Effects of small-sided game and change-of-direction training on reactive agility and change-of-direction speed

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Abstract
The purpose of this study was to determine the effects of training change-of-direction speed and small-sided games on performance in the Planned-AFL agility test and reactive agility. Twenty-five elite-standard U-18 Australian Rules football players were randomly allocated either to a change-of-direction group or a small-sided games group. Players participated in one or two 15-min sessions per week with 11 sessions conducted over a 7-week period during the season. Tests conducted immediately before and after the training period included the Planned-AFL agility test and a video-based reactive agility test specific to Australian Rules football. The reactive agility test variables were total time, decision time and movement response time. The small-sided games group improved total time ($P = 0.008$, effect size = 0.93), which was entirely attributable to a very large reduction in decision time ($P < 0.001$, effect size = 2.32). Small-sided games produced a trivial change in movement response time as well as in the Planned-AFL agility test ($P > 0.05$). The change-of-direction training produced small to trivial changes in all of the test variables ($P > 0.05$, effect size = 0–0.2). The results suggest that small-sided games improve agility performance by enhancing the speed of decision-making rather than movement speed. The change-of-direction training was not effective for developing either change-of-direction speed as measured by the Planned-AFL test or reactive agility.

Keywords: small-sided games, change-of-direction, agility, training

Introduction
Agility is important for many team sports, racquet sports and martial arts. In invasion sports such as all codes of football, agility skill can help an attacker evade opponents to achieve forward movement of the ball and increase scoring opportunities. Agility is also important for defenders to be in a position to either tackle or place pressure on the attacking team with the intention of achieving a turnover of possession. In all football codes, a change-of-direction movement always occurs in response to a stimulus, including movements from other players, and therefore agility can be defined as a rapid whole body movement with change of speed or direction in response to a stimulus (Sheppard & Young, 2006). Change-of-direction movements such as side-steps that are pre-planned without a need to react to a stimulus can be described as change-of-direction speed (Young, James, & Montgomery, 2002). Although such movements are rare in sports competition, it is common for strength and conditioning coaches to prescribe change-of-direction training involving sprinting around obstacles such as poles or cones. Likely attractions of such training are the ability to prescribe the change-of-direction technique and to monitor the number of repetitions performed by each athlete.

Training with either pre-planned or reactive change-of-direction activities is effective for developing change-of-direction speed in various sports (Bloomfield, Polman, O’Donoghue, & McNaughton, 2007; Polman, Walsh, Bloomfield, & Nesti, 2004; Young, McDowell, & Scarlett, 2001), however, the benefits of training with this modality on agility requiring reaction to a stimulus have not been studied. This is probably because sport-specific tests of “reactive agility” have been developed only in the last decade. Reactive agility tests have been designed to assess the speed and accuracy of a defender responding to a change-of-direction movement of an attacker either projected on to a screen (Farrow, Young, & Bruce, 2005; Henry, Dawson, Lay, & Young, 2011; Serpell, Ford, & Young, 2010) or performed by a “live” person (Gabbett & Benton, 2009; Veale, Pearce, & Carlson, 2010; Young & Willey, 2010). Typically, these tests have been shown to possess construct validity because higher-standard athletes perform better ($P < 0.05$) than lower-level athletes (Gabbett & Benton, 2009; Serpell et al., 2010).
Some studies have used both reactive agility and change-of-direction speed tests, and shown that while the reactive tests discriminated between higher- and lower-level performers, the change-of-direction speed tests did not (Gabbett, Kelly, & Sheppard, 2008; Serpell et al., 2010; Young, Farrow, Pyne, McGregor, & Handke, 2011). This suggests that the perceptual and decision-making component of the reactive agility test is very important to performance. This is supported by the finding that when decision time was isolated from the total test time, it was smaller ($P < 0.05$) in the higher-performance group (Farrow et al., 2005; Gabbett & Benton, 2009; Serpell et al., 2010).

Two recent studies on Australian Rules football (Henry et al., 2011; Young et al., 2011) each compared two reactive tests. The first test used video-projected footage of a player changing direction as a stimulus and the other test involved a similar movement but used an arrow (Young et al., 2011) or a flashing light (Henry et al., 2011) to direct the change-of-direction movement. Both studies found that a higher-performance group was better ($P < 0.05$) than a lower-performance group only with the video stimulus. These results indicate the superiority of the higher-performance players occurs when they react to a sport-specific stimulus, and this is likely to be related to their ability to use relevant visual information (cues) to enhance the speed and accuracy of their decision-making.

