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Reliability and Validity of a Reactive Agility Test for Australian Football

James P. Veale, Alan J. Pearce, and John S. Carlson

Purpose: The aim of this study was to test the reliability and construct validity of a reactive agility test (RAT), designed for Australian Football (AF). **Methods:** Study I tested the reliability of the RAT, with 20 elite junior AF players (17.44 ± 0.55 y) completing the test on two occasions separated by 1 wk. Study II tested its construct validity by comparing the performance of 60 participants (16.60 ± 0.50 y) spread over three aged-matched population groups: 20 athletes participating in a State Under-18 AF league who had represented their state at national competitions (elite), 20 athletes participating in the same league who had not represented their state (subelite), and 20 healthy males who did not play AF (controls). ***Results:*** Test-retest reliability reported a strong correlation (0.91), with no significant difference ($P = .22$) between the mean results (1.74 ± 0.07 s and 1.76 ± 0.07 s) obtained (split 2+3). Nonparametric tests (Kruskal-Wallis and Mann-Whitney) revealed both AF groups performed significantly faster on all measures than the control group (ranging from $P = .001$ to .005), with significant differences also reported between the two AF groups (ranging from $P = .001$ to .046). Stepwise discriminant analyses found total time discriminated between the groups, correctly classifying 75% of the participants. ***Conclusions:*** The RAT used within this study demonstrates evidence of reliability and construct validity. It further suggests the ability of a reactive component within agility test designs to discriminate among athletes of different competition levels, highlighting its importance within training activities.

Keywords: change of direction, speed, decision making, testing, exercise physiology

Agility, commonly defined as an individual's ability to change direction while at speed, has been deemed an identifiable athletic quality in the development of individual and/or team success in field and court sports.[1–3] Nevertheless, it is generally accepted that many current tests used to measure agility performance within field based team sports are not matched with known game-day movement characteristics.[3] To date, a number of time-motion studies have documented common change of direction angles undertaken when athletes are moving at high speeds in field sports

Veale is with the Centre for Ageing, Rehabilitation, Exercise and Sport (CARES), Victoria University, and the School of Sport and Exercise Science, Victoria University, Footscray, VIC, Australia. Pearce is also with the Centre for Ageing, Rehabilitation, Exercise and Sport (CARES), Victoria University, and the School of Sport and Exercise Science, Victoria University, Footscray, VIC, Australia. Carlson is with the Centre for Ageing, Rehabilitation, Exercise and Sport (CARES), Victoria University, Footscray, VIC, Australia.

such as Australian Football (AF),[4] rugby[5,6] and soccer.[7] However, agility is now regarded to be more complex and incorporate such neuropsychological factors as anticipation,[8,9] intuition,[9] sensory processing,[8] and decision making[10,11] with such physiological factors as response time,[12–14] acceleration and maximum speed,[14,15] change of direction (COD) speed, and mobility.[3] Therefore, as the time-motion research has not reported the number of high-intensity COD that are made in direct response to a stimulus (eg, evading or pursuing an opponent, or reacting to a moving ball), the data produced so far have only allowed for the identified closed-skill nature of agility to be assessed from self-initiated starts and predetermined COD.[2,3,12,14]

According to Murray,[16] prior knowledge of the test design in the execution of many commonly used COD agility skills removes the uncertainty involved in the test, resulting in evaluating only the COD speed—a skill influenced by individual differences in running velocity preceding and following the directional change.[3] Therefore, whereas studies using closed-skill tests have shown the ability to distinguish between elite and subelite players,[7,17] the preplanned nature of these tests limits their applicability to real game demands and subsequently their use in identifying potential talent under typical sport situations.[14] Moreover, these factors interact with each other to varying degrees dependent upon the sport-specific context. It is now commonly accepted that visual cues processing, anticipation, and reaction time are all important to team sport agility performance.[2,3,8,9,11,12] In agility tasks specific to team sports, the timing and location of the stimuli have been reported to influence performance.[2] Furthermore, research across a variety of settings has repeatedly demonstrated the superior ability of elite athletes in identifying useful anticipatory information from early in their opponent's movement patterns.[6–9,11]

