Running head: NEW SOCCER AGILITY TEST

Reliability and Validity of a New Test of Agility in Male Soccer Players

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Contents

Index of Tables

Index of Figures

Abstract

Agility testing is an important aspect of soccer and to the author's knowledge, no soccer-specific agility assessment tool has been created. Agility is the process of coordinating appropriate parts of the body in a rapid and functional manner in the face of environmental constraints. Based on this definition and the physical requirements of soccer, a new soccer agility test (NSAT) was developed. The purpose of this study was to evaluate the reliability and validity of the new agility testing protocol designed to measure agility in competitive male soccer players. In addition to reliability, concurrent and discriminant validity were the focus of this study. A total of 55 male soccer players, from three different levels of competition PDL (22.1 ± 2.7 years; 178.1 ± 6.2 cm; 76.3 ± 7.0 kg), Reserve (15.4 ± 1.5 years; 172.2 ± 7.2 cm; 65.0 ± 10.1 kg), and Elite (10.9 ± 0.8 years; 138.4 ± 21.5 cm; 39.7 ± 7.7 kg), were recruited. All participants performed the T-test and the NSAT in random order on two separate occasions in order to assess agility performance. The NSAT was found to be highly reliable within-day (ICC: PDL = .88-.90; Reserve = .91-.92; Elite = .88-.89) based on analysis of the fastest trials performed by each participant for all teams. However, between-day reliability was found to be low for the PDL (.52) and Elite (.22) teams which may warrant the introduction of a formal familiarization session in order to account for possible learning effects. Concurrent validity was only confirmed for the Reserve (r_{Day1} =.75; r_{Day2} = .55) and Elite (r_{Day1} =.68; r_{Day2} = .60) teams with moderate to high correlations being found between the T-test and the NSAT. These results may suggest that the NSAT and T-test measure different constructs when testing high level soccer players, based on the results found when evaluating concurrent validity for the PDL (r_{Day1} =.21; r_{Day2} = .48) team. The NSAT was also shown to discriminate among the three different teams on testing Day 2 [$F_{3x2x2}(2,39) = 6.08$, $p > .05$] with regards to time to completion.

Review of literature

Agility

In the current literature the terms agility, change of direction speed, quickness, and cutting are often used interchangeably. This has created much debate as to the exact definition of the term agility and what it encompasses. It is therefore important that a thorough definition of agility be presented in this review in order to differentiate between commonly used terms in the current literature. Researchers have previously defined agility as the ability to change direction rapidly (Bloomfield, Ackland, & Elliot, 1994; Clarke, 1959; Mathews, 1973) as well as the ability to change direction both rapidly and accurately (Barrow & McGee, 1971; Johnson & Nelson, 1969). However, many researchers argue that there is more to agility than a simple change in direction. To determine if this is the case, it is necessary to take an in depth look into what exactly is being assessed. Chelladurai (1976) outlined the first comprehensive definition of agility. He proposed the definition of agility should include recognition of the perceptual and decision-making components of agility. Therefore, a complete definition of the term agility must include the criterion of a reaction to a stimulus. Chelladurai's (1976) definition of agility includes 4 classifications: simple, temporal, spatial, and universal (Table 1). It is important to identify the type of skills being assessed in order to classify agility. The simple and temporal classifications represent agility tasks, which are closed skills. Closed skills represent tasks where the participant may or may not be required to respond to a stimulus, however, the response is pre-planned and therefore there is little uncertainty in the skill (Cox, 2002). An example of a closed skill where a stimulus is present is the sprint start. A sprint start is sometimes confused with an open skill. This is due to the fact that the starter's pistol introduces some uncertainty; however, the sprinter knows what they will be doing after they hear the shot (Sheppard &

Young, 2006). The spatial and universal classifications represent agility tasks, which are open skills. An open skill requires the participant to react to a stimulus and involves a great deal of uncertainty (Cox, 2002). An example of an open skill is the movement of a football receiver as they accelerate and decelerate while changing directions in order to evade an oncoming defender.

Table 1

Classification of agility (Modified from Chelladurai, 1976)

Agility classification	Definition	Example of sporting skill
Simple	No spatial or temporal uncertainty	Gymnast's floor routine: pre-planned activity, initiated when the athlete desires, with movements that the athlete has pre-planned. Stimulus is the athlete's own movement and the physical domain in which they are executing the skill
Temporal	Temporal uncertainty, but movement is pre-planned (spatial confidence)	Athletics sprint start: pre-planned activity, initiated in response to a stimulus (starter's pistol) wherein there is no certainty as to exactly when the pistol will fire
Spatial	Spatial uncertainty, but timing of movement is pre-planned (temporal confidence)	Volleyball or racquet sport service receipt: the umpire determines a narrow window of time wherein the server must serve the ball to the opponent. However, there is no certainty on the part of the receiver as to where the service will be directed
Universal	Spatial and temporal uncertainty	Ice hockey or football: during offensive and defensive plays, the athletes cannot anticipate with certainty when or where opposition players will move to

Following Chelladurai's (1976) definition, many simpler definitions for agility, which described it simply as a rapid change in direction, were outlined including those mentioned previously in this review. However, recent definitions of agility have developed from investigations of the relationship of reaction to a stimulus and agility. Young, James, and Montgomery (2002) created a deterministic model (*Figure 1*) for agility, which outlined the main factors that determine agility while investigating change of direction speed variables. They define agility as running speed with at least one change of direction performed in a competitive game which may include being in possession of a ball or piece of equipment (Young et al., 2002). The researchers also took time to breakdown and define the components of perceptual and decision making factors involved with agility. They described visual scanning as the ability to process visual information in a competitive game, anticipation as the prediction of an event in a game that influences the movements of a player, pattern recognition as the ability to recognize patterns of play made by an opposing team or player, and knowledge of situations as the knowledge of probable movements of other players based on previous game experiences (Young et al., 2002). This new definition of agility now put previous definitions under the title of change of direction speed.