Small-sided games have become a popular training method for many team sports such as football codes because they have the potential to develop multiple fitness components as well as technical and tactical components (Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011). Most research on small-sided games has focussed on the effect of game design on various aspects of fitness (Hill-Haas et al., 2011) and sometimes technical demands. However, there is a paucity of research on the use of small-sided games to enhance agility. One recent study (Davies, Young, Farrow, & Bahnert, 2013) compared four small-sided game designs to assess the influence of density (field area per player), player number and rules on the agility demands in professional Australian Rules football. A 3 v 3 format produced slightly more agility manoeuvres but there was a considerable variability within the group. Apart from this research using an acute study design, there have been no controlled longitudinal training studies designed to determine the effects of small-sided games on agility performance. Therefore, the purpose of this study was to determine the effects of small-sided games and change-of-direction training on reactive agility and change-of-direction speed performance in elite-junior Australian Rules football players. The outcomes are expected to be useful for coaches who wish to design training to enhance agility performance.

**Methods**

**Participants**

Twenty-five male Australian Rules footballers with mean ± SD age of 17.4 ± 0.7 years, stature 181.5 ± 6.5 cm and body mass 75.8 ± 6.6 kg, were recruited and participated fully in the study. The players were all members of one elite-standard U-18 club that competed in the highest standard of junior competition in Australia. Typically, the best players from this competition are recruited to play professionally in the Australian Football League (AFL). To be eligible for the study, the players had to reside in the town where the study took place and be free of injury and illness. The study was approved by the University’s Human Ethics Research Committee.

**Study design**

The study took place during the early part of the competition season, and involved initial testing to assess change-of-direction speed and agility, then a 7-week training period and finally, testing immediately after training evaluate changes in the test scores. Players were randomly allocated to either a change-of-direction or small-sided games training group. The training was always performed immediately after an initial group warm-up conducted by the club’s fitness staff. The head coach allocated 15 min to the change-of-direction and agility training that was always followed by team-training activities for another 1.25 h. These activities were varied and typically involved elements of Australian Rules football skills including, kicking, marking (catching), handballing and tackling. Locomotion consisted of various combinations of walking, slow-to-fast running, sprinting and some running with changes of direction. Some of these activities involved all players using the entire ground to replicate the demands of competition, and others involved fewer players in smaller areas to target specific technical and tactical aspects of the game.

**Testing**

Two tests were conducted: before and after training. The first test was a change-of-direction speed test described as the Planned-AFL agility test, and involved sprinting around a course defined by 5 poles with changes of direction all greater than 90º (Pyne, Gardner, Sheehan, & Hopkins, 2005; Young et al., 2011). This test was chosen because it is
widely used to assess elite-standard junior Australian Rules football players for talent identification (Pyne et al., 2005), although there were no published reports to describe its reliability. The score was the time taken to cover the course (typically just under 9 s), and the fastest of three trials was retained for analysis. A 2-min passive recovery was allowed between trials. Time was recorded with a Speedlight dual infrared beam electronic light gate system which measured to the nearest 0.01s (Swift Performance Equipment, Brisbane, Australia).

The second test was a video-based reactive agility test, and was similar to a previously used test that has construct validity (Young et al., 2011). The test used in the present study was modified to further enhance ecological validity by using sport-specific agility settings that included multiple players, multiple views, movements such as a fake handball before side-stepping, changing direction immediately after catching the ball, picking the ball from the ground or bouncing the ball before changing direction. A dummy trial involving no change of direction was also included to increase the unpredictability of the task. There was a total of 8 trials with the mean being used for analysis. A similar test using different clips has been shown to have reasonable test and retest reliability to detect moderate changes (Young et al., 2011).

The test started with the participant standing immediately behind a light gate so that the first forward movement triggered the playing of a video depicting one or more players including the ball carrier performing a change-of-direction movement to either the left or right. The video clips were projected from overhead onto a large screen so that the projected players appeared approximately life-sized. Standardised instructions were given to each participant and stated: “You will have 4 practice trials followed by 8 test trials. When the tester is ready, put your foot on the line and stand still. When you move forward and break the beam, the video will show an attacker either moving towards or away from you and he will either change direction to the left or right or run straight. If the ball carrier changes direction to your left, you run through the left gate or if he changes to the right, you run through the right gate as fast as possible. If he runs straight ahead, you just ignore it and make no change-of-direction movement. Do this as fast and accurately as possible as you would in a game. If you make a mistake and run to the wrong side, you must recover by running to the correct gate”. Typically, the participant performed the change of direction about 3 m away from the screen (Figure 1), although this was not controlled to reflect the “open skill nature of agility”. A high-speed video camera was positioned 3 m behind the participant to allow measurement of various phases of the total test.

