Are the Perceptual and Decision-Making Components of Agility Trainable? A Preliminary Investigation

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Abstract

Serpell, BG, Young, WB, and Ford, M. Are the perceptual and decision-making components of agility trainable? A preliminary investigation. *J Strength Cond Res* 25(5): 1240–1248, 2011—Agility is an open motor skill; requiring change of direction speed (CODS) and perceptual and decision-making ability. The aim of this study was to determine whether the perceptual and decision-making component of agility can be trained. Fifteen rugby league players were tested on a sport-specific reactive agility test (RAT) and a CODS test. Players were then allocated to a training group ($n = 8$) or a nontraining group ($n = 7$). The training group underwent 3 weeks of reactive agility training that was designed to enhance perceptual and decision-making ability. After 3 weeks, all players were tested again. The training group's mean reactive agility time was 1.92 ± 0.17 seconds preintervention and 1.66 ± 0.14 seconds postintervention. The nontraining group's mean reactive agility time was 1.89 ± 0.16 and 1.87 ± 0.15 seconds, respectively. Mean CODS time for the training group was 1.64 ± 0.15 seconds preintervention and 1.66 ± 0.14 seconds post-intervention. The nontraining group's mean CODS time was 1.61 ± 0.12 and 1.62 ± 0.12 seconds. Mean perception and response time for the training group, measured on the RAT, was 0.33 ± 0.33 seconds preintervention and 0.04 ± 0.22 seconds postintervention. The nontraining group's values were 0.34 ± 0.20 and 0.27 ± 0.28 seconds, respectively (results are $\pm\sigma$). Differences in mean reactive agility time and perception and response time from pre to postintervention for the training group were statistically significant, as were differences in those values between the training and nontraining group post intervention. All other comparisons were not. Results from this study suggest that the perceptual and decision-making components of agility are trainable. Coaches should incorporate some open motor skills training in their programs when training agility.

Key Words anticipation, reaction, rugby, football

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Introduction

Agility is a fitness quality required for most field sports. However, unlike other components of fitness, the best way to train agility remains unclear (36). This may stem from the fact that agility is a fitness quality that is poorly understood.

Agility has traditionally been defined as speed in changing direction. However, recently, it has emerged that agility requires perceptual and decision-making skills also (see Figure 1) (4,5,7,26,27,36–39). Consequently Sheppard and Young (26) have 'redefined' agility by describing it as "a rapid whole body movement with change of velocity or direction in response to a stimulus" (p. 922).

Training methods for agility have typically focused on its physical qualities. Thus, with varying success, conditioners have implemented various speed drills in their programs; have aimed to improve strength and power in an attempt to facilitate improvements in acceleration and deceleration; and have used plyometrics to improve reactive strength (6,16,21,26,29,35–39). These methods of training assume that agility is a closed motor skill. A closed motor skill is executed in a stable environment and can be preplanned. If agility was simply speed in changing direction, then those methods of training alone might be adequate. However, according to Sheppard and Young's definition, agility is an open motor skill (26). That is, agility is a skill executed in a constantly changing environment or in response to an unpredictable stimulus, requiring constant adaptation by the performer and therefore perceptual and decision-making ability, and ability to react quickly. Therefore, it may be argued that agility training should incorporate some form of open motor skill training focusing on the perceptual and decision-making elements of agility.

Research describing the trainability of the perceptual and decision-making elements of agility has not previously been published. It has been argued that skills learnt through short-sided

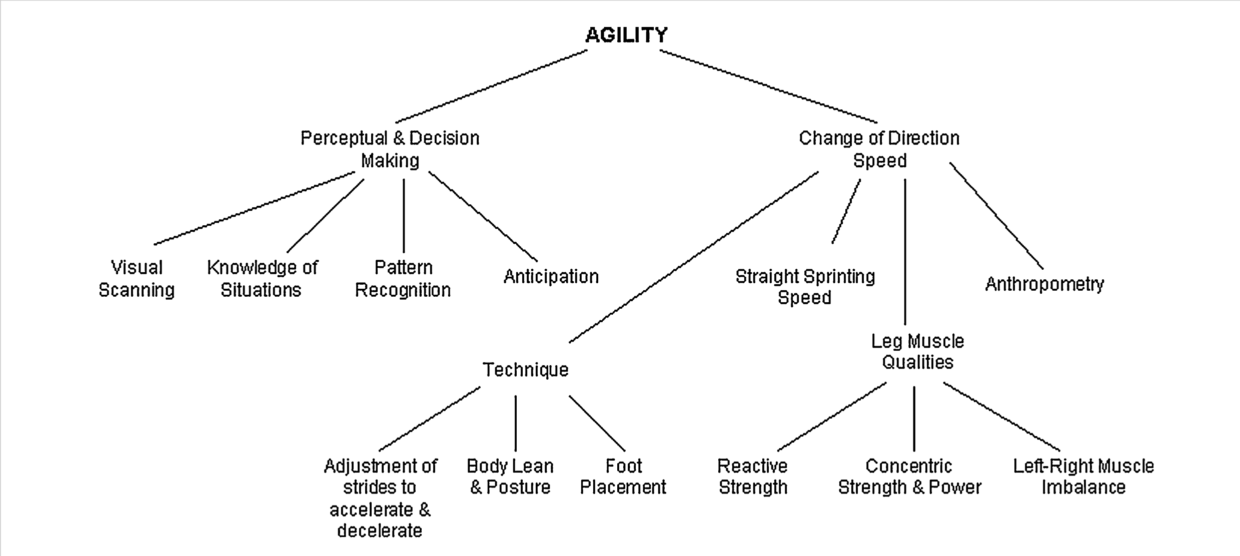

Figure 1. Model of agility (38).

conditioning games are transferable to the playing environment and that engagement in conditioning games can protect against injury (10,12). However, no published research has specifically measured whether the perceptual and decision-making elements of agility can be trained; it has simply been implied. Thus, although results from studies that have investigated the effectiveness of conditioning games offer some reason to suggest that the perceptual and decision-making components of agility are trainable, to conclusively argue that this is the case, the effectiveness of a specific open motor skill training program that focuses on developing perceptual and decision-making skill(s) should be determined.

Specific open motor skills training for perceptual and decision-making skills can be complex because the optimal learning conditions are likely to be task and context dependent (3,17,19,23). Different motor skill training programs typically involve different proportions of explicit and implicit learning (3,8,17–19,22–24,28,31,33,34). Explicit learning requires specific instruction about how to develop a skill (3,8,17,22,23,33), typically resulting in the performer being able to verbalize the skill they have acquired; a quality that is desired when the human motor apparatus becomes impaired (i.e., fatigued, injured, etc.) (3,8,17,19,20,22,23,33). Conversely, implicit learning occurs when task performance improves in the absence of explicit knowledge of how to perform that task; it is said to be more psychologically robust under mentally stressful conditions (e.g., time pressure) (3,17,19,20,22,34). Whether perceptual motor skill training in sport should be predominantly explicit or implicit in nature remains unclear (3,15,17,30,33). However, it has been argued that for complex motor tasks (e.g., execution of agile maneuvers), motor skill training involving a greater proportion of explicit learning is most effective, especially if expediency in learning is required (3,22,23,28). One such approach is guided discovery learning (3,17,19,23,28).

In guided discovery learning, the learner is 'directed' to an information-rich source. One benefit to guided discovery learning is that it involves a high proportion of explicit learning because the learner is given instruction and also a small proportion of implicit learning because the learner is not given specific detail. Therefore, it facilitates expediency in learning and also psychological robustness. A guided discovery approach to training open motor skill in sport has previously been described by Smeeton et al. (28) and Gabbett et al. (13) in tennis and softball populations, respectively. In Smeeton et al.'s study (28) with a tennis population, each learning trial consisted of 2 parts. Firstly, participants were shown a life-size video of an opponent returning a ball and were told to respond to the video as quickly as possible by moving to the left or right, depending on the anticipated direction of the ball. The video was occluded at racket ball contact. Upon completion of that task, participants in the guided discovery group were given some general verbal instruction about where to direct their attention (e.g., look at racket swing). In the second part of the learning trial, participants were shown a life-size video of the same shot and were told to respond the same way. However, the second video differed from the first because it was not occluded, and consequently, participants were able to see the outcome of the shot. Thus, with this methodology, instruction on what to look for was withheld on the first task so that responses were left to individuals' visual tracking ability and because the clips were occluded before the outcome of the return strike was seen, it also relied on their innate ability to identify important kinematic advance cues that would influence shot direction. The instruction between efforts advised participants on the location of advance cues (i.e., kinematic cues). That is, these instructions were explicit in nature, and they 'directed' participants to an information rich source. Finally, repeating the effort and having the ability to see the outcome of the return shot provided feedback on the success of their initial prediction of return shot direction and ultimately enabled participants to draw some relationship between advance cues and shot outcome. Development of this relationship may have been implicit in nature. This approach was shown to be effective in reducing decision time. In Gabbett et al.'s (13) study with a softball population, a similar methodology and results were observed.

Based on results from the studies by Smeeton et al. (28) and Gabbett et al. (13), it seems reasonable to assume that a guided discovery approach to training agility would facilitate improvements in perceptual and decision-making skills for agility. However, when designing a motor skills training program, it is important that the proportion of implicit and explicit learning be considered, and being aware that the effectiveness of any motor skills training program may be questionable if the visual–perceptual components of a task are trained separately to the movement required. Research has shown that by separating perception from action, the superiority that experts have over novices in executing skill is removed because it is the coupling of perception and action that is crucial to performance, not one or the other. It has also been argued that by separating perception from action, the sport specificity of the task becomes questionable, thus so does the external validity (9,17,24,30). Therefore, when training agility as an open motor skill, maintaining the link between change of direction speed (CODS) and the perceptual and decision-making components of agility might be beneficial.

The aim of this study was to use a guided discovery intervention similar to Smeeton et al.'s (28) and Gabbett et al.'s (13) and combine perception with action to determine whether or not the perceptual and decision-making components of agility are trainable. This approach was adopted as opposed to other practical methods, such as small-sided conditioning games or unplanned agility drills, because it was believed more likely to result in a measurable difference in perceptual and decision-making skill after intervention. A sport-specific reactive agility test (RAT) for rugby league with sufficient validity and reliability was used to measure perception and response time and CODS and reactive agility time pre and postintervention. The test has been described elsewhere (25).

Methods

Experimental Approach to the Problem

A pretest posttest control group experimental design was adopted for this study. A group of semiprofessional rugby league players were recruited to this study, and approximately, half of those athletes were allocated to a training group and half were recruited to a control group. Both groups were tested on a rugby league–specific RAT and a CODS test. The training group then undertook 2 sessions of reactive agility training each week for 3 weeks. A perception action guided discovery approach was adopted for reactive agility training. The control group did not undergo any extra agility training. Both groups were tested on the RAT and CODS test after the 3-week training period.

Subjects

Fifteen participants were independently and randomly sampled from an Australian National Youth Competition (NYC) rugby league team. The NYC is the under 20's national competition in Australia. It is considered a development pathway to National Rugby League (NRL). The NRL is arguably the most premier rugby league competition in the world. It is not uncommon for NYC players to also represent their respective teams in the NRL in the same season. All players who compete in the NYC are fulltime athletes.

Eight participants were allocated to the training group, 7 were allocated to the control group. Rugby league players can be categorized as belonging to 1 of 4 playing groups–props, halves and hookers, back rowers, and the outside backs (11). To accurately reflect the different playing groups in each experimental group, the same number of participants from each playing group was randomly allocated to the training group and the control group with the exception of the back row playing group; the training group had 1 more back rower than the control group. Randomization was achieved using an online randomization tool (14).

Procedures

Ethical approval for this project was granted by a University Human Research Ethics Committee for use of human subjects. All participants were informed of the experimental risks associated with this project before involvement. All participants were 18 years of age or older and signed an informed consent document consenting to voluntary participation.

After approval to conduct research using human subjects by the ethics committee, training video clips were constructed and 'rules'for instruction were developed so that a guided discovery training program similar to that of Smeeton et al. (28) and Gabbett et al. (13) could be implemented. After construction of training video clips and the development of rules subjects were recruited and, before and immediately after intervention, were tested on a rugby league–specific RAT. Details of testing procedures and dependent variables are outlined later in the 'procedures' section of this paper following details of 'construction of video clips,''rules for training video clips,' and details of 'reactive agility training.'

Construction of Training Video Clips. Four players from a first grade NRL team who play in the 'outside backs' playing

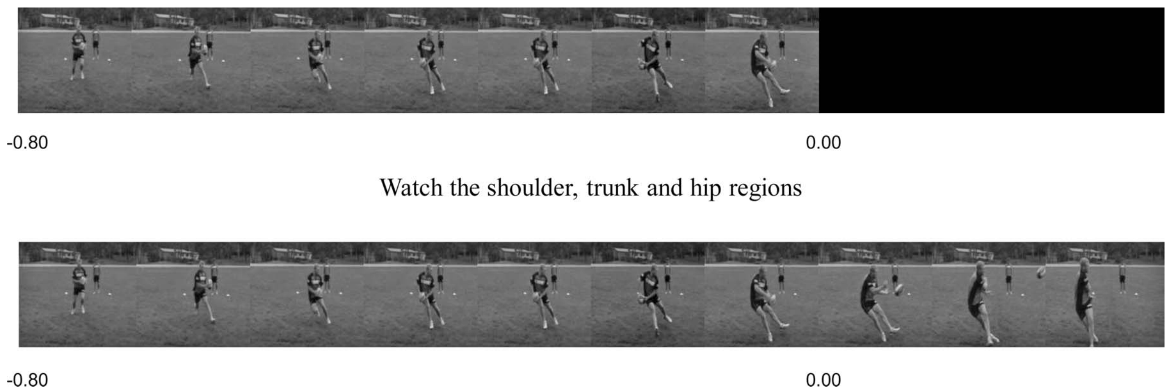

Figure 2. An example of the videos seen and the instructions given for each reactive agility training drill.

group or as one of the 'halves' assisted with creating the testing video clips.

Video clips were constructed using a Sony HDV Handycam digital video camera (New Jersey, USA) capable of recording at 50 Hz. Video clips were recorded on a rugby pitch on an overcast day. 'Actors' wore rugby boots and their training uniform. The camera was positioned 16 m in front of the actors at a height of 1.50 m. Each of the actors was asked to run toward the camera and approximately 6 m away from the camera, execute a movement similar to what they would in a game. The actions they were asked to complete were as follows: (a) change direction by 45° to the left while holding a ball; (b) change direction by 45° to the right while holding a ball; (c) change direction by 45° to the left and pass the ball left; (d) change direction by 45° to the right and pass the ball right; (e) change direction by 45° to the left and pass the ball right; (f) change direction by 45° to the right and pass the ball left; (g) fake right and change direction by 45° to the left while holding a ball; (h) fake left and change direction by 45° to the right while holding a ball; (i) fake right, change direction by 45° to the left and pass the ball left; (j) fake left, change direction by 45° to the right and pass the ball right; (k) fake right, change direction by 45° to the left and pass the ball right; and (l) fake left, change direction by 45° to the right and pass the ball left.

Therefore, a strength of this study was that a variety of sport-specific scenarios was captured on video for training. Furthermore, scenarios 7–12 involved some deception.

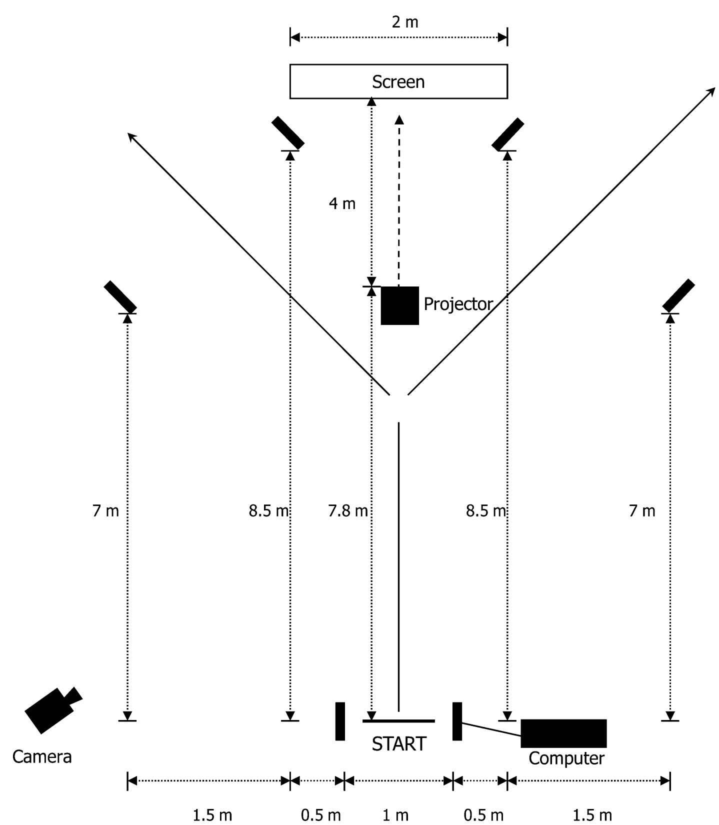

Figure 3. The rugby league reactive agility test (RAT) (25).

Forty of the 48 video clips collected were randomly selected to be used as training clips using an online randomization tool (14). All video clips were edited using Dartfish software (version 4.5.2.0) so that they started playing 0.80 seconds before ball release in the videos where the ball was released. In the videos where the ball was not released, videos were edited so that they started playing 0.80 seconds before the actor's first definitive foot strike initiating a change of direction. A copy of all 40 video clips was then made. The copied videos clips were edited again so that in the clips where the ball was released the video was occluded with a black screen at ± 0.00 seconds of ball release. In the copied videos where the ball was not released, the video was occluded at ± 0.00 seconds of the actor's first definitive foot strike initiating a change of direction (see Figure 2 for an example training clip).

Rules for Training Video Clips. Rules were identified from a review of sport science literature that discussed key areas of the visual display used by athletes from other field sports (22,24,32,33). Coaching staff and former and current players from an NRL team were then consulted and presented with those rules for discussion. It was concluded that players should be instructed to focus on the shoulder, trunk, and hip regions of the attacking player in the video clip.

Reactive Agility Training. Participants in the training group undertook 2 reactive agility training sessions per week for 3 weeks. Training was implemented in the final 3 weeks of the NYC preseason for season 2008 and took place on a hard surface indoors. Participants wore their training uniform and their choice of footwear. Reactive agility training sessions were used as a warm-up for participants' first training session for the day after a day off.

Each reactive agility training session involved participants completing 10 perception-action guided discovery reactive agility drills per session. Each session lasted approximately 15 minutes per player. All perception-action guided discovery-training drills had 2 parts. In the first part, participants were presented with one of the occluded video clips (previously described) on a 2- × 2-m screen. Participants were instructed to run toward it as soon as the tester started playing the clip and react to the video by changing direction as they would in a typical game situation. Upon completion of the first part, participants in the training group were instructed to focus on the shoulder, trunk, and hip regions of the attacking player in the video clip. In the second part, participants completed the same drill a second time watching the same attacking opponent; however, this time the video was unoccluded. Figure 2 provides an example what the participants were asked to react to as they ran toward the screen. At the commencement of each training session, the 10 training clips were randomly selected from the 40 video clips constructed using an online randomization tool (14). The video clip was projected on the screen with a Sanyo PLC-XU48 video projector. Video clips were played through Microsoft Windows Media Player.

All participants were 100% compliant with the reactive agility training.

Players in the nontraining group undertook a 'normal' warm-up before their normal scheduled training session that

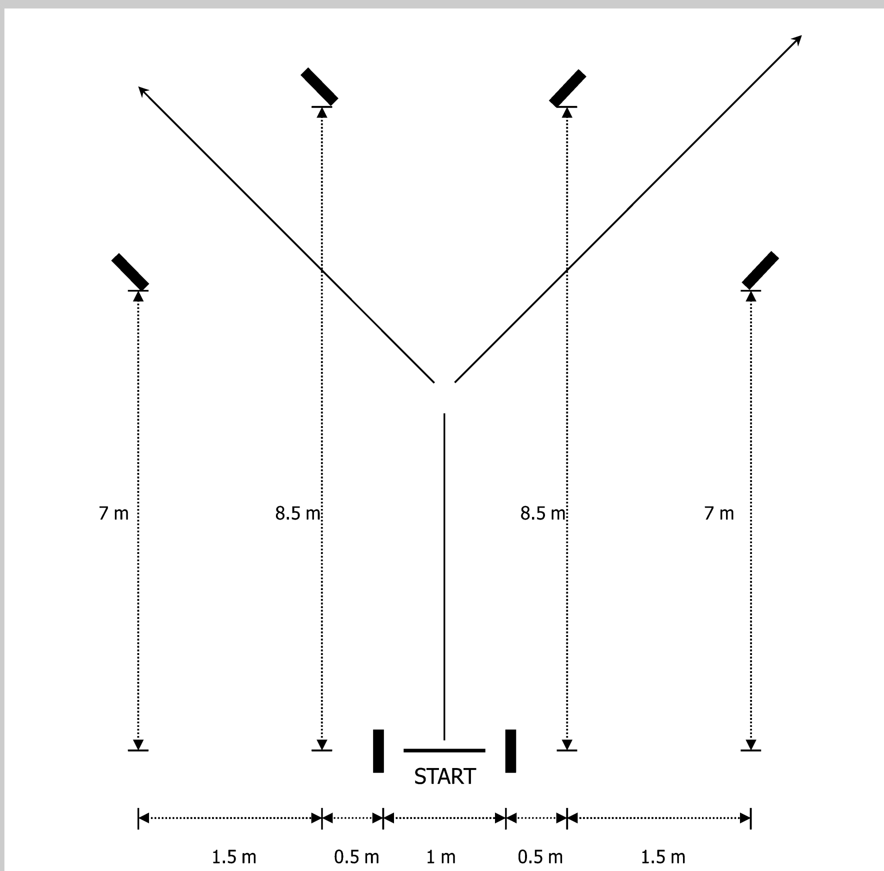

Figure 4. Change of direction speed test (25).

was directed by their conditioning coach. This involved engaging in some prehabilitation exercises and completing the first set of prescribed exercises they were completing at submaximal intensity.

Pre and Posttraining Tests. All participants completed a rugby league–specific RAT and CODS test 3 times–firstly as a familiarization test; secondly, 1 week later as a preintervention test; and finally, a further 3 weeks later as a postintervention test. Testing was undertaken on a sprung wooden floor before participants' first training session of the week (after a 2-day weekend). Participants wore their training uniform with their choice of footwear. The reliability and validity of the RAT and CODS test have been discussed elsewhere (25). See Figure 3 for a schematic of the RAT.

In summary, players commenced the RAT in their own time starting the test by running through a set of swift dual beam light gates. The starting gate was interfaced with an ASUS M6000 laptop computer loaded with purpose built software designed to start playing 1 of 8 test video clips when the infrared beams of the light gate was broken. Test video clips were occluded with a black screen at a similar point to that described previously in the 'construction of training video clips' section of this paper. A Sanyo PLC-XU48 video projector projected the video on a 2- × 2-m screen that was placed in front of the athlete being tested. Thus, as players ran through the starting light gate a life-size video of an attacking opponent started playing. Participants were instructed to respond to the video as they would in a normal game situation. Eight trials on the RAT were completed per person. All participants saw the same 8 test videos. Video clips were played in a different random order for each player. To ensure that they were not simply guessing their responses, at the end of each trial, participants were asked to rate their level of confidence about the decision they made on a 10-cm visual analog scale. All RAT trials were recorded on video using a Sony HDV Handycam digital video camera capable of recording at 50 Hz.

After completion of 8 trials of the RAT, participants completed 6 trials of the same test under CODS conditions (see Figure 4). They completed the test with no video projected on the screen. Instead, participants were simply instructed on which direction change to make

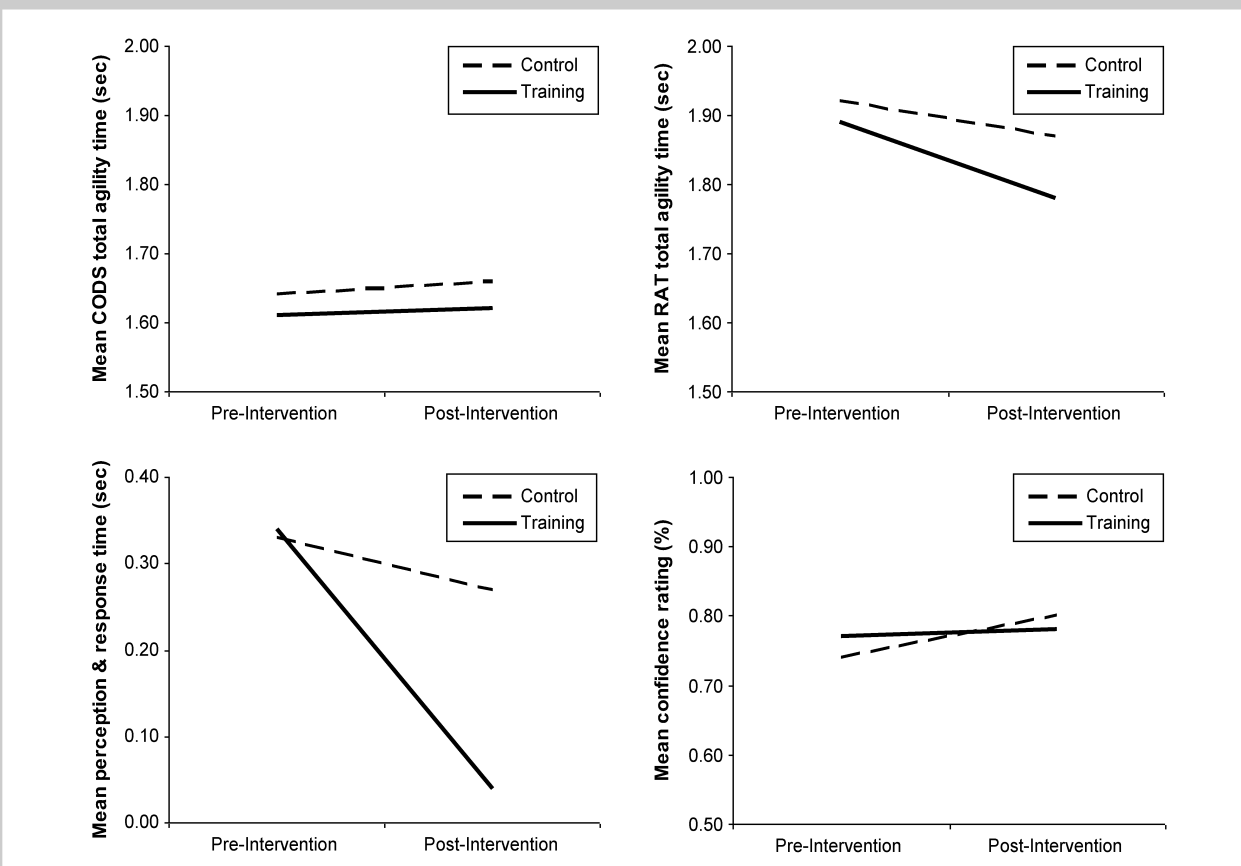

Figure 5. Mean total agility time for change of direction speed (CODS) test and reactive agility test (RAT) pre and postintervention and mean perception and response time and confidence rating pre and postintervention.

Table 1. Comparison of test results pre and postintervention for the control and training groups.*†

Measurement	Control pre ($n = 7$)	Control post ($n = 7$)	Training pre ($n = 8$)	Training post ($n = 8$)
Change of direction speed test total agility time (s)	1.64 ± 0.15	1.66 ± 0.14	1.61 ± 0.12	1.62 ± 0.12
RAT total agility time (s)	1.92 ± 0.17	1.87 ± 0.15	1.89 ± 0.16	1.78 ± 0.11‡§
RAT perception and response time (s)	0.33 ± 0.33	0.27 ± 0.28	0.34 ± 0.20	0.04 ± 0.22§
RAT confidence rating (%)	73.95 ± 32.92	80.48 ± 31.97	77.39 ± 30.81	78.25 ± 31.81

*RAT = reactive agility test.
†Values are means ± *SD*s.
‡Significantly different to control group pre and postintervention ($p < 0.05$).
§Significantly different to preintervention ($p < 0.05$).

before commencement of each trial. The direction change was made 5 m from the start line, the approximate distance players changed direction under RAT conditions. The change of direction was alternated and an even number of changes of direction to the left and to the right were made.

Dependent Variables. In the RAT and CODS test, total agility time was recorded as the time taken to complete the respective tests. The time taken for a participant to perceive the on screen opponent's attacking action combined with the time taken for that participant to initiate a response was their perception and response time. Perception and response time was measured by post hoc analysis of video recordings of players completing the RAT and was considered the time between occlusion of the video clip to the participants' first definitive foot strike initiating change of direction. Time was measured by counting frames between video occlusion and participants' foot strike and multiplying by the duration of each frame (0.02 seconds).

Players' response on the visual analogue scale was recorded as their confidence rating. A mark on the visual analog scale at 7 cm, for example, indicated a player's decision was made with 70% confidence.

Statistical Analyses

All assumptions required for parametric statistical analyses were satisfied for RAT total agility time and perception and response time for both the training and nontraining group's pre and postintervention. Therefore, a 2-way analysis of variance with Tukey's HSD post hoc analysis was performed to determine if and where a statistically significant difference existed in mean RAT total agility time and mean perception and response time between groups pre and postintervention and within groups pre and postintervention. The assumptions required for parametric statistical analysis were not satisfied for CODS test data and confidence rating data. Therefore, Mann–Whitney *U* tests were performed on test data for those variables to determine if any statistically significant difference existed between groups pre and postintervention. Wilcoxon's were applied to determine if any statistically significant differences existed within groups pre and postintervention.

Results

Figure 5 provides a graphical summary of the results obtained from the control and training groups on the RAT and the CODS test both pre and postintervention.

Table 1 shows descriptive statistics for mean total agility for the CODS test and the RAT, and mean perception and response time and confidence rating from the RAT for the training and the control group pre and postintervention.

Figure 5 and Table 1 show that there was no significant difference in means for any dependent variable between the training and control group preintervention. However, after intervention, the training group's mean total agility time and perception and response time on the RAT improved significantly, whereas the control group's did not. There was no significant difference in mean total agility time on the CODS test and RAT confidence rating within groups from pre to postintervention or between groups post intervention.

Discussion

The aim of this study was to determine whether or not the perceptual and decision-making components of agility are trainable. The results indicate that these components can be trained. It was seen that mean RAT total agility time improved significantly in the training group but not in the control group. A significant improvement in mean perception and response time was also seen in the training group but not for the control group. However, there was no significant difference in mean CODS between pre and postintervention tests for either group. Finally, mean confidence rating for both groups pre and postintervention was greater than 50% (a confidence rating of 50% would indicate responses were left to chance (8,18,25)). Therefore, it is reasonable to assume that differences in performance on the RAT for the training group postintervention can be attributed to improved perception and, as a consequence, ability to respond earlier. That is, consistent with sports science literature, reactive agility improvements were likely related to players improved ability to identify advance kinematic cues (1,2,8,25).

It could be argued that improvements in RAT total agility time for the training group were related to test familiarity. However, no video clip used in training was used in the RAT; training took place in a different environment to the testing environment; and all participants were given a familiarization session before pre-intervention testing. Furthermore, there was no change in mean CODS for the training or testing group post intervention. These points suggest that the training group's improvements were not likely because of test familiarization. This notion is supported by Abernethy et al. (1) who used a similar methodology and argued that because a range of video clips were used and because the clips used in the test differed from those used in training, skills learned were generic and could not be related to test familiarity. A similar observation was made in a study by Farrow and Abernethy (8). Thus, it can be assumed that perception and response time, and subsequently RAT, improvements were because of generic skill acquisition and not related to test familiarity. The significance of this is particularly great because the test and training video clips used in the present study involved some deception (a full list of actions executed by actors in the methodology section of this paper). Therefore, it appears that it is possible that athletes can be trained to identify even the most subtle advance kinematic cues even when their opponents are trying to deceive them.

Although the present study has shown that agility can be improved by training the perceptual and decision-making components of agility, further research into training those perceptual skills from a more practical sense is required. This study does not give any insight into an athlete's ability to transfer skills learnt in a laboratory setting to the field. Identifying the extent to which this can be done is important as perception can be influenced by many other factors such as playing conditions, sounds, color, brightness, etc. Equally important would be research to identify how long those skills are retained after training or if the type of training needs to be altered for optimal learning conditions or if more practical methods, such as conditioning games or unplanned agility drills, can be effective. It may be that unplanned agility drills and conditioning games could be equally effective, especially if combined with some instruction similar to what was used in the present study. The notion of using conditioning games or unplanned agility drills is supported by previous work that has shown that skills learned from conditioning games transfers to the playing environment and result in athletes being less likely to injure (10,12). However, no research, specifically related to agility, investigating the effectiveness of combining conditioning games or unplanned agility drills with instruction has been published.

The methodology used in the present study for developing rules for instruction for those undergoing perceptual skills training may be considered only an educated guess about the key kinematic cues. More accurate measures that have been adopted in previous studies include the use of liquid crystal glasses (1) or adopting video-based temporal occlusion methodology (18). Nevertheless, because the present study resulted in improved agility performance after instructing participants to focus on the shoulder, trunk, and hip regions, it is likely that 1 or more of these areas are a source of important advance kinematic cues.

Despite some limitations, this paper provides solid evidence to support the theory that the perceptual and decision-making elements of agility can be trained. It has also highlighted that further research examining the ability to transfer skills from laboratory-based settings to the field, research identifying optimal, and/or more practical training methods for training perceptual skills, and research into the identification of sources containing important advance kinematic cues might be beneficial (despite the fact that this study has shown that the hip, trunk, and/or shoulder regions are likely to be a source of information). Furthermore, as this study has shown that training perceptual skill for agility is possible, and evidence from previous work has shown that skilled athletes are less susceptible to deceptive movements (18), then research to identify what agile maneuvers are more deceptive and how those deceptive movements can be trained might also be useful.

Practical Applications

This study has contributed to the theory that agility is an open motor skill and so, to some degree, it should be trained as an open motor skill. Using technology, and adopting a guided discovery perception action approach, the study proved that athletes' perceptual and decision-making ability for agile maneuvers can be trained. That is, it has shown that it is possible to develop an athlete's ability to identify kinematic cues from their opponents and react earlier. However, despite being proven successful, motor skills training programs for agility such as the one described in this paper may not always be practical. It may be possible to train the perceptual components of agility through the use of conditioning games and/or unplanned agility drills. This notion is supported by research papers that have argued that skills learnt while engaging in skill-based conditioning games can transfer into the playing environment and that athletes who engage in skill-based conditioning games are less likely to get injured (10,12).

Acknowledgment

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