 4.57 m (5 yards) to one side and touched the line with one hand. The participant then turned and sprinted 9.14 m (10 yards) to the other side and touched the other line**,** before turning and sprinting back through the timing gate. Coaches were positioned at either end of the shuttle to ensure participants touched the line. If they did not, the trial was stopped and re-attempted. Two trials were completed; one with movement initiation to the left, and one with movement initiation to the right (Lockie et al., in press-a; Lockie et al., in press-c; Lockie et al., 2016c). The order of trials was randomized amongst the participants.

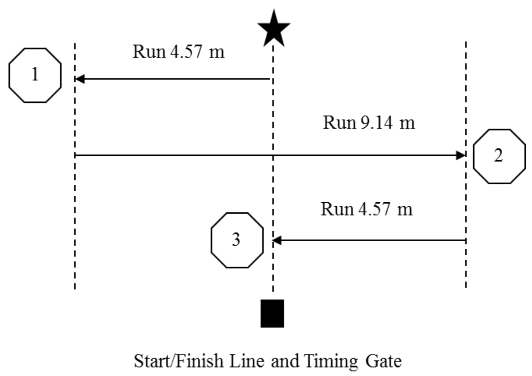

Fig 2 Dimensions and running path for the pro-agility shuttle.

60-yard (54.86-m) shuttle

Kuzmits & Adams (2008) described the 60-yard shuttle as a test of physical endurance, lateral speed, and coordination. This test has been used to assess women's soccer players (Lockie et al., in press-a), and thus was included in this study. The dimensions and running path for the 60-yard shuttle is shown in Figure 3. One timing gate (TC Timing System, Brower Timing, Utah) was used for this test, set at a height of approximately 1 m and width of 1.5 m. Participants started the shuttle from a standing start with a split-stance 50 centimeters (cm) behind the start line (Lockie et al., 2016a; Lockie et al., 2016b; Lockie et al., in press-a; Lockie et al., in press-c). They then ran 4.57 m (5 yards) to the first line, touched the line with one hand, before running back to touch the start line. The participant then ran 9.14 m (10 yards) to touch the second line**,** before running back to retouch the start line. Lastly, participants ran 13.72 m (15 yards) to the final line, touched, and then sprinted back through the timing gate. Coaches were positioned to monitor each line and ensure they were touched. As for the pro-agility shuttle, if participants did not touch the line in one of the sprints, the trial was stopped and re-attempted. Two trials were completed; one where the participant faced towards the left when touching the ground, and one where the participant faced the right.(Lockie et al., in press-a) The order of trials was randomized amongst the sample.

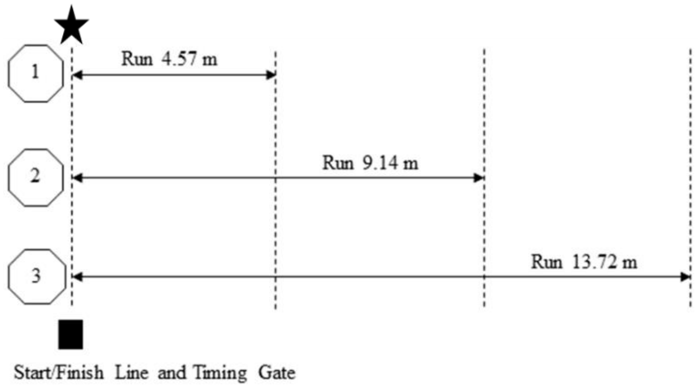

Fig 3 Dimensions and running path for the 60-yard (54.86-m) shuttle.

30-m Sprint

The 30-m sprint has been used to assess the linear speed of soccer players in the literature (Lockie et al., 2016a; Lockie et al., 2016b; Lockie et al., in press-a; Lockie et al., in press-c; Magal et al., 2009; Vescovi, 2012), thus was incorporated into this study. Time for the 30-m sprint was recorded by a timing lights system (Fusion Sports, Sumner Park, Australia). Gates were positioned at 0 m, 5 m, 10 m, and 30 m, to measure the 0-5 m, 0-10 m, and 0-30 m intervals. The 0-5 m and 0-10 m intervals measured acceleration; the 0-30 m time quantified maximum velocity specific to soccer players (Lockie et al., 2016a; Lockie et al., 2016b; Lockie et al., in press-a; Lockie et al., in press-c; Magal et al., 2009; Vescovi, 2012). Gate height was set at 1.2 m, gate width at 1.5 m, and participants began the sprint from a standing start, similar to the 60-yard shuttle, 50 cm behind the start line to trigger the first gate (Lockie et al., 2016a; Lockie et al., 2016b; Lockie et al., in press-a; Lockie et al., in press-c). Participants were instructed to run maximally once they initiated their sprint, and completed three trials.