The total time from the start of the forward movement to the run through the left or right finish gate was recorded by the same electronic timing system used to assess change-of-direction speed. This time was then divided into components as described below.

Decision time: time between the instant the projected ball-carrier planted his foot to change direction to the instant, the tested player planted his foot to change direction. The foot plant refers to the foot of the “outside leg” i.e. the left leg if turning right or the right leg if turning left. This variable is not the true decision time because the decision is made before the final foot plant; however, the final foot plant was used because it is an easily recognisable event. Decision time was determined from

![Figure 1. Set-up of the reactive agility test.](image-url)
high-speed video footage recorded at 125 Hz by a digital camera (Redlake PCI 2000S, Cheshire, CT, USA) positioned behind the player (Figure 1).

Movement response time: time from the instant the tested player planted his foot to change direction to the instant of passing through the finish gate. This was calculated from the equation:

\[
\text{Movement response time} = \text{Total time} - (\text{Stimulus presentation time} + \text{Decision time}),
\]

where stimulus presentation time was the time from when the video started playing (first forward movement) to the instant when the video-projected player planted his foot to change direction.

All testing was conducted indoors in a well-illuminated sports hall on an all-purpose floor with the room temperature controlled at 18–20°C. The players wore shorts, a T-shirt and running shoes, and were instructed to prepare for testing as though they would for a normal training session, for example, adequately hydrated. Players arrived at the test site in pairs and immediately began a 15 min warm-up under the direction of the club’s fitness coach, and consisted of some jogging, dynamic stretches of the leg muscles and some change-of-direction activities. One player was assessed on the Planned-AFL agility test, while the other performed the reactive agility test. At the completion of the tests, the two players were then assessed on the other test. Although the order of testing was not thought to influence the results because of the complete recovery between trials, each individual completed the two tests in the same order for the pre-training and post-training tests. All tests were conducted in the afternoon at the same time as normal training, and this time was the same for both test occasions.

**Training**

The players were randomly allocated either to a small-sided games group \((n = 13, \text{age} = 17.5 \pm 0.8 \text{ years}, \text{height} = 182.5 \pm 5.9 \text{ cm} \text{ and body mass} = 76.2 \pm 6.0 \text{ kg})\) or a change-of-direction group \((n = 12, \text{age} = 17.3 \pm 0.5 \text{ years}, \text{height} = 180.4 \pm 7.2 \text{ cm} \text{ and body mass} = 75.5 \pm 7.5 \text{ kg})\). Training was scheduled 2 times per week, typically on a Tuesday and Thursday over a 7-week period. In 3 of the 7 weeks, training was held only once per week, leaving a total of 11 sessions completed. All training activities were explained by one of the researchers and all sessions were supervised. For both training types, three short-duration programmes were designed within the 7-week period to allow for progression and variety. Apart from the one or two training sessions per week, each player participated in one match on the weekend and a light recovery session the day after the match.

**Change-of-direction training**

The change-of-direction training involved pre-planned movements requiring short maximum effort sprints around various courses defined by cones or poles resulting in 1–5 changes of direction and/or speed. There were 4 activities per session to provide variety, typically with a slow walk-back recovery between repetitions (approximately 15 s). The number of changes of direction per session progressed from 36 at the start of the programme to 48 by the end. In all the activities, the distance sprinted before and after a change of direction was 2–5 m. The activities were designed to practice lateral-cutting movements at varying angles and to incorporate acceleration and deceleration. Most of the activities involved changes of direction less than 90°, as this has been shown to be typical of Australian Rules football games (Dawson, Hopkinson, Appleby, Stewart, & Roberts, 2004). Players performed most of the activities individually but in two exercises, each player performed the prescribed movement pattern next to a partner and raced against him. In one exercise, a football was carried and the change-of-direction movement finished with a kick at goal. The racing was intended to maximise intensity, and use of the football was intended to encourage motivation.