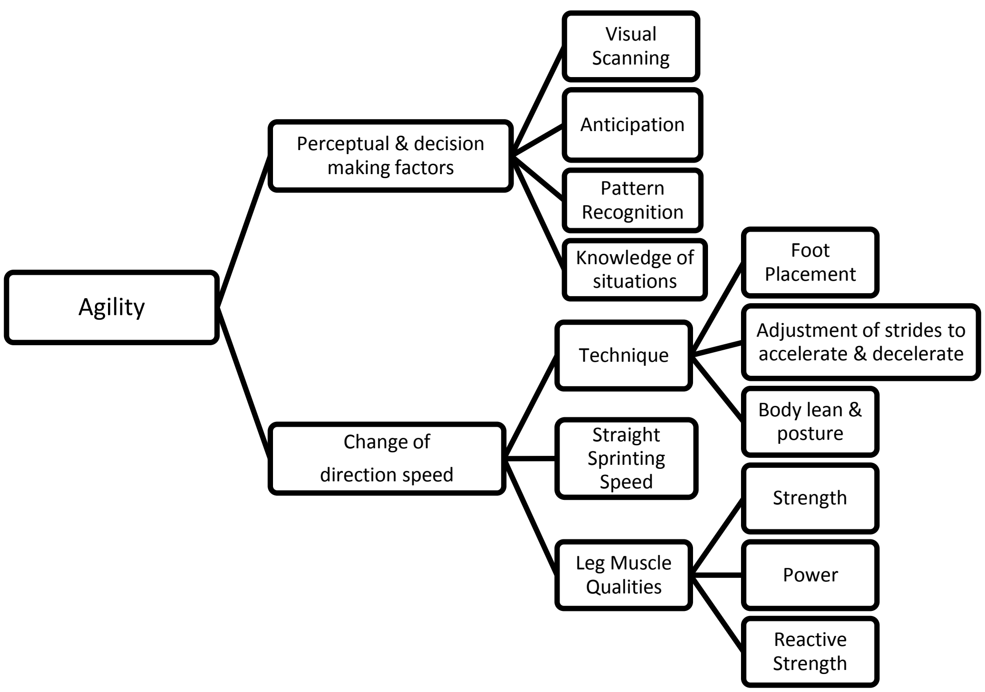

Figure 1. Model indicating the main factors determining agility (modified from Young et al., 2002)

Following an extensive review of the literature, Sheppard and Young (2006) developed a simplified definition of agility. The authors argued that rather than using inclusion criteria such as those proposed by Chelladurai (1976), researchers and coaches should define agility using exclusion criteria (Table 2). Sheppard and Young (2006) defined agility as "a rapid whole-body movement with change of velocity or direction in response to a stimulus" (p. 922). Using Table 2, a coach or researcher can easily classify a skill as agility or not by using the criteria outlined. According to Sheppard and Young (2006), an agility task must involve an open skill.

Table 2

Criteria for the classification of agility (modified from Sheppard & Young, 2006)

Agility	Other physical or cognitive skills
Must involve initiation of body movement, change of direction, or rapid acceleration or deceleration	Entirely pre-planned skills such as shot-put classified by their skill function rather than included as a type of agility
Must involve whole-body movement	Running with directional changes classified as change of direction speed rather than agility or quickness
Involves considerable uncertainty, whether spatial and/or temporal	Closed skills that may require a response to a stimulus (e.g. the sprint start in response to the starter's pistol is pre-planned (closed), and therefore is not agility)
Open skills only	
Involves a physical and cognitive component, such as recognition of a stimulus, reaction, or execution of a physical response	

Although Sheppard and Young (2006) included reaction to a stimulus in their definition, only 3 out of 13 independent agility definitions found in the literature included reaction to a stimulus as a component of agility. This raises the question of what effect reaction time has on agility. In order to assess this, Sheppard, Young, Doyle, Sheppard, and Newton (2006) developed a test of reactive agility where the participant must react to a stimulus while they complete the protocol. They found that testing reactive agility helped to distinguish between high and low level performers suggesting that simply testing closed skills may not adequately provide for this distinction. Gabbett, Kelly, and Sheppard (2008) also found that since the test was designed as a tool to measure defensive reactive agility, it might favour according to position. They also stated that this test only builds a foundation upon which further tests can be developed to assess all positions equally (Gabbett et al., 2008). Therefore, although it is clear that quicker reaction time may characterize a higher level performer, the effect it has on agility is not clear. It may be suggested that if the participant is able to react quickly in a proficient and accurate manner, it may be a demonstration of greater agility levels.

Change of Direction Speed vs. Agility

Change of direction speed is defined as a movement where no immediate reaction to a stimulus is required and thus the direction change is pre-planned (Brughelli, Cronin, Levin, & Chaouachi, 2008; Young et al., 2002). According to Young et al. (2002), change of direction speed is a component of agility. Based on this definition, many tests commonly referred to as agility tests where participants are required to run around a series of stationary obstacles such as cones are actually testing change of direction speed instead of agility because there is no reaction in response to a stimulus (Sheppard & Young, 2006). However, the majority of definitions of agility in the current literature do not refer to a stimulus. It could be argued that from a perceptual point of view that the change of direction is stimulated by the presence of the cone in the path of travel and therefore qualifies as a stimulus.

Quickness vs. Agility

The term quickness has also been used to define skills similar to agility (Moreno, 1995). Quickness is defined as a multi-planar or multi-directional skill that combines acceleration, explosiveness, and reactiveness (Moreno, 1995). Vives and Roberts (2005) used the words speed, rapidity, and instancy in order to define quickness in reference to rate of movement of an object. Based on these definitions, it would appear that quickness resembles change of direction speed and represents a component of agility due to the lack of a response to a stimulus.

Cutting Movement vs. Agility

Another term which is commonly used regarding changes of direction during sprint performance is cutting (Bernier, 2003; Sanna & O'Connor, 2008). Cutting refers "to the specific portion of a directional change where the athlete's foot contacts the ground to initiate the change of direction" (Sheppard et al., 2006, p. 920). Imwalle, Myer, Ford, and Hewett (2009) defined cutting as pivoting with a rapid change in direction while running. Cutting has also been defined as straight-ahead running abruptly redirected at a prescribed angle between 30° and 90° from the original direction of travel (Golden, Pavol, & Hoffman, 2009). Once again, there is no reaction to an external stimulus and cutting refers only to the actual change of direction itself.

Development of a New Definition of Agility

There have been many definitions of agility ranging from a simple rapid change in direction (Bloomfield, Ackland, & Elliot, 1994; Clarke, 1959; Mathews, 1973) to the more complex, "a rapid whole-body movement with change of velocity or direction in response to a stimulus" (Sheppard & Young, 2006, p. 922). There are 13 unique agility definitions found in literature related to agility and testing (Table 3). It is clear that while there are several reoccurring terms found in the definitions listed in Table 3, there is no clear consensus regarding the definition of agility. *Figure 2* shows a breakdown of the frequency of key terms found within the definitions from Table 3.

Table 3

Unique agility definitions in the literature

Author	Year	Agility definition
Draper & Lancaster	1985	The ability to change the direction of the body rapidly and is a combination of strength, speed, balance, and coordination.
Baechle	1994	Agility includes whole-body change of direction as well as rapid movement and direction change of limbs.
Bloomfield et al.	1994	The ability to change direction rapidly.
Twist & Benickly	1995	The ability to maintain or control body position while quickly changing direction during a series of movements.
Gambetta	1996	The ability to change direction and start and stop quickly.
Cable	1998	The ability to change speed and direction rapidly without loss of balance and is dependent on muscle strength, speed, balance, and skill.
Verstegen & Marcello	2001	The ability to react to a stimulus, start quickly and efficiently, move in the correct direction, and be ready to change direction or stop quickly to make a play in a fast, smooth, efficient, and repeatable manner.
Brown & Vescovi	2003	The ability to integrate several biomotor skills such as dynamic balance, muscular coordination, effective core development, and stretch shortening cycle development.
Craig	2004	The ability to change your direction of movement quickly.
Barnes	2005	The ability of the neuromuscular system to coordinate explosive changes of direction of individual and/or multiple body segments in all planes of motion at variable velocities by effective use of the stretch shortening cycle.
Sheppard & Young	2006	A rapid whole-body movement with change of velocity or direction in response to a stimulus.
Barnes et al.	2007	The ability to change direction with a minimal loss of control and/or average speed.
Walker & Turner	2009	Ability to change direction of the body rapidly, without losing balance, using a combination of strength, power, and neuromuscular coordination.