Arrowhead COD speed test

As previously shown, the dimensions, marker positions, and running path for the Arrowhead test are shown in Figure 1, with one timing gate (Fusion Sports, Coopers Plains, Australia) positioned at the start line (height: 1.2 m; width : 1.5 m). The methods adopted in this study have been described in the literature (Lockie et al., in press-c). Participants used a similar start position as per the 60-yard shuttle and 30-m sprint (i.e. 50 cm behind the start line) (Lockie et al., 2016a; Lockie et al., 2016b; Lockie et al., in press-a; Lockie et al., in press-c). When ready, participants sprinted to the middle marker, turned to the left or right (depending on the trial) to sprint around the side marker, sprinted around the top marker, before sprinting back through the timing gate to finish. Participants were required to step around and not over the markers. If they did not do this, the trial was stopped and reattempted. Six trials in total were completed; three with movement initiation to the left, and three with movement initiation to the right. The order of these trials was randomized amongst the participants.

Statistical analyses

Statistical analyses were processed using the Statistics Package for Social Sciences (Version 24.0; IBM Corporation, New York, USA). The analysis for this study was modelled on previous research (Lockie et al., in press-b; Lockie et al., 2013). Descriptive statistics (mean ± standard deviations [SD]; 95% confidence intervals [95% CI]) were provided for each variable. Stem-and-leaf plots confirmed there were no outliers in the data for each variable. For the relative reliability analysis, intra-class correlation coefficients (ICC) were used. An ICC equal to or above 0.70 was considered acceptable (Baumgartner & Chung, 2001; Lockie et al., in press-b; Lockie et al., 2013). Absolute reliability was assessed by paired samples t-tests ($p < 0.05$), which were used to determine any significant differences between the sessions for each speed test (Lockie et al., in press-b; Lockie et al., 2013; Sheppard et al., 2006), and typical error (TE) (Hopkins, 2000; Lockie et al., in press-b; Lockie et al., 2013). The Hopkins (2009) spreadsheet was used to determine the TE (s) for the Arrowhead tests with turns to the left and right, expressed as a coefficient of variation (CV, %). A CV of less than 5% was set as the criterion for reliability. The usefulness of the Arrowhead test was determined by comparing the TE to the smallest worthwhile change (SWC) in time (Hopkins, 2004). The SWC was determined by multiplying the between-participant SD by either 0.2 ($SWC_{0.2}$) (Hopkins, 2004; Lockie et al., in press-b; Lockie et al., 2013), which is a small effect, or 0.5 ($SWC_{0.5}$) (Cohen, 1988; Lockie et al., in press-b; Lockie et al., 2013), which is a moderate effect. If the TE was below the SWC, the test was rated as 'good'; if the TE was similar to the SWC, the test was rated as 'OK'; and if the TE was higher than the SWC, the test was rated as 'marginal' (Hopkins, 2004). For the validity analysis, Pearson product-moment correlations (r) were used to define relationships between the Arrowhead and the 30-m sprint, pro-agility shuttle, and 60-yard shuttle (Lockie et al., in press-b; Lockie et al., 2013; Sassi et al., 2009; Wilkinson et al., 2009). Significance was set at $p < 0.05$. For this study, an r value less than 0.30 was considered small; 0.31 to 0.49 moderate; 0.50 to 0.69 large; 0.70 to 0.89 very large; and 0.90 and higher near perfect for predicting relationships (Hopkins, 2002).

RESULTS

The reliability data for the Arrowhead test is shown in Table 1. The ICCs and CVs for both the left- and right-turn Arrowhead test were acceptable. There were no significant between-session differences in average left- or right-turn Arrowhead test performance. The TE for the left- and right-turn Arrowhead test slightly exceeded the $SWC_{0.2,}$ which meant the Arrowhead test was marginally useful for determining performance changes with small effects. However, the Arrowhead test was capable of detecting moderate performance changes, with the TE being below the $SWC_{0.5}$.