**Small-sided games**

Games involved either 4 v 4 players on a 20 × 23 m field or 2 v 2 players on a 15 × 15 m field. All games were 30–45 s bouts with the same recovery period (1:1 exercise-to-rest ratio). Disposal of the ball was only with handballing, with no kicking allowed. In the first game (four sessions), a maximum of four handballs was allowed after which an attacker had to attempt to evade an opponent, therefore encouraging agility skill. Limiting the number of handballs was employed because previous research (Davies et al., 2013) showed professional players preferred to handball rather than evade an opponent in similar games. A turnover occurred after a two-handed tag (no tackling). Scoring was by running with the ball into a 5 m-wide scoring zone at either end of the field. In the second game (next four sessions), scoring occurred only when a ball-carrier attempted to evade his opponents, therefore further encouraging repetitions of agility. The final game (three sessions) involved a 2 v 2 format with the same team maintaining possession for the duration of each bout.
(30 s). This ensured all players had equal time defending and attacking. In games two and three, full tackling was allowed.

While the number of change-of-direction movements was controlled for the change-of-direction training group, this was not possible for the small-sided games group. Therefore, to get an indication of the number of agility manoeuvres (volume), one session of each of the three games was videotaped with the camera (Panasonic, SHR-H80, Osaka, Japan) set up to view all players throughout the entire game. The recorded footage was later analysed to count the number of agility events according to the definitions of Davies et al. (2013). Briefly, an agility event was counted for an attacker or a defender producing a maximum or near-maximum deceleration or change of direction to influence a contest. This procedure for counting agility events was found to have adequate inter-rater reliability (Davies et al., 2013).

Statistical analyses

Group responses to the training were compared via a mixed-design factorial analysis of variance. Changes from training in each outcome measure for each group were also analysed with paired t-tests, with statistical significance set at 0.05 for both tests. Effect sizes for the differences between the means (difference/pooled standard deviation) were calculated with descriptors of “trivial” for 0–0.19, “small” for 0.20–0.59, “moderate” for 0.60–1.19, “large” for 1.20–1.99 and “very large” for 2.00–4.00 (Hopkins, 2012). It was hypothesised that the small-sided games group would achieve greater gains in reactive agility performance than the change-of-direction group because of the inclusion of the decision-making element of the agility training.

Results

The mean number of training sessions completed by all players was 9.6 out of a maximum of 11, indicating a good compliance (87%). The difference between the groups in the number of training sessions completed was trivial (1%, P = 0.71).

The means ± SD results for all the test variables are shown in Table 1. The Analysis of Variance revealed a group × time interaction for total time (P = 0.025) and for decision time (P = 0.002) in the reactive agility test, which indicates that the improvements in these variables for the small-sided games group were greater than the change-of-direction group (P < 0.05). Paired t-tests confirmed that for total time, the change-of-direction group produced a trivial change (effect size = 0, P = 0.941), whereas the small-sided games group
Table II. Number of agility manoeuvres for the change-of-direction group and estimated for the small-sided games group.

<table>
<thead>
<tr>
<th>Programme/Game</th>
<th>Change-of-direction</th>
<th>Small-sided games</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Maximum</td>
</tr>
<tr>
<td>1</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>2</td>
<td>47</td>
<td>47</td>
</tr>
<tr>
<td>3</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>Programme mean</td>
<td>43.7</td>
<td>43.7</td>
</tr>
</tbody>
</table>

Achieved a moderate 3.8% improvement in performance (effect size = 0.93, \( P = 0.008 \)). Similarly, the change-of-direction group demonstrated a trivial improvement in decision time (effect size = 0.16, \( P = 0.383 \)), compared with a very large 31% improvement for the small-sided games group (effect size = 2.32, \( P < 0.001 \)). Some improvement in decision time was achieved by 100% of the small-sided games players, whereas only 58% of the change-of-direction group improved in this variable. There were trivial-to-small changes in movement response time and in the Planned-AFL agility test for both groups (\( P > 0.05 \)) (Table I).

The number of agility manoeuvres per player per session performed in training was the same for all players within the change-of-direction group, whereas the number for the small-sided games group was estimated from video analysis (Table II). These results indicate more agility manoeuvres were performed by the change-of-direction group.

Discussion

An important and novel finding of this study was that agility performance as measured by total time was improved from small-sided games training (\( P < 0.05 \)), but not from the change-of-direction training. The results indicate that the improvement in agility performance in the small-sided games group was entirely due to the very large improvement in decision time, since there was no improvement in movement response time. Compared with other studies (Henry et al., 2011; Serpell et al., 2010), the decision times were longer, which probably reflects the high cognitive complexity of the reactive task in this study. Nevertheless, it is likely that the ability to make a faster decision when reacting to an attacker’s change-of-direction movement was a result of practice during the small-sided games training.