Referred to as advanced cue utilization, the superior ability of a player to make accurate predictions based on information provided by their opponent's posture and bodily orientation has been shown in experienced versus inexperienced soccer players and also in talent identified junior soccer players.[8,9] Consequently, the relevance of reactive agility testing is mainly based on logical validity[18] because, according to Cox,[19] open skill tests eliminate the ability for preplanning and practicing of the task, thus making it more sport specific (eg, evading an opponent) by producing a test response that is not automated or rehearsed. Therefore not only should logical validity be addressed in reactive agility test (RAT) design, but also construct validity, where the test should be able to discriminate between experts and novices based on advanced cue utilization. However, to date, a limitation in many open skill tests is the use of generic cues such as a light bulb and computerized direction indicators, or two dimensional film-based scenarios rather than a real-life stimulus (such as an opponent moving toward the athlete) to evaluate an unplanned mode of agility testing.[3,8,12]

While a variety of open (anticipatory) and closed (COD) skill testing has been independently used to successfully discriminate between elite and subelite athletes,[2,3,7–9,11,12,17] sport-specific field tests for agility involving physical performance and decision making using a three-dimensional stimulus is limited in both research and test design.[14] Specific to the football codes, Sheppard et al[14] recently designed a RAT that involves the components of perception, decision making and movement in direct response to the behavior of another person. However, although this test has shown an ability to discriminate between elite (first division athletes from one team participating in an elite senior state league competition) and subelite (reserve grade athletes from the same team) AF players[14] and rugby league players (comparing national and recreational rugby league athletes),[13] it is limited to the use of a single COD. Extra directional changes and the assessment of more split times would allow the complexities involved in changing direction at speed in response to open or closed skill activities, as well as different techniques used on approach and exit speed in each COD, to be assessed. Such a design could be suggested to improve the sport specificity of the test by returning the athlete to their initial course of direction, which in a sporting situation is most commonly toward the goals. Furthermore, the use of an auditory beep presents a confounding factor due to the faster processing of auditory versus visual information cues.[20] Therefore, while previous research at the elite junior AF level has studied speed and COD abilities within the talent identification process,[17,21–23] the aim of this study was to systematically test the design of a novel RAT specific to the elite junior AF population. This evaluation provides test-retest reliability data and assesses the construct validity of the test design by comparing the results of two AF population groups to a control group of age-matched nonathletic healthy males.

Methods

All participants involved in both studies I (Reliability testing) and II (Construct validity analysis) were provided with verbal and written communications of the study's requirements. Ethical approval was granted by the University Human Research Ethics Committee and in accordance with the Declaration of Helsinki, each volunteer and parent provided written informed consent.

Study I—Reliability Testing

Participants. A homogenous group of 20 athletes (17.44 ± 0.55 y; 183.4 ± 7.4 cm; 78.5 ± 8.2 kg) from one team competing in the Victorian Under 18 (U18) AF league were tested on two occasions separated by 1 wk.

Test Procedures. The reactive agility test (RAT) designed for this study (Figure 1) involved two changes of direction (COD) and 12 m in total distance. It was assessed on an indoor basketball court. Six electronic timing gates (Custom built, Sick Electronics) were set up in the following manner; the first gate at the start line (0 m) and the second 2 m in front of the start line, the third and fourth gates 5 m to the left and right at 45° angles to the center of the second gate. The fifth and sixth gates were placed a further 5 m away at 45° angles in an opposite direction to the corresponding second and third gates. One run involved an initial left and then right 45° COD, whereas the alternate option involved an initial right and then left 45° COD (Figure 1).