The descriptive data for the 30-m sprint and two shuttle tests is shown in Table 2. Table 3 displays the correlation data between the Arrowhead test, and the 30-m sprint, pro-agility shuttle, and 60-yard shuttle. There were significant, positive correlations between the left-turn Arrowhead test and the 30-m sprint and 60-yard shuttle, both of which were large relationships. The right-turn Arrowhead test correlated with the 60-yard shuttle, with a positive large relationship.

Table 1 Descriptive data (mean ± SD; 95% CI) for testing sessions 1 and 2, *p* value for differences between the sessions, and reliability statistics (ICC, TE, CV, $SWC_{0.2}$, $SWC_{0.5}$, and ratings of usefulness) for the left- and right-turn Arrowhead in collegiate female soccer players (n = 20).

	Arrowhead Left	Arrowhead Right
Session 1 (s)	8.946 ± 0.300 (8.805 to 9.086)	8.985 ± 0.296 (8.847 to 9.124)
Session 2 (s)	8.939 ± 0.316 (8.790 to 9.086)	8.983 ± 0.307 (8.840 to 9.128)
p value	0.87	0.97
ICC	0.92	0.93
TE (s)	0.08	0.09
CV (%)	1.01	0.89
$SWC_{0.2}$ (s)	0.06	0.06
Rating	Marginal	Marginal
$SWC_{0.5}$ (s)	0.16	0.16
Rating	Good	Good

Table 2 Descriptive data (mean ± SD; 95% CI) for the 0-5 m, 0-10 m, and 0-30 m sprint intervals the pro-agility shuttle, and 60-yard shuttle in collegiate female soccer players (n = 20).

Speed Test	Mean ± SD (95% CI)
0-5 m	1.150 ± 0.046 (1.129 to 1.172)
0-10 m	1.991 ± 0.057 (1.965 to 2.018)
0-30 m	4.745 ± 0.146 (4.677 to 4.814)
Pro-agility Shuttle	5.069 ± 0.173 (4.983 to 5.156)
60-yard Shuttle	13.533 ± 0.388 (13.340 to 13.726)

Table 3 Correlations between the Arrowhead with an initial turn to the left or right, and the 0-5 m, 0-10 m, and 0-30 m intervals of a 30-m sprint, the pro-agility shuttle, and the 60-yard shuttle in Division I collegiate female soccer players (n = 20).

		Arrowhead Left	Arrowhead Right
0-5 m	*r*	0.051	0.059
	95% CI	-0.401 to 0.483	-0.394 to 0.489
	R^2	0.003	0.003
	p	0.830	0.804
0-10 m	*r*	0.294	0.257
	95% CI	-0.171 to 0.652	-0.210 to 0.628
	R^2	0.086	0.066
	p	0.208	0.274
0-30 m	*r*	0.545	0.410
	95% CI	0.134 to 0.795	-0.040 to 0.721
	R^2	0.297	0.168
	p	0.013*	0.073
Pro-Agility Shuttle	*r*	0.272	0.335
	95% CI	-0.194 to 0.638	-0.127 to 0.677
	R^2	0.074	0.112
	p	0.275	0.174
60 yard Shuttle	*r*	0.656	0.684
	95% CI	0.300 to 0.851	0.345 to 0.865
	R^2	0.430	0.468
	p	0.003*	0.002*

DISCUSSION

This study investigated the reliability and criterion validity of the Arrowhead test, which was originally designed as a COD test specific for soccer (SPARQ, 2009), in Division I collegiate female players. The test was designed to include accelerations and direction changes (SPARQ, 2009), as these are actions required in soccer matches (Andrzejewski et al., 2012). The results indicated that the Arrowhead test was reliable, and demonstrated relationships with the 30-m sprint and 60-yard shuttle. However, these relationships may also highlight some limitations in using the Arrowhead test as a COD speed assessment. The Arrowhead may be better used as a maximal velocity or a longer distance sprint test with direction changes. The results from this study have implications for soccer and strength and conditioning coaches in how they may use the Arrowhead test for their players.

An effective test must be reliable for coaches to be able to trust the data they collect from the assessment. There were no significant differences between the left- or right-turn Arrowhead tests between the two sessions. Additionally, the results demonstrated that the Arrowhead test with an initial turn to the left (ICC = 0.92; CV = 1.01%) or right (ICC = 0.93; CV = 0.89%) had high ICCs and low CVs. The CV attained for the Arrowhead in this study was lower than that for other COD speed tests in male soccer players. This included a modified T-test that had a duration of approximately 6 s (CV = 2.7%) (Sassi et al., 2009), and soccer-specific assessments that featured 90° and 180° direction changes over a duration of approximately 6-8 s (CV = 2.9-5.6%) (Sporis et al., 2010). Furthermore, although the sample in this study for the reliability analysis was relatively small (n = 20), Buchheit, Lefebvre, Laursen, & Ahmaidi (2011) affirmed that when good relative reliability is found, increasing the sample size may not greatly influence the results.

