COPYRIGHT NOTICE

Blinded

Title: The importance of a sport-specific stimulus for training agility

Key words: agility, stimulus, training, perception and decision making

Lead summary: The purpose of this article is to review recent evidence to help guide the training of agility. Agility skill usually involves reacting to a stimulus before performing a movement with a change of direction or velocity. Research has shown that better performers can be distinguished from lower skilled athletes by the ability to quickly and accurately react to opponent's movements, but not to a generic stimulus such as a flashing light. Therefore training for agility should include a perceptual and decision making component involving reacting to movements of others, and this may be accomplished with evasive drills or small-sided games.

Introduction

Traditionally agility has been described as the ability to change body direction and position rapidly (8).This view of agility was extended by Chelladurai in 1976 (5) who described the perceptual and decision making component of agility. In 2002 a deterministic model was proposed which defined agility as including a change of direction (COD) speed component encompassing technical, strength and power factors, as well as a perceptual and decision making component (28). More recently the definition of agility has been revised to reflect the fact that in most sports such as invasion sports like basketball or soccer and racket sports like tennis or badminton, changes of direction occur in response to a stimulus, usually from an opponent's actions. According to Sheppard and Young (22), agility is "a rapid whole-body movement with change of velocity or direction in response to a stimulus". For example, a defending soccer player may decelerate and perform a side-step in response to an attacker's evasive movements or an attacking basketball player may cut to one side if he or she perceives a defender moving the opposite way. Although agility movements are typically reactive, there are a few scenarios in sport where COD movements are pre-planned with no decision making. Examples include base running in baseball and softball, as well as running between the wickets in cricket, but these examples are rare (15). For the purposes of this article, the above definition of agility will be adopted whereby a reactive element is always present. In contrast, change of direction movements that are pre-planned with no reactive element or decision making will be described as change of direction (COD) speed.

In 2006 a review of the research relating to agility highlighted the importance of the perceptual and decision making component (27). However there have been several relevant studies in recent years that provide new insights, and some important implications for training. Therefore the purpose of this article is to describe recent research findings and provide practical applications for the training of agility. While the focus of this article will be on invasion sports, the principles are transferable to other sports requiring agility such as racket sports.

Research on agility

One way to investigate if a test of agility relates to performance is to determine if it can discriminate between athletes of different performance or skill levels. For example, if a higher skilled group is superior in an agility task than a lower skilled group, this provides some evidence that the test may be related to performance in that sport. Using this methodology, it has been demonstrated that higher skilled players performed significantly better in an agility test involving responding to an opponent's cutting movement than lower skilled athletes in Australian football (12, 23, 31) and in rugby league (9, 20). In all these cases, the higher skilled athletes were *not* significantly better on tests of COD speed involving similar movement patterns. These findings suggest that the reactive aspect of agility is a vital component of performance. Indeed, Serpell et al (20) reported that a group of professional rugby league players possessed significantly faster decision and response times to a variety of sport-specific cutting maneuvers displayed on a large screen than an elite U-20 group.

The notion of agility being reactive appears to be more commonly accepted and as such, more research and coaching reports are appearing that have recommended the use of a

stimulus to initiate an agility maneuver. For example, a light stimulus has been used in agility research (3, 10, 17) and recommended for assessing tennis agility (6). One electronic timing equipment manufacturer claimed that reacting to their flashing light system can train "critical athlete qualities such as reaction time, decision making, reactive change of direction, agility, peripheral vision, skills, endurance and even team work in reactive simulations and small sided games" (Fusion Sport, Queensland, Australia). A flashing light can be thought of as a non-sport specific or generic stimulus because it is not used in any sports requiring agility. One study by Oliver and Myers (17) compared two tests. The first was a pre-planned straight 5 m sprint followed by either a left or right cut, and sprint for a further 5m in the new direction. The second test involved exactly the same movement but the change of direction was directed by a flashing light. The correlation between the two tests was r=0.93, indicating a commonality of 87%. This very strong relationship suggests the qualities assessed by the reactive test with the light stimulus were not very different from the pre-planned version of the test. The authors concluded that the test involving reacting to the flashing light "required limited perceptual abilities" and the sport specific perceptual factors "cannot be replicated by a generic light stimulus" (17).

Two recent studies with Australian Rules footballers have used a reactive test based on video footage of an attacker changing direction as well as a test involving the same movement pattern with a generic stimulus such as an arrow (31) or a flashing light (12). In both of these studies, the higher level players were superior to a lower skilled group in the task involving reacting to the sport-specific stimulus of the attacker's movements, whereas the higher skilled group did not demonstrate superior performances when tested with the generic stimulus. Collectively, the results mentioned above suggest that agility may have a

stronger correlation to performance than pre-planned COD movements and further, it is a sport-specific stimulus of an opponent's movements that is most important for the athlete's performance. The reasons for this are likely to be related to perceptual and decision making skills.