The terms “change direction”, “rapidly/quickly”, “control/coordination”, “speed/velocity”, and “whole-body” appear the most with frequencies of 13, 10, 6, 6, and 7. Alternatively, the term “stimulus” only appears 3 times.

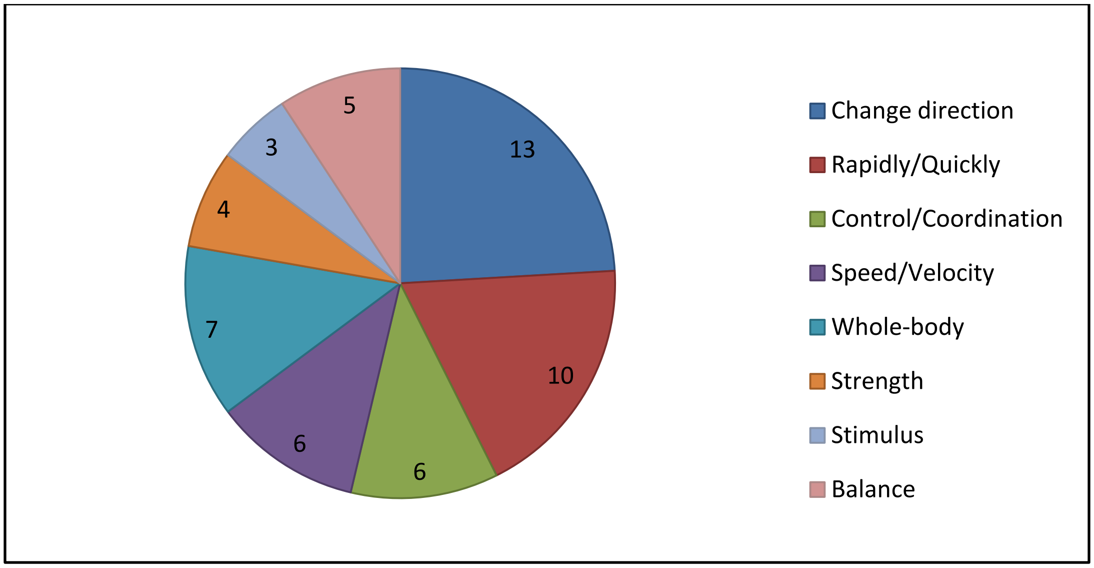

Figure 2. Frequency of terms in agility definitions in the literature.

In contrast to the typical empirical definitions of agility provided, Jeffreys (2006) argued that agility can be improved through practice. This suggested that a theoretical motor learning approach should also be considered. Jeffreys (2006) used a different approach and broke down agility into three types of target functions: initiation, transition, and actualization. During initiation, an athlete aims to either initiate or change movement (Jeffreys, 2006). This includes cross-steps, first-step starts, drop steps, and cut steps. These target functions may also cross over into the transitional classification. During transition, the athlete's main concern is keeping him/herself in a position in which he/she will be able to read and react to a stimulus (Jeffreys, 2006). Examples of transitional movements include side shuffles, backpedalling, and chop steps. Actualization target functions ultimately decide the success of the sequence and normally involve either a sport skill or a sprint to a given position (Jeffreys, 2006). In the case of soccer, kicking, passing, tackling, or heading the ball are classified as actualization target functions. During the development of agility, a coach or trainer can break down each developmental task and identify the areas of focus such as feet, legs, and arms, and target mechanics related to agility for each of those components (Jeffreys, 2006). These areas of soccer are all subject to the set of motor abilities which the player possesses.

In order to describe agility, it is important to understand the motor abilities that underlie it. Burton and Miller (1998) defined a motor ability as a general trait or capacity of an individual that underlies the performance of a variety of movement skills. Fleishman (1984) identified 11 perceptual-motor and 9 physical proficiency abilities that underlie human movement. The perceptual-motor abilities which pertain to agility are indicated in Table 4.

Table 4
Perceptual-motor abilities (modified from Fleishman, 1984)

Ability	Definition
Multilimb coordination*	The ability to coordinate the movement of a number of limbs simultaneously.
Control precision*	Requires highly controlled movement adjustments, particularly where larger muscle groups are involved.
Response orientation*	Involves quick choices among numerous alternative movements, more or less as in choice reaction time.
Reaction time	Important in tasks where there is a single stimulus and a single response, where speed of reaction is critical, as in simple reaction time.
Rate of control*	Involves the production of continuous anticipatory movement adjustments in response to changes in the speed of a continuously moving target or object.
Manual dexterity	Underlies tasks in which relatively large objects are manipulated with the hands and arms.
Finger dexterity	Involves tasks requiring the manipulation of small objects.
Arm-hand steadiness	The ability to make precise arm and hand positioning movements where strength and speed are not required.
Wrist-finger speed	Involves rapid movement of the wrist and fingers with little or no accuracy demands.
Aiming	A highly restricted type of ability that requires the production of accurate hand movements to targets under speeded conditions.

*Ability related to agility tasks

The following examples pertain to agility tasks in soccer but may be extended to other sports as well. Multilimb coordination is required when a player changes direction in order to avoid a defender. An example of control precision occurs when dribbling a soccer ball through opposing players, which involves coordinating the muscles of the lower body with a high degree of control along with other regions of the body. Response orientation is important when an offensive player must make a choice between taking a certain route around a defender, shooting the ball and making a pass to a teammate. Rate of control is important because the sport of soccer revolves around the ball, which is continuously moving. Players must adjust their speed and direction based on the location, speed of travel and orientation to the ball along with the position of other players on both teams.

The physical proficiency abilities (Table 5), which pertain to agility, are explosive strength, dynamic strength, dynamic flexibility, gross body equilibrium, speed of limb movement, and gross body coordination. Explosive strength is required every time a player changes direction at high speed and during jumping and kicking actions. Dynamic strength is utilized continuously through movements such as running and walking. Dynamic flexibility is required during whole-body movement including changes of direction where the muscles of the leg act elastically to help propel the limb. Gross body coordination and equilibrium are both important when a player is required to dribble, kick, or pass the ball while maintaining balance and control. Speed of limb movement is extremely important when trying to maintain whole-body control while performing various tasks such as changing direction, jumping, and accelerating/decelerating.