As the Arrowhead test proved to be reliable when performed by collegiate female soccer players, it is worth investigating the usefulness of the test. Buchheit, Spencer, & Ahmaidi (2010) stated that the usefulness of a test refers to the practicability of the test to confidently monitor an athlete’s progress. Test usefulness can be investigated by comparing the SWC relative to the TE of a test (Hopkins, 2004). The results indicated that the Arrowhead test would be useful in detecting moderate changes in performance for collegiate women’s soccer players, but had only marginal usefulness for small changes. The homogeneity of the group can contribute to a low $SWC_{0.2}$ (Lockie et al., in press-b; Lockie et al., 2013). Indeed in a sample of Division I collegiate female soccer players similar to that from the current study, Lockie et al. (in press-c) found very few significant differences in the performance of a range of physiological assessments (i.e. vertical and standing broad jump, 30-m sprint, Arrowhead test, pro-agility shuttle, and Yo-Yo Intermittent Recovery Test Level I). From these results, Lockie et al. (in press-c) noted the relative homogeneity of collegiate female soccer players, especially during the pre-season period, which was also when data was collected for this study. A larger, more heterogeneous sample of soccer players could potentially result in a greater SD in the Arrowhead, and by extension the SWC could increase and change the rating of usefulness for the Arrowhead test (Lockie et al., in press-b). Future investigations could evaluate a greater range of soccer players (e.g. males and females; players from high school, collegiate, and professional levels of play) to establish whether this occurs. Nonetheless, the results from the current study indicated that the Arrowhead could be able to detect moderate changes in performance when performed by Division I collegiate female soccer players. The performance changes that may be measured by the Arrowhead test, however, may not be representative of COD speed per se.

There were significant correlations between the Arrowhead test with the 30-m sprint and the 60-yard shuttle, but not the 0-5 m sprint interval, 0-10 m sprint interval, or the pro-agility shuttle. The participants sprinted approximately 37 m during the Arrowhead COD test, with three direction changes. This test has a duration of approximately 8.9 s when completed by collegiate female soccer players, as shown by the results from this study and Lockie et al. (in press-c). Chan et al. (2011) found that professional male soccer players completed the Arrowhead test in approximately 8.2 s, while youth male players completed the test in approximately 8.6 s. The 60-yard shuttle covers a distance of approximately 54.86 m, with five direction changes, and this study and Lockie et al. (in press-a) found collegiate female soccer players complete this test in approximately 13.5 s. In contrast, the pro-agility shuttle features shorter accelerations over distances of 4.57 m and 9.14 m, similar to the acceleration intervals from the 30-m sprint. The Arrowhead test appears to place less emphasis on sprint acceleration and COD ability, and more emphasis on a soccer player's maximum velocity. The Arrowhead, therefore, could potentially assess a player's ability to complete longer distance sprint efforts (i.e. longer than 20 m) that include direction changes, as these can occur during a soccer match (Andrzejewski, Chmura, Pluta, Strzelczyk, & Kasprzak, 2013)

However, these results may also indicate that the Arrowhead test does not truly assess COD speed. Linear acceleration capabilities is an important component of COD speed (Sheppard & Young, 2006), and as stated the correlation data showed no significant relationships with linear speed over 5 m and 10 m. Further to this, Nimphius, Callaghan, Spiteri, & Lockie (2016) stated that an assessment that incorporates a large degree of linear sprinting could actually mask the COD ability of an athlete. This is because an athlete may be able to compensate for below-standard COD ability by demonstrating faster linear speed. Sayers (2015) asserted that a test that limits the linear sprint distance involved, or allows for the measurement of time or velocity immediately following a COD within a test, may be a better method for assessing COD ability. Future research could analyze whether this is possible within the direction changes that feature in the Arrowhead test. Nevertheless, in addition to the decreased emphasis on sprint acceleration and COD ability, the duration of the test (i.e. 8-9 s) may also influence what the limiting factors are when competing the Arrowhead test. For a test of this duration the limitations may instead be metabolic (Vescovi & McGuigan, 2008), where fatigue rather than COD ability could increase the test duration. This further highlights that the Arrowhead test may be more of an assessment of longer distance sprint efforts that include direction changes, as opposed to COD speed by itself. Coaches should be cognizant of this if they use the Arrowhead test to assess soccer players. Although reliable, the criterion validity analysis suggests that the Arrowhead test related to multidirectional sprint efforts over an extended distance (i.e. ~30-50 m), rather than short sprint or COD efforts that placed an emphasis on acceleration (i.e. ~5-10 m).