Following the same protocol of Sheppard et al[14] and Gabbett and Benton,[13] the tester (who was the same researcher used in all test protocols) stood 6 m in front of the starting line and initiated the test in a randomized order of one of four ways:

1. Step forward with right foot and change direction the left
2. Step forward with the left foot and change direction to the right
3. Step forward with the right foot, then left, and change direction to the right
4. Step forward with the left foot, then right, and change direction to the left

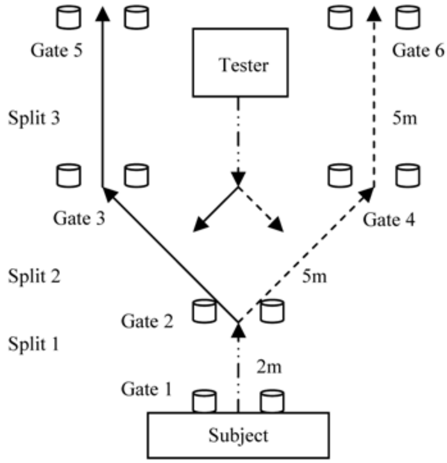

Figure 1 — The reactive agility test (RAT) used in this study.

Participants were instructed to sprint forward before any COD (through gate 2) in response to the tester moving forward and then to the left or the right in response to, and in the same direction as, the left or right movement of the tester. Participants were directed to respond to the change of direction cues as they would in a game situation,[13] moving as quickly as possible to intercept the tester to the left or to the right (gates 3 or 4) and to then continue this path through the final gates (gates 5 or 6).

Reliability assessment of the test design involved each participant completing 12 trials on two occasions separated by 1 wk. After the completion of a standardized 10-min warm-up (comprised of basic run-throughs at an increasing tempo, dynamic stretching, and simple COD activities), each participant completed three trials each of the four possible tester initiated movements in a randomized order.

Study II—Construct Validity Testing

Participants. Using the known group difference method to measure the construct validity of the designed RAT, 60 age-matched participants (16.60 ± 0.50 y) were recruited from the following: 20 athletes participating in a State Under 18 (U18) AF league who had represented their state at a national competition (elite group; height 185.7 ± 5.9 cm, weight 77.1 ± 4.4 kg), 20 athletes participating in the same state U18 AF league but had not represented their state at a national competition (subelite; height 184.6 ± 6.8 cm, weight 75.8 ± 6.0 kg), and 20 healthy age-matched males who did not play AF (controls; height 179.2 ± 0.5 cm, weight 67.1 ± 11.5 kg). Through prescreening of participants, all AF athletes (elite and subelite) reported an average preseason weekly training volume of 8 h/wk and no competitive matches. A priori power analysis (GPower V3.0.10) revealed that a minimum sample size of 14 participants in each group would result in statistical power at 0.80 at an alpha level of 0.05 and effect size of 0.5. A sample of 20 participants was recruited for each group in case of participant dropout and to account for the risk of type 2 statistical errors.

Test Procedures. Using the basic RAT test protocol described above, each of the groups (elite AF players, subelite AF players, and nonathletic active controls) were tested separately at the same venue. Each group was tested only once and no athlete had previous exposure to the RAT. After the same standardized 10-min warm-up, each participant was allowed three familiarization runs of the test, before completing three attempts with their fastest overall time recorded as their best attempt. Each trial was conducted in a randomized tester initiated direction.

Data Processing and Statistical Analysis

Study 1—Reliability Testing. The mean time for the 12 trials completed, which was an average of the six trials to the left and the six to the right, was recorded for the two COD split times (split 2 and split 3) and for the total time taken (split 2+3) as the final score for the reactive agility test during the test and retest conditions. Test-retest reliability was assessed by applying t test, Pearson correlations (r value) and typical error of measurement (TEM) calculations to the data obtained from the first and second testing sessions. Descriptive data for each split and the overall test time are presented using group mean (± SD). For all statistical testing, alpha was set at $P < .05$.