It is noteworthy that the mean number of agility manoeuvres for the small-sided games training was estimated to be about 25 per session per player, over an average of 9.6 sessions. Since this is not a large dose of decision-making practice, it appears that small-sided games provide a powerful training stimulus to enhance decision-making speed. This observation is in agreement with previous research on professional rugby league players (Serpell, Young, & Ford, 2011), which showed that 6 sessions of 15 min duration of video-based reactive agility training resulted in a shorter decision time (\( P < 0.05 \)), than the trivial change in a control group. Although the football players in this study could have been exposed to contests requiring agility in matches and some team training activities, these activities probably do not provide as much of a concentrated dose of perceptual and decision-making skill, than the small-sided games used in the present study, which were designed to increase the number of agility events. It is also possible that some players avoided “taking on a man” in competition play by quickly disposing of the ball (Davies et al., 2013), and therefore experience less agility exposure. Possibly, low doses of concentrated reactive agility training from small-sided games are especially beneficial to such players.

However, the limited dose of agility training in the small-sided games group was probably not enough to induce a meaningful change in movement time. This may be explained by participants typically performing many short sprints with changes of direction in normal training and football matches, and therefore the additional exposure during the 7-week intervention was not enough to induce any additional adaptations. This could also explain why the small-sided games training had no effect on the Planned-AFL agility test (\( P > 0.05 \)), which involved change-of-direction movements, but no decision-making.

Although the mean number of agility manoeuvres for the small-sided games was estimated to be about 25, this varied for different players. The maximum and minimum values were 34 and 14, respectively, which suggests that each individual did not experience the same agility demand. This inter-player variability was also described by Davies et al. (2013), who used similar games with professional Australian Rules football players. Despite the varied demands, it is noteworthy that all players in the small-sided games group achieved at least some improvement in decision time.

The change-of-direction training produced trivial-to-small changes in the Planned-AFL agility
test and the reactive agility test variables ($P > 0.05$). This was despite the greater dose of change-of-direction activity (about 44 change-of-direction movements per session per player) compared to the small-sided games group. This strengthens the suggestion that a much greater change-of-direction training load is needed to produce positive adaptations when athletes are already performing a considerable volume of this type of activity. Another reason for the lack of improvement in change-of-direction performance for both groups could be the nature of the Planned-AFL agility test. This test involves 5 changes of direction around poles with all of them being well over $90^\circ$. The change-of-direction training designed for this study generally involved changes of direction that were less than $90^\circ$, because this is typical in professional Australian Rules football matches (Dawson et al., 2004). Therefore, it is possible that the test simply did not reflect the training and game change-of-direction demands. This suggestion is supported by a finding that the Planned-AFL agility test has been shown to not discriminate higher- and lower-level footballers, whereas a reactive agility test did. (Young et al., 2011).

A limitation of this study was a lack of clear evidence for the reliability of the change-of-direction and agility tests used. Although widely adopted, the Planned-AFL agility test has not been evaluated for test–retest reliability. A previous version of the reactive agility test (Young et al., 2011) did not demonstrate very high reliability. The test used in the present study involved measuring the mean of an additional two trials; that is 8 trials in total. This greater number of trials could improve the reliability of the variables generated, but this needs to be assessed in future research.

### Conclusion and practical applications

This was the first study to determine the effects of small-sided games specifically designed to train agility on change-of-direction and reactive agility performance. Approximately 10 sessions of 15 min duration were performed in-season by elite-standard U-18 Australian Rules footballers. The small-sided games training produced a moderate improvement in agility performance ($P < 0.05$), as measured by a reactive agility test, and this was exclusively attributable to a very large gain in decision-making speed rather than movement speed. Based on these results, small-sided games are recommended to enhance reactive agility, provided the games are designed carefully to encourage evasive skills. A challenge for coaches is to develop games that provide a fairly consistent training stimulus to all participants. This may be achieved by using a small number of players (e.g. 3 v 3), so that consistent involvement is more likely, and also by encouragement from coaches.

The change-of-direction training group obtained no meaningful changes in either the Planned-AFL agility test or any of the reactive agility test variables, indicating that this training was ineffective at enhancing the qualities assessed by these tests and/or the dose provided an inadequate stimulus. The lack of sensitivity of the Planned-AFL agility test to change-of-direction training suggests this test should not be used as a tool for assessing change-of-direction speed in Australian Rules football.

### References