There are certain study limitations that should be acknowledged. This study did not investigate differences between different levels of play for female soccer players (e.g. high school vs. collegiate vs. professional players) to document discriminant validity for the Arrowhead test. Although Chan et al. (2011) provided some measure of discriminant validity for the Arrowhead test by comparing youth and professional male soccer players, further analysis is required. This study did not isolate the time required to execute, or the velocity exiting, a direction change within the Arrowhead, even though this has been recommended in the literature (Nimphius et al., 2016; Sayers, 2015). This takes on greater emphasis considering the results suggested that the Arrowhead test may relate more to maximum velocity and extended sprinting capabilities, as opposed to COD speed. Future research should attempt to isolate and measure the individual direction changes that occur in the Arrowhead test. Within the context of these limitations, the current study indicated that the Arrowhead test is reliable, and correlated with the 0-30 m sprint interval and 60-yard shuttle when performed by Division I collegiate female soccer players. The Arrowhead test could be utilized to assess a soccer player's ability to complete longer distance sprint efforts that incorporate a COD component.

CONCLUSION

The results from this study indicated that the Arrowhead test is reliable, as evidenced by high ICCs and low CVs, when completed by Division I collegiate female soccer players. The Arrowhead test could also detect changes in performance that had a moderate effect. However, the results also suggested that the Arrowhead test may not purely measure COD speed. This was because this test had significant relationships with the 0-30 m sprint interval and 60-yard shuttle, but not the 0-5 m and 0-10 m sprint intervals, or the pro-agility shuttle. This indicates that performance in the Arrowhead test places greater emphasis on a soccer player's maximal velocity and extended sprinting capabilities. The distance covered in the Arrowhead test (~37 m) and the duration of the test (8-9 s) would also support this conclusion. The Arrowhead test could be utilized to assess a soccer player's ability to complete longer distance sprint efforts that incorporate direction changes, as opposed to being purely a test of COD speed.

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POUZDANOST I KRITERIJUMSKA VALJANOST TESTA PROMENE PRAVCA KRETANJA U OBLIKU STRELE U FUDBALU

Test promene pavca kretanja u punoj brzini u obliku vrha strele (prema engl. Arrowhead change-of-direction speed test (COD), prvenstveno je kreiran za potrebe fudbalera, i odlikuju ga tri promene pravca tokom prelaska rastojanja od oko 37m u punom trku. Cilj istraživanja bio je da se utvrdi pouzdanost i kriterijumska valjanost ovog testa kod fudbalera, studenata. Dvadeset fudbalerki istog tima koji se takmiči u Prvoj Diviziji sprovelo je navedeni test različitim danima, kao i testove pravolinijskog trčanja (30-m sprint; u intervalima 0-5, 0-10, 0-30 m) i okretnosti (promene pravca napred-nazad, prema engl. pro-agility i 60-yard shuttle), kako bi se utvrdila valjanost. Pouzdanost je utvrđivana koeficijentom korelacije unutar klase (prema engl. ICC) i koeficijentom varijacije (prema engl. CV). T-testom za parne uzorke utvrđivane su razlike u performansama COD. Korisnost je određena upoređivanjem najmanje promene sa malim ili umerenim uticjem na tipičnu grešku COD. Korelacije su utvrđene između sva tri testa. ICC i CV i za levi (ICC=0.92; CV=1.01%) i za desni okret (ICC=0.93; CV=0.89%) kod COD bile su prihvatljive, tj., COD testom moguće je utvrditi umerene promene u performansama. Nisu utvrđene statistički značajne razlike u vremenima izvođenja COD testa (p=0.87-0.97). Značajne relacije utvrđene su između COD testa, 30-m sprint i 60-yard shuttle (r= 0.55-0.68), zbog čega se Arrovhead (COD) test može koristiti u proceni sposobnosti fudbalera da završe sprint na dužim rastojanjima, a koji uključuju promene pravca.

Ključne reči: *fudbalsko udruženje, pravolinijska brzina, maksimalna brzina, pro-agility, 60-yard shuttle*