Study 2—Construct Validity Testing. All data were first screened to assess normal distribution. To have sufficient data to test for questions of normality, all data and splits (1–3; splits 2+3, total time) from the 60 trials were used to establish the distributional properties. Each variable's z-score of skew or kurtosis was observed to be negatively skewed, and confirmed with Shapiro-Wilk tests demonstrating statistical significance, suggesting each split was not normally distributed (split 1 SW = 0.89, $df = 60$, $P < .001$; split 2 SW = 0.83, $df = 60$, $P < .001$; split 3 SW = 0.75, $df = 60$, $P < .001$; split 2+3 SW = 0.76, $df = 60$, $P < .001$; total time SW = 0.85, $df = 60$, $P < .001$). Consequently, Kruskal-Wallis and Mann-Whitney tests were used for statistical analysis with Cohen's effect size conventions used to illustrate magnitude of the differences between groups for each split and total time. We used criteria similar to those of Hopkins[24] to interpret the magnitude of the effect sizes being: <0.2 trivial, 0.2 to 0.6; small, 0.6 to 1.2 moderate, 1.2 to 2.0 large and >2.0 very large. Stepwise discriminant analyses were used for all RAT split times and total test time, with competition level as the dependent variable.[25] Descriptive data for each split (1–3; splits 2+3) and the overall test time are presented using group mean (± SD). For all statistical testing, alpha was set at $P < .05$.

Results

Study 1—Reliability Testing

Results of the reliability testing reported a strong correlation (0.91) between the two testing sessions conducted a week apart, with no significant difference (P = .22) between the mean results (1.74 ± 0.07 s and 1.76 ± 0.07 s; TEM = 0.011) obtained for total test time (split 2+3). Furthermore, using Pearson correlations

(r value), moderate correlations (0.71 and 0.72) were recorded between the results for split 2 (0.90 ± 0.05 s and 0.92 ± 0.05 s; TEM = 0.008) and split 3 (0.84 ± 0.06 s and 0.84 ± 0.05 s; TEM = 0.008) on both testing occasions. No significant difference was reported between the times recorded for each of the four tester initiated movement directions ($P = 0.11$).

Study 2—Construct Validity Testing

The results for the three groups are presented in Table 1. A Kruskal-Wallis test revealed a main effect of group, with Mann-Whitney post hoc tests indicating that the AF groups were significantly faster than the nonathletic healthy group for all time splits recorded (1–3, 2+3 and total time; ranging from $P = .001$ to .005). Analysis between the AF groups reported the elite athletes were significantly faster over split 2 ($P = .002$), split 3 ($P = .046$), split 2+3 ($P = .002$) and in total time ($P = .001$). Furthermore, effect size (ES) comparison showed moderate differences at split 2 and split 3 (ES = 0.9 and 0.6 respectively), split 2 + 3 and total time (ES = 1.1) between the two AF groups. Stepwise discriminant analyses found RAT total time discriminated between the three population groups ($P < .001$), correctly classifying 75% of the participants. Power analysis showed a high power associated with the differences between the elite and subelite groups (ranging between 0.80 and 0.95 across the split times recorded).

Discussion

The aim of this study was to test the reliability and construct validity of a novel reactive agility test (RAT), modified from the protocol of Sheppard et al[14] for use within the elite junior Australian Football (AF) population. Importantly, within the same population on two occasions separated by 1 wk, the results of the RAT demonstrated no significant difference ($P = 0.22$) and good reliability ($r = 0.91$) between test results, suggesting no learning effect via “test practice.”[2,3,14,16] Discriminating between the abilities of junior AF athletes compared with aged-matched nonathletic healthy male participants (Table 1), the RAT used in this study also discriminated between AF athletes of a higher competition standard (Table 1). Furthermore, moderate ES differences between the times recorded by the two AF groups demonstrated the existence of a practical significance, with the observed difference translating to the elite group completing the 12 m course on average 0.52 m before the subelite group.[17] These results suggest a sport-specific nature and construct validity of the RAT design. The RAT also reported similar trends to previous research evaluating the effectiveness of open skilled agility tests in distinguishing between performance abilities of AF athletes at the elite and subelite level.[14]

Within team sports, skills that require COD and agility (for example, evading an opponent or receiving the ball) are preceded by high-intensity movement.[3,14] The RAT used within this study was made up of two key components: reactive acceleration (split 1) and reactive COD at speed (split 2+3). Subsequently, unique to this RAT design was the 2-m acceleration distance (rolling start) before the first directional change. Designed to imitate the AF-specific nature of the test design, the AF populations recorded significantly faster split times from a stationary start over the first 2 m in response to the researchers test initiated movement (split 1)

Table 1 Mean (±SD) results of the three population groups (elite, subelite, and control) tested during the study (n = 20 per group, $P \leq .05$)

	Split 1 (s)		Split 2 (s)		Split 3 (s)		Split 2+3 (s)		Total Time (s)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Elite (National Level)	0.63[a]	0.07	0.93[a,b]	0.08	0.86[a,b]	0.07	1.79[a,b]	0.10	2.42[a,b]	0.10
Sub-Elite (State Level)	0.65[c]	0.07	0.99[c]	0.06	0.89[c]	0.04	1.88[c]	0.06	2.53[c]	0.10
Control	0.76	0.13	1.10	0.15	1.10	0.19	2.20	0.30	2.96	0.31

[a] Denotes elite footballers were significantly faster than the control group ($P < .05$).

[b] Denotes elite footballers were significantly faster than the subelite footballers ($P < .05$).

[c] Denotes subelite footballers were significantly faster than the control group ($P < .05$).

compared with the nonathletic healthy controls, equating to a measureable distance of 0.35 m (Table 1). This faster response and acceleration might be a sport-specific training response as a result of the importance of gaining optimal field position during a match situation (eg, getting to the ball first or closing down the distance to an opposing player quicker).[17] In the absence of a difference between the two AF groups, of noticeable importance was the recording of a faster response time in the direction of the tester's movement by the elite compared with the subelite group (split 2 and split 2+3 [Table 1]). Therefore, despite no difference in reactive acceleration, the elite group displayed a superior ability to "read and react" to the testers movements, covering the total test distance significantly faster than their subelite counterparts.[14] This further suggests the importance of decision making and superior cognitive abilities within reactive COD activities performed by AF athletes.[14]

According to Young et al,[2] COD speed and perceptual decision-making factors are the two main components of agility performance. Within adult populations, straight line and COD speed have previously been demonstrated as distinct and specific individual abilities.[1,26,27] Therefore, it can be suggested from the data presented within this study, that AF athletes possess a superior ability to alter movement speed to change direction when reacting to a stimulus, with performance improvements across athletes of a higher competition standard (Table 1). Although we did not measure kinematic movement patterns or the athlete groups' perceptual cues, we suggest that better performance was due to a combination of optimal adjustment of stride pattern and body position, as well as anticipating the opponent's (tester) action by observing postural cue information.[8,12] As a result, the significantly faster test performance of the AF populations, as well as the elite level athletes within the two AF groups, suggests the RAT has specific construct validity to a team sport environment by demonstrating the superior ability of athletes compared with their non sporting counterparts at reading and reacting to an opponent's directional movement changes.

Given the nature of the RAT design and the fact that the participant is responding to someone moving toward them, it should be stated that this test is specific to defensive situations, where future research could look into situations where a stimulus moving away from a person (ie, attacking) might provide different results. Nevertheless, agility training within a sporting environment would benefit from the inclusion of a reactive component that varies in shape and form; eg, a person compared with a stationary pole/object. Displaying parallels to the use of game-based training activities to provide physiological adaptations specific to the game environment,[28] game-based agility training has the potential to assist in the development of decision making and anticipation of both player and ball movements within team sports.[14] In addition, despite measuring different abilities, closed skill COD activities should still be incorporated as a movement training tool within the team sport environment, where improvements in an athlete's ability to decelerate into and accelerate out of a turn will aid in enhancing performance.

In conclusion, even though this study acknowledges only a relatively small population sample was measured within each population group, significant differences were highlighted among the three population groups for performance in the novel RAT design presented. Consequently, at an earlier age and while athletes are still developing in both maturity and skill abilities, this RAT demonstrated how the incorporation of physical demands, perceptual processes and technical skills within a sport-specific agility test can distinguish among talented young athletes. Therefore, although this study has reported the ability to discriminate within AF ranks, future research assessing the longitudinal validity of the RAT protocol in measuring changes over time is necessary.[14,29]

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