Table 5
Physical proficiency abilities (modified from Fleishman, 1984)

Ability	Definition
Explosive strength*	The ability to expend a maximum of energy in one explosive act. Advantageous in activities requiring a person to project themselves or some object as high or as far as possible. Also important for mobilizing force against the ground.
Static strength	Involves the exertion of force against a relatively heavy weight or some fairly immovable object.
Dynamic strength*	The ability to repeatedly or continuously move or support the weight of the body.
Trunk strength	Dynamic strength that is particular to the trunk and abdominal muscles.
Extent flexibility	The ability to extend or stretch the body as far as possible in various directions.
Dynamic flexibility*	Involves repeated, rapid movements requiring muscle flexibility.
Gross body equilibrium*	Ability to keep or regain one's body balance or stay upright when in an unstable position. This ability includes maintaining one's balance when changing direction while moving or standing motionlessly.
Balance with visual cues	The ability to maintain total body balance when visual cues are available.
Speed of limb movement*	Underlies tasks in which the arm(s) or leg(s) must be moved quickly, but without a reaction-time stimulus, to minimize movement time.
Gross body coordination*	The ability to perform a number of complex movements simultaneously
Stamina	Enduring strength and energy - the ability to engage the entire body in strenuous physical activity for a prolonged period of time.

*Ability related to agility tasks

In addition to these abilities, Keele, Ivry, and Pokorny (1987) identified coordination factors that suggest there may be a general timekeeping ability, which may underlie the performance of tasks involving timing such as anticipating a ball or the movement of a defender. Table 6 outlines the coordination factors relevant to agility.

Table 6
Coordination factors underlying agility (modified from Keele et al., 1987)

Coordination factor	Definition
Movement rate	Applies to a series of movements which must be made at a maximum speed.
Perceptual timing	Underlies tasks in which accurate judgements about the time course of perceptual events is required.
Force control	Important for tasks in which forces of varying degrees are needed to achieve the desired outcome.

The coordination factors, which underlie agility, are movement rate, perceptual timing, and force control. Movement rate is utilized when a player performs a complex manoeuvre in order to avoid another player while running. Perceptual timing is important in anticipating another player's movements as well as the movement of the ball. Force control is important when a player must make small adjustments to their direction in order to take the best path around an opposing player as well as passing or kicking the ball. All of these factors contribute directly to agility tasks.

Using the terms which occur frequently in unique agility definitions found in the literature, a key term analysis was performed on Tables 4 and 5. The analysis is displayed in *Figure 3*.

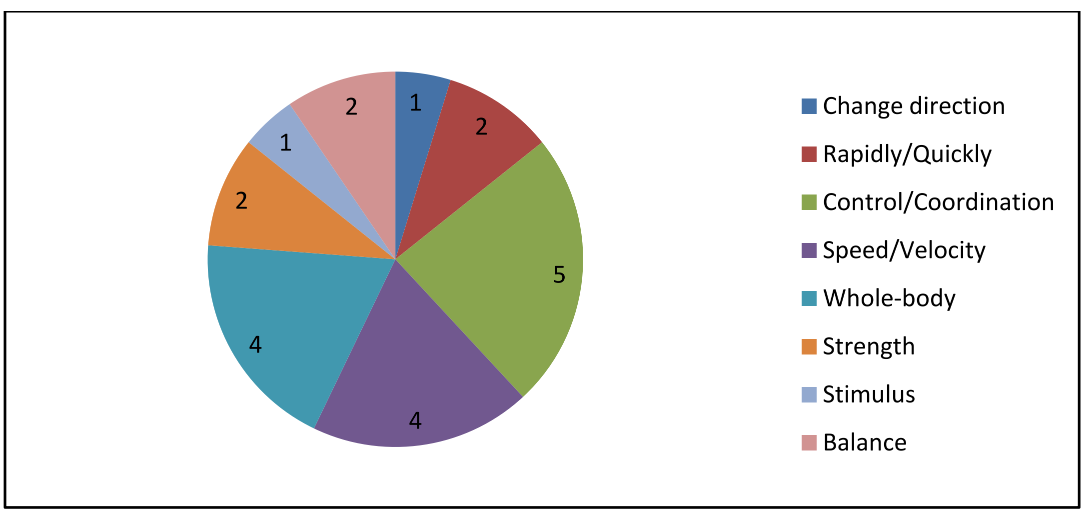

Figure 3. Frequency of terms within ability definitions related to agility.

All terms found in Figure 2 appeared at least once or twice in the analysis; however, “control/coordination”, “speed/velocity”, and “whole-body”, are the only ones that occurred more than twice. A new definition of agility should include these criteria.

Based on the current literature and a review of the motor skills underlying agility, the author would like to propose the following new definition of agility: “agility is the process of coordinating appropriate parts of the body in a rapid and functional manner in the face of environmental constraints.” Unlike previous definitions of agility, this definition takes into account the theory of motor learning, which helps explain the fundamental skills that a person may be required to complete during an agility task. It does not simply describe an agility task as one where a change in direction occurs in reaction to a stimulus but instead tries to describe a participant reacting and coordinating their movements with regard to the environment in order to achieve a goal whether they are running around cones or defenders.

Soccer and Agility

The sport of soccer carries a specific set of physical movement demands which players must meet in order to succeed. The following sections will evaluate the sport of soccer which requires agility along with change of direction speed (Barnes, Schilling, Falvo, Weiss, Creasy, & Fry, 2007; Young, James, & Montgomery, 2002).

Skill breakdown of soccer.

Soccer players perform a variety of different movements and skills during a match. Time motion analysis is a technique that is used to analyze the frequency of different movements and physical requirements in many different sports. It has been used to evaluate basketball (Ben

Abdelkrim, El Fazaa, & El Ati, 2007), volleyball (Sheppard, Gabbett, & Reeberg Stanganelli, 2009), and extensively in soccer (Bangsbo, J, 1994; Bloomfield, Polman, & O'Donoghue, 2007; Bradley, Sheldon, Wooster, Olsen, Boanas, & Krustrup, 2009; Burgess, Naughton, & Norton, 2006; Gabbett & Mulvey, 2008; Mohr, Krustrup, & Bansbo, 2003) in addition to other sports. Although the number of skills analyzed during a soccer match vary from study to study, there are several basic locomotor skills which are frequently mentioned (Table 7). These include standing, walking, jogging, striding, and sprinting. Backpedalling is also frequently included in time motion analyses although it may be included under a heading such as low-intensity running (Mohr, Krustrup, & Bangsbo, 2003). This suggests that some backpedalling data may be excluded from some studies. Soccer is characterized by periods of aerobic and anaerobic activity (Reilly, Bangsbo, & Franks, 2000) and includes movements such as short sprints, rapid acceleration or deceleration, turning, jumping, kicking, and tackling (Kaplan, Erkmen, & Taskin, 2009). Mohr et al. (2003) found that elite soccer players travelled on average a total distance of 10.86 km during each game. This distance can vary depending on the team and level of play.

Table 7
Definition of basic locomotor skills in soccer

Skill	Definition
Standing	No locomotor activity (Gabbett & Mulvey, 2008; Mohr et al., 2003).
Walking	Movement involves at least one foot being in continual contact with the ground (Burgess, Naughton, & Norton, 2006; Gabbett & Mulvey, 2008; Mohr et al., 2003).
Jogging	Movement involves a flight phase and minimal arm swing (Burgess et al., 2006; Gabbett & Mulvey, 2008; Mohr et al., 2003).
Striding	Movement is similar to jogging but involves a longer stride and more pronounced arm swing (Burgess et al., 2006; Gabbett & Mulvey, 2008).
Sprinting	Maximal effort with a greater extension of the lower leg during forward swing and higher heel lift relative to striding (Burgess et al., 2006; Gabbett & Mulvey, 2008; Mohr et al., 2003).

The total distance travelled can then be further broken down into individual actions. Bangsbo (1994) found that the sprints occurring during games ranged from 1.5-105 m and that the average sprint distance was 17m. According to Verheijen (1998), a professional soccer player makes between 1400 and 1600 runs during each match. This equates to changing direction approximately every 3.5-4 s during the game (Verheijen, 1998). Mohr et al. (2003) found that top-class players performing a total of 1346 ± 34 runs during a match. Most of the crucial moments in soccer involve high-speed anaerobic activity and contribute directly to which team will win or lose the match (Luhtanen, 1994; Reilly et al., 2000). Little and Williams (2005) divide high-speed actions into those requiring acceleration, maximal speed, or agility. Bloomfield et al. (2007) found that players performed a varying number of turns during a game based on position played with defenders making approximately 700 turns per match versus 500 turns for midfielders and 600 turns for strikers. In addition to forwards sprinting, players were also required to backpedal, as well as shuffle from side to side in order to pursue and evade opposing players (Sporis, Jukic, Milanovic, & Vucetic, 2010). Bloomfield et al. (2007) found that strikers and defenders fell to the ground the most frequently during a match with defenders being required to get-up quickly more frequently. This suggests that falling to the ground and getting up quickly may be an important physical necessity for players. The results of these analyses suggest that the ability to change direction at speed and recover quickly in order to repeat sprint performance are two important components of the soccer skill set. This means that any agility test specific to soccer players will need to address high-speed actions involving changes in acceleration and direction. Researchers have also found that less than 50% of purposeful movements in the study were performed in the forward direction (Bloomfield et al., 2007). A "purposeful movement" is defined as a movement made in possession of the ball, competing for the ball, evading opponents in order to become available to receive the ball, supporting team mates in possession of the ball, tracking and channelling opponents who are in possession or might receive the ball in addition to technical and tactical positioning movements (Bloomfield et al., 2007).

Agility testing.

Agility testing typically involves a participant navigating a series of stationary cones or lines spaced specific distances apart with the objective of completing the course in as little time as possible. Tests can range from simple involving only two lines to very complex with multiple cones and multiple changes of direction. The following sections discuss several of the most commonly used agility protocols.

505 agility test.

The 505 agility test allows a coach or trainer to evaluate ability to change direction 180 degrees while sprinting. During the 505 agility test, a participant must sprint from the start line through the timing gates and continue on to the turning line (*Figure 4*). Once the participant reaches the turning line, they must change direction through a 180° turn on their dominant leg and re-accelerate through the timing gates again. The time to complete the 5m out and back is recorded. The 505 agility test takes between 2-3 seconds to complete (Gabbett et al., 2008; Jones et al., 2009).

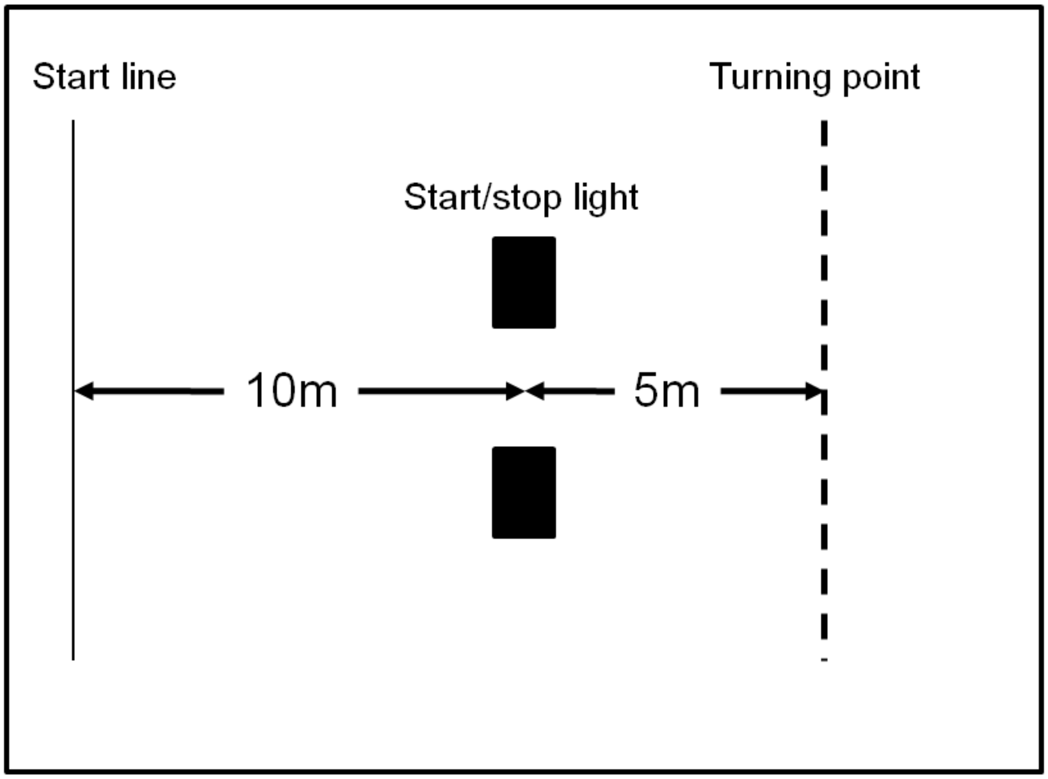

Figure 4. Equipment setup for the 505 agility test (modified from Jones et al., 2009).

The 505 agility test only measures a single change of direction and the participant's ability to decelerate, turn, and then re-accelerate through the finish line. If this test is used with soccer players, it fails to measure many of the basic locomotor skills which are required such as jumping, getting-up from the ground, side-stepping, and backpedalling. Also, based on the definition of agility described by Jeffreys (2006), this test places an emphasis on the initiation and actualization target functions while there is no true transition such as a side shuffle or backpedal. The 180° turn represents a movement similar to a cut step rather than a true turn.

Illinois agility test.

The Illinois agility test is another agility test evident in the literature (Jarvis, Sullivan, Davies, Wiltshire, & Baker, 2009; Miller, Herniman, Ricard, Cheatham, & Michael, 2006; Vescovi & McGuigan, 2008). The test requires a participant to run through a series of cones

(*Figure 5*). Four cones are setup to outline the course area, which is 5m by 10m, along with an additional four cones placed down the centre of the course at intervals of 3.3m (Roozen, 2004).

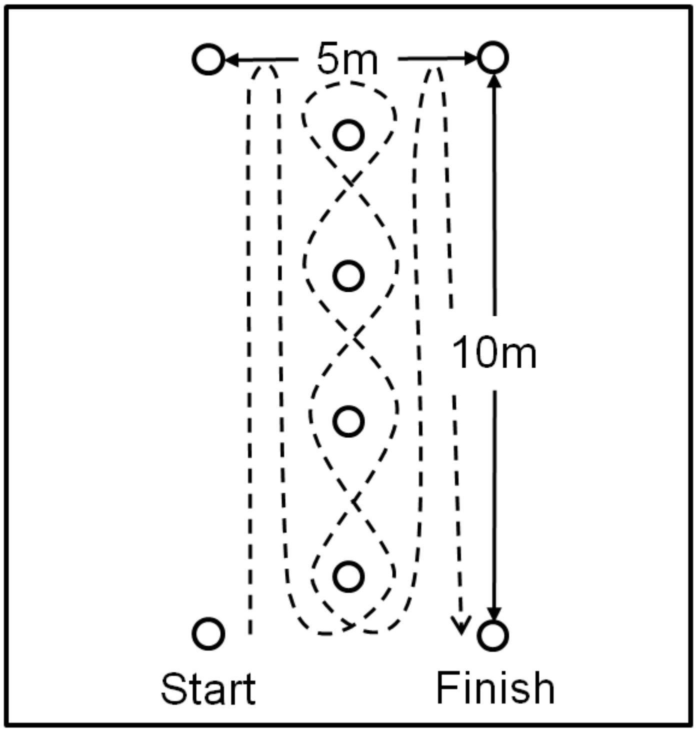

Figure 5. The Illinois agility test (Roozen, 2004).

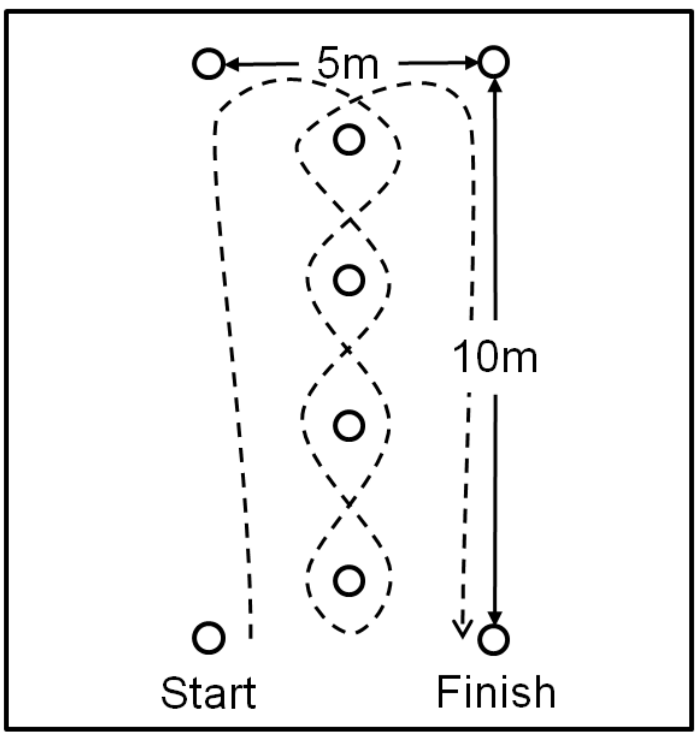

Figure 6. Modified Illinois Agility Test (Vescovi & McGuigan, 2008).

The participant begins the test lying face down with their hands at shoulder level. When instructed to begin, the participant must get up and run the course as fast as possible (Roozen, 2004). Vescovi and McGuigan (2008) used a modified version of the Illinois agility test in order to test agility. They argue that the test may have metabolic limitations due to the time to completion of the original test being 16-18s and therefore modified the test by having the participant omit 2 of the four straight sprint components of the test (*Figure 6*) (Vescovi & McGuigan, 2008). In the current literature, the standard Illinois agility test takes on average between 14 and 18 seconds to complete (Caldwell & Peters, 2009; Miller et al., 2006; Jarvis et al., 2009). The modified Illinois agility test suggested by Vescovi and McGuigan (2008) takes approximately 10 seconds to complete. The Illinois agility test has been measured using both stopwatches (Roozen, 2004) and timing gates (Jarvis et al., 2009; Vescovi & McGuigan, 2008).

The Illinois agility test includes changes in acceleration, turning, and running at different angles. This caters well to most of the locomotor skills present in soccer. However, there is once again an emphasis on initiation and actualization target functions with no side shuffles, backpedalling or chop steps present in this test. Another issue is the duration of the standard test protocol. Vescovi and McGuigan (2008) suggest a duration of 16-18s is longer than the typical purposeful movement sequence in soccer. Bloomfield et al. (2007) found that the mean duration of each purposeful movement during a soccer match was 13.1s ± 3.2. Therefore, a test with a shorter duration or a modified version of the Illinois agility test might be better suited to testing soccer players.

Shuttle run.

The Shuttle run is a commonly used agility test (Chaouachi, Vincenzo, Chaalali, Wong, Chamari, & Castagna, 2011; Jullien, Bisch, Largouet, Manouvrier, Carling, & Amiard, 2008; Kaplan, Erkmen, & Taskin, 2009). It measures a player's ability to run and turn at maximum speed (Kaplan et al., 2009). The test is typically setup using either two or three parallel lines. The placement of the start/finish line varies depending on the test. During the three line test, the participant begins the test from one side of the centre line (*Figure 7*). During the two line test, the participant begins the test from one line or the other (*Figure 8*). The test begins when the researcher signals the participant to start. The participant must run at maximum speed and then quickly turn when they reach the opposing line. During the turn, both feet must cross the line or the trial is disqualified. The test is finished when the participant has completed the required number of changes of direction and crosses the finish line with both feet. The number of changes of direction completed during the shuttle run ranges from 2 (Markovic et al., 2007) to 9 (Kaplan et al., 2009). The distance between lines also varies a great deal ranging from 4.57m (5yd) to 18.29m (20yd). One of the more commonly used distances is 4.57m due to ease of testing when using an American football field which has lines at 4.57m intervals.

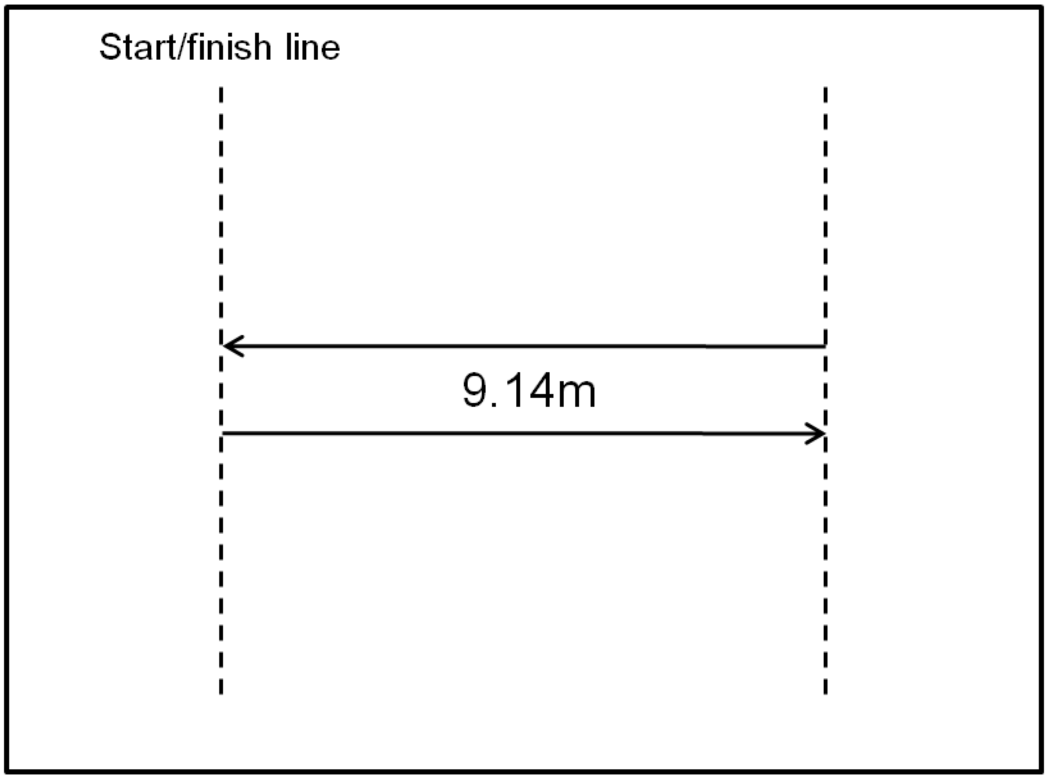

Figure 7. The 3 line shuttle run (modified from Brown & Ferrigno, 2005).

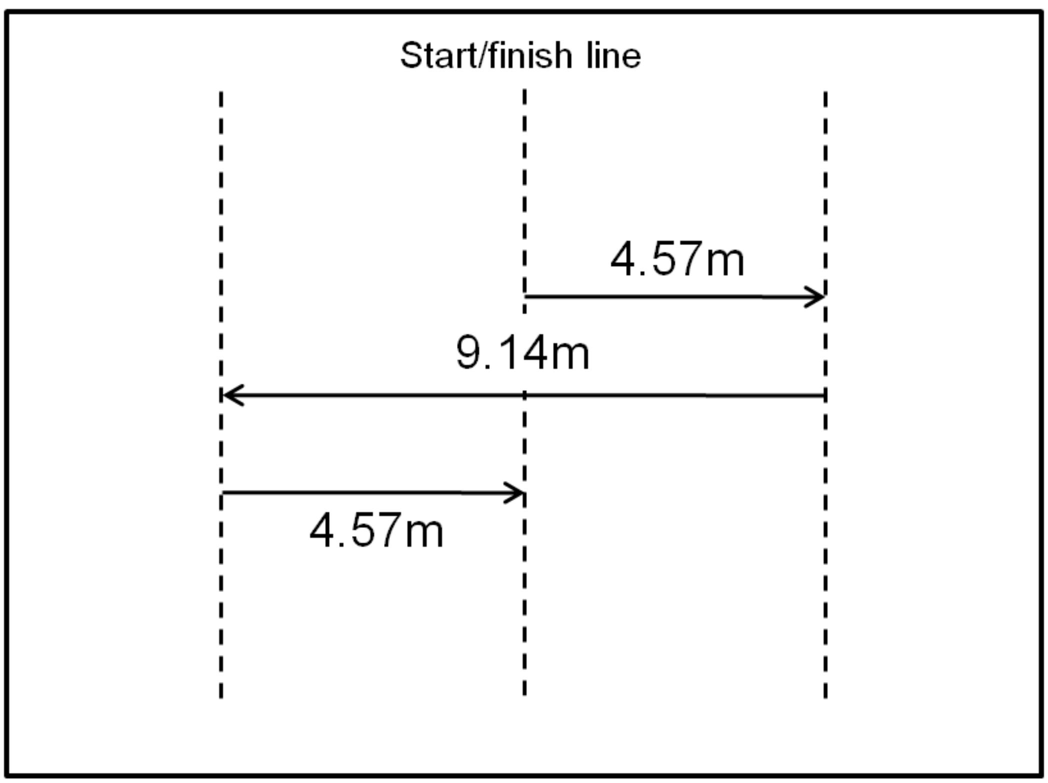

Figure 8. The 2 line shuttle run (Kaplan et al., 2009).

Similarly to the 505 agility test, the shuttle run places an emphasis on straight line speed and changes in acceleration. This means that the shuttle run does not meet the requirements of the theoretical breakdown of agility set forth by Jeffreys (2006). The shuttle run once again places an emphasis on initiation and actualization movements with no transitional period. It could be argued that the 180 degree changes of direction are transitional in nature but they represent a form of cut step where the performer is merely changing direction in the quickest fashion. There are currently many different shuttle run test protocols in use in the current literature. For this reason, it is hard to compare the results of one protocol to the next. Time to completion typically ranges from 5-10 seconds (Jullien et al., 2008; Lidor et al., 2007). There are however extreme cases such as the 5 × 10 shuttle run test used by Kaplan et al. (2009) which took approximately 180 seconds to complete. Similar to the standard Illinois agility test, a shuttle run test being used for soccer players should last less than 14 seconds in order to apply to the requirements of a soccer match (Vescovi & McGuigan, 2008). The variety found in shuttle run testing takes away from the concept of standardization that should be found in an agility testing protocol. Even within the same sport, the protocols vary limiting a coach or trainer's ability to compare their athletes to others.

T-test.

The t-test is one of the most commonly used agility tests (Chaouachi et al., 2011; Hoffman, Ratamess, Cooper, Kang, Chilakos, & Faigenbaum, 2005; McBride, Triplett-McBride, Davie, & Newton, 2002; Miller et al., 2006). Table 8 identifies studies from the current literature that used the t-test. The t-test involves forward sprinting, lateral movement, and backpedalling (*Figure 9*) (McBride et al., 2002) over a distance of approximately 36.5m.

The following is a description of the standard T-test protocol (Semenick, 1990) (Figure 9). During the T-test, a participant starts by sprinting 9.14m from the starting cone to the centre cone, which they must touch. The participant must remain facing the top of the T shaped course during the entire test. Immediately following this, they begin to shuffle laterally towards the outside cone 5m away. The participant must touch the outside cone, then reverse their lateral shuffle, and continue 9.14m until they reach the other outside cone. Upon touching the outside cone, the participant once again reverses their lateral shuffle and continues for 4.57m returning to the middle cone. After touching the middle cone, the participant backpedals for 9.14m as quickly as possible through the finish line.

The standard T-test takes approximately 10 seconds to complete. The time to completion is typically measured using a single set of timing gates placed at the start/finish line (Pauole et al, 2000). However, the T-test can also be measured using a stopwatch as well.

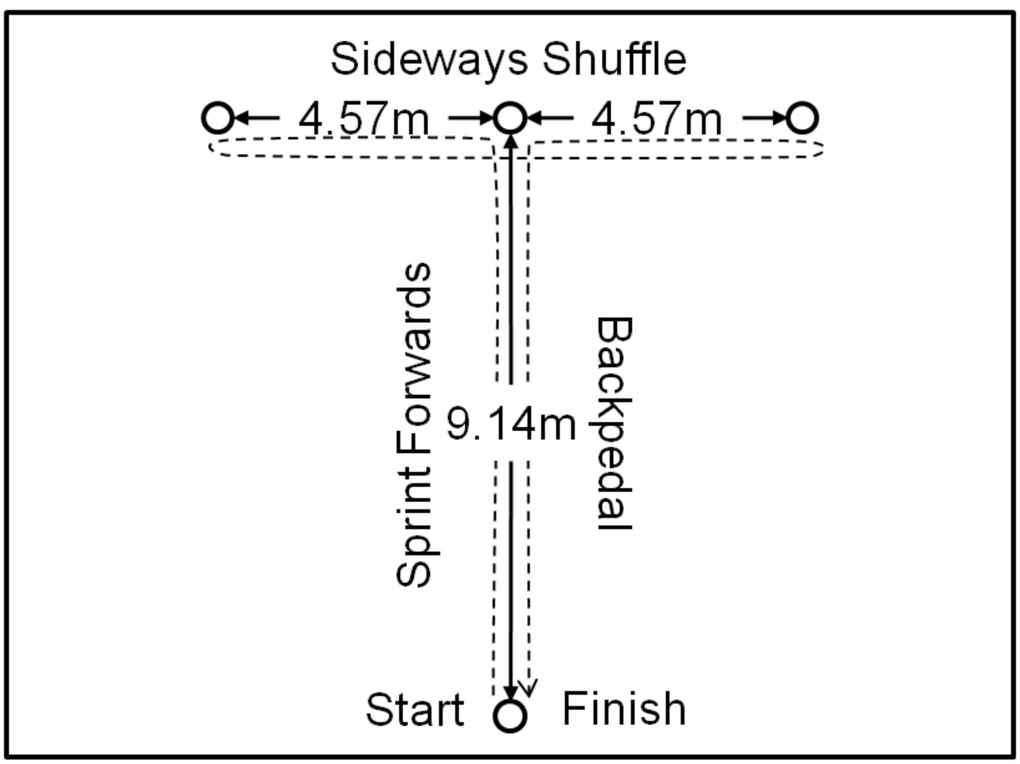

Figure 9. Equipment setup for the T-test (modified from Semenick, 1990).

The T-test is the first test evaluated in this review that meets all of the requirements set forth in Jeffreys' (2006) definition of agility. The T-test involves initiation movements in the form of the first step and cut steps, transitional movements in the form of side shuffling and backpedalling, and actualization movements in the form of sprinting to a given position. However, the order of the movements performed during the test is arranged such that the sequence ends in a transitional phase with backpedalling. Placing a large emphasis on backpedalling also provides a bias towards defenders who spend 10.1% of the time moving directly backwards versus strikers and midfielders who spend only 5.6% and 5.2% of the time moving directly backwards respectively (Bloomfield et al., 2007). Since most of the crucial movements in soccer occur at a high intensity (Little & Williams, 2005), the last portion of an agility test should involve an actualization movement such as a sport skill or a sprint.

Table 8
T-test scores in the current literature

Study	Sport background	Sample	Age (yrs)	Mean ± *s* (s)
Chaouachi et al., 2009	National level basketball players	N=14 males	23.3 ± 2.7	9.7 ± 0.20
Cronin et al., 2003 Modified T-test	3 years strength-training experience	N=10 males	24.2 ± 2.3	3.77 ± 0.37
Delextrat & Cohen, 2008	Elite basketball players (first university team)	N=8 males (elite)	25.4 ± 2.4	9.21 ± 0.24
	Average basketball players (second university team)	N=8 males (average)	21.9 ± 2.1	9.78 ± 0.59
Delextrat & Cohen, 2009	English national league division II basketball players	N=30 females	25.2 ± 3.0	10.45 ± 0.51
Gabbett et al., 2008	Junior basketball players	N=6 males N=8 females	16.3 ± 0.7	10.47 ± 0.53 (open skill warm-up) 10.48 ± 0.61 (closed skill warm-up)
Haj Sassi et al., Haj	Sport science students	N=52 males	22.4 ± 1.5	10.08 ± 0.46

Table 8

T-test scores in the current literature

Study	Sport background	Sample	Age (yrs)	Mean ± *s* (s)
Sassi et al. 2009 T-test & *modified agility T-test (MAT)		N=34 females	22.6 ± 1.4	11.92 ± 0.52 *6.19 ± 0.32 *7.20 ± 0.35
Jarvis et al., 2009	Rugby	N=19 males	23.0 ± 5.4	11.7 ± 1.3
Miller et al., 2006	Students	N=19 males (10 control, 9 training)	24.2 ± 4.8 (control)	Pre 12.6 ± 1.1 / Post 12.6 ± 1.1
		N=9 females (4 control, 5 training)	22.3 ± 3.1 (training)	Pre 12.8 ± 1.0 / Post 12.1 ± 1.1
Munro & Herrington, 2011	Recreational athletes	N=11 males N=11 females	22.3 ± 3.7 22.8 ± 3.1	10.74 ± 0.50 13.02 ± 0.87
Pauole et al., 2000	College students w/ varying levels of sport participation	N=152 males	22.3 ± 4.0	11.20 ± 0.80 (male low sport) 10.49 ± 0.89 (male recreation) 9.94 ± 0.50 (male athletes)
		N=152 females	22.4 ± 3.9	13.55 ± 1.33 (female low sport) 12.52 ± 0.90 (female recreation) 10.94 ± 0.60 (female athletes)
Sporis et al., 2010	Elite junior soccer	N=150 males	19.1 ± 0.6	8.12 ± 0.27

Number of trials