Perception and decision making in invasion sports

The finding that an elite Australian football playing group did not perform any better than a lower skilled group on an agility test that involved a generalised visual stimulus (directional arrows) (31), builds on a well-established literature in the sport expertise field. This demonstrates that elite performance is not only sports-specific but context sensitive (1, 2, 16). Generic visual parameters such as visual reaction time have been examined to determine their relationship to sports performance. The findings of these studies have been clear, and have generally been unable to demonstrate a systematic, reproducible link between the visual parameter tested and sports performance, particularly as it pertains to expertise (11, 25). For instance, Helsen and Starkes (11) in a multi-dimensional approach to predicting performance between expert, intermediate and novice soccer and hockey players found that 84% of variance was accounted for by sports-specific capacities, and the only *generic* visual component to even contribute slightly (3%) was peripheral vision. The most likely reason is that generalized (non-sports specific) tests only measure the visual reception of information rather than the sports-specific perceptual interpretation of visual information, and it is the latter which appears to be the critical feature in distinguishing the visual-perceptual skill of expert and novice performers (2).

The superiority of highly skilled athletes resides in their ability to perceive and use the context-specific information typically displayed in their performance setting. In the case of

an agility task, the reactive condition needs to contain a simulated opponent (such as an attacker) as they change direction. Consistent with previous research, it is likely that the more skilled players use advanced kinematic information from their opponent's movement pattern to anticipate the direction of the simulated attacker and respond and move more quickly. For instance, Jackson et al. (14) found in a simulated rugby tackling scenario that the skilled players advantage over lesser skilled players was most prominent approximately 120ms before placement of the 'stepping' foot. Generalizing from coaching literature and anecdote, similarly rugby union players are often told to try and watch the angle of their opponent's hips to anticipate the direction of an opponent's dodge. Lesser skilled players, however, are not necessarily attuned to the same information. This ability to use appropriate visual cues and anticipate an opponent's actions is likely to explain why high level performers can react before the foot plant stimulus of their opponents (30).

However the exact visual cues that guide elite performers in agility tasks is not well known. One method currently used is mobile eye tracking technology. This measurement approach documents the visual scanning behaviours (i.e. gaze fixations) of performers as they complete a task of interest. The location of each fixation indicates an area of interest whereas the number and duration of fixations provides an index of the amount of information processed by the performer. The logic behind such an approach is that whatever aspects of the performance a performer is visually attending is an area of relevance to solving the task at hand. While not without limitation (26), such technology can certainly be useful when trying to better understand the cues used by players in an agility task. For example, Salvelsbergh et al (19) found that skilled soccer goal-keepers possessed more efficient visual search strategies than lesser skilled goal-keepers when facing a penalty

kick. In short, while the novice goal-keepers spent a longer time fixating on the trunk, arms and hips, the expert players focused on the kicking leg, non-kicking leg and ball areas as the moment of ball-contact approached. This type of measurement approach provided insights into which important information sources (e.g. kicking leg) skilled movers use, compared to lesser skilled movers when completing a reactive task. While the visual search qualities may still vary among athletes depending on the sport and the specific scenario (24), typically the higher skilled performers search more systematically and focus on the critical information to predict movements.

Practical applications – Training agility

There have been numerous studies that have investigated the effect of COD training on COD speed (4, 18, 28), but no research has yet described the potential benefits of agility training on agility or sports performance. Due to the importance of the perceptual and decision making factors discussed above, there are two training modalities likely to be effective for agility development in invasion sports.

1. Evasion drills. This involves at least one attacker and defender, but may also include additional players such as two attackers versus one defender. All players must stay within a relatively small area that is marked out, and the objective is for the attacker(s) to evade the defender(s) according to the rules of the specific sport. In these scenarios, both attackers and defenders are required to react to their opponent's actions when performing a change of direction. Advantages of evasion drills are that they are highly sport-specific, and they are competitive by nature which encourages motivation and intensity. They also allow the coach to control the

number of repetitions that each player is exposed to in both attacking and defending roles. A simple example in basketball is a 1 v 1 activity where an attacker attempts to evade a defender as he or she drives to the basket. The players swap partners so they are required to observe a variety of kinematic cues and they also swap attacking and defending roles.

2. Small-sided games (SSG). This involves games that use a reduced number of players and field/court area with modified rules. The proposed benefits of SSG are the potential to simultaneously develop various fitness components, skills and tactics as well as being time-efficient (13). Although there has been considerable research on the physiology of SSGs, little is known about the effectiveness for agility development. A recent study (7) investigated the influence of field size, player number and a rule modification on agility demands in professional Australian Rules football players. When tackling was replaced with a tagging rule that resulted in a turnover, players tended to pass the ball rather than attempt to evade their opponents. Therefore to maximize the agility demands of SSGs, rules need to be adopted that encourage evasive skill such as limiting the number of passes or directly rewarding evasive actions via the scoring system.

   Since there can be considerable variability in agility demands among players (7), coaches should give careful consideration to matching ability levels in games, and should provide encouragement to ensure all players are engaged. Due to the multiple players, a potential advantage of SSG compared to evasive drills is the complexity of the decision-making, which may be expected to have good transfer to competition. Further, the speed and accuracy of reaction has been shown to be

highly trainable, even in high performance athletes (21). Since it is not known whether the important perceptual and decision making skills are different for attacking and defending roles, both evasion drills and small-sided games can be used for either attacking or defending according to the needs of the athlete. A basketball example might be a 3 v 3 game on a half court with a rule that only 3 consecutive passes are allowed before the attacker must attempt to evade the defenders.

Although evasive drills and SSG can be highly sport-specific, it is acknowledged that athletes with relatively little training background may benefit from some planned COD speed training to learn basic COD techniques such as the side-step or cut. The use of objects such as cones, poles and ladders are widely used to define COD movement patterns, but care should be taken to avoid too much training involving visually targeting these objects (eg. looking down at the ground at a ladder), as this is not a requirement of most sports. If obstacles are desired, a real person such as a player or coach would be preferred due to the enhanced realism.

It was established earlier that the use of a generic or non-sport-specific stimulus does not allow development of sport-specific perceptual and decision making skills. However there may be some value of this type of reactive training because it can induce a temporal overload or “time-stress” in reactive activities. Compared to a pre-planned cutting task, Individuals required to perform a side-step in response to a flashing light significantly altered their technique and lost movement speed, presumably due to inadequate time for postural adjustment, leading to a greater risk of knee ligament injury (3). It is possible that practising under simple time-stress may reduce reaction time and therefore allow a faster and safer cutting technique (3).

However once relevant COD techniques have been learned under planned conditions and with time-stress, agility training should progress to include evasive drills and/or SSG to target sport-specific reactive performance. The recommended applications of the various COD and agility training methods are shown in Table 1. This table may be used for designing a periodized training program.

Table 1. Characteristics of change of direction (COD) and agility training methods and their application to programing.

References

1. Abernethy, B, Thomas, K. T., & Thomas, J. T. Strategies for improving understanding of motor expertise (or mistakes we have made and things we have learned!!). In: Cognitive issues in motor expertise. J. L. Starkes & F. Allard Eds,. Elsevier Science Publishers, B.V., 317-356, 1993.
2. Abernethy, B., Wann, J., & Parks, S. Training perceptual motor skills for sport. In: Training for sport: Applying sport science. Elliott, B ed. Chichester: John Wiley, 1-68, 1998.
3. Besier, T.F., Lloyd, D.G., Ackland, T.R., Cochrane, J.L. Anticipatory effects on knee joint loading during running and cutting maneuvers. Med Sci Sports Exerc. 33: 1176-1181, 2001.
4. Bloomfield, J., Polman, R., O'Donoghue, P., McNaughton, L. Effective speed and agility conditioning methodology for random intermittent dynamic type sports. J Strength Cond Res. 21: 1093-1100, 2007.
5. Chelladurai, P. Manifestations of agility. Can Assoc Health Phys Ed Rec. 42: 36-41, 1976.
6. Cooke, K., Quinn, A., Sibte, N. Testing speed and agility in elite tennis players. Strength Cond J. 33: 69-72, 2011.

7. Davies, M.J., Young, W., Farrow, D., Bahnert, A. Comparison of small-sided games on agility demands in elite Australian football. Int J Sports Physiol Perf, In Press.
8. Draper, J.A., Lancaster, M.G. The 505 test: A test for agility in the horizontal plane. Aust J Sci Med Sport. 15-18, 1985.
9. Gabbett, T.J., Kelly, J.N., Sheppard, J.M. Speed, change of direction speed, and reactive agility of rugby league players. J Strength Cond Res. 22: 174-181, 2008.
10. Green, B.S., Blake, C., Caulfield, B.M. A valid field test protocol of linear speed and agility in rugby union. J Strength Cond Res. 25: 1256-1262, 2011.
11. Helsen, W. F., & Starkes, J. L. A multidimensional approach to skilled perception and performance in sport. Applied Cog Psych. 13: 1-27, 1999.
12. Henry, G., Dawson, B., Lay, B., Young, W. Validity of a reactive agility test for Australian football. Int J Sports Physiol Perform. 6: 534-545, 2011.
13. Hill-Haas, S.V., Dawson, B., Impellizzeri, F.M., Coutts, A.J. Physiology of small-sided games training in football. Sports Med. 41: 199-220, 2011.
14. Jackson, R.C., Warren, S., Abernethy, B. Anticipation skill and susceptibility to deceptive movement. Acta Psych. 123: 355-371, 2006.
15. Jeffreys, I. A task-based approach to developing context-specific agility. Strength Cond J. 33: 52-59, 2011.
16. Mann, D. T. Y., Williams, A. M., Ward, P., & Janelle, C. M. Perceptual-cognitive expertise in sport: A meta-analysis. J Sport Exercise Psych. 29: 457-478, 2007.
17. Oliver, J.L., Myers, R.W. Reliability and generality of measures of acceleration, planned agility, and reactive agility. Int J Sports Physiol Perform. 4: 345-354, 2009.
18. Polman, R., Walsh, D., Bloomfield, J., Nesti, M. Effective conditioning of female soccer players. J Sports Sci. 22: 191-203, 2004.

19. Savelsbergh, G.J.P., Williams, A.M., van der Kamp, J., Ward, P. Visual search, anticipation and expertise in soccer goalkeepers. J Sports Sci. 20: 279-287, 2002.
20. Serpell, B.G., Ford, M., Young, W.B. The development of a new test of agility for rugby league. J Strength Cond Res. 24: 3270-3277, 2010.
21. Serpell, B.G., Young, W.B., Ford, M. Are perceptual and decision-making components of agility trainable? A preliminary investigation. J Strength Cond Res. 25: 1240-1248, 2011.
22. Sheppard, J.M., Young, W.B. Agility literature review: classifications, training and testing. J Sports Sci. 24: 919-932, 2006.
23. Sheppard, J.M., Young, W.B., Doyle, T.L.A., Sheppard, T.A., Newton, R.U. An evaluation of a new test of reactive agility and its relationship to sprint speed and change of direction speed. J Sci Med Sport. 9: 342-349, 2006.
24. Vaeyens, R., Lenoir, M., Williams, A. M., Mazyn, L., & Phillippaerts, R. M. The effects of task constraints on visual search behavior and decision-making skill in youth soccer players. J Sport Exercise Psych. 19: 147-169, 2007.
25. Ward, P., Williams, A.M. Perceptual and cognitive skill development in soccer: The multidimensional nature of expert performance. J Sport Exerc Psych. 25: 93-111, 2003.
26. Williams, A. M., & Ericsson, K. A. Perceptual-cognitive expertise in sport: Some considerations when applying the expert performance approach. Human Move Sci. 24: 283-307, 2005.
27. Young, W., Farrow, D. A review of agility: Practical applications for strength and conditioning. Strength Cond J. 28: 24-29, 2006.

28. Young, W.B., McDowell, M.H., Scarlett, B.J. Specificity of sprint and agility training methods. J Strength Cond Res. 15: 315-319, 2001.
29. Young, W.B., James, R., Montgomery, R. Is muscle power related to running speed with changes of direction? J Sports Med Phys Fit. 42: 282-288, 2002.
30. Young, W.B., Willey, B. Analysis of a reactive agility field test. J Sci Med Sport. 13: 376-378, 2010.
31. Young, W., Farrow, D., Pyne, D., McGregor, W., Handke, T. Validity and reliability of agility tests in junior Australian football players. J Strength Cond Res. 25: 3399-3403, 2011.

Table

	Planned COD movements	**Agility activities with generic stimulus**	**Agility activities with sport-specific stimulus**
Examples	Cutting/side-stepping, side-shuffling, backpedaling. Cones, poles and ladders may be replaced with “live” obstacles where appropriate.	Flashing lights, flashing arrows, coach pointing, coach calling out direction.	Evasive drills, small-sided games.
Main benefits	Development of footwork, balance and general COD techniques.	Provides “time-stress”, natural footwork movements.	Sport specific movements, develops perceptual and decision making skills, holistic development of agility. Good transfer to performance.
Main weaknesses	Can involve unnatural non-specific footwork, no perceptual and decision making development.	Doesn’t develop perceptual and decision making aspects of sport eg. anticipation.	Difficult to control agility load (repetitions) for all athletes in games.
Role in athlete development & in a periodized program	Suitable for developing athletes or athletes lacking basic COD technique.	Progression from planned COD movements.	Well-trained athletes, athletes lacking perceptual and decision making skill, emphasize in pre-competition & competition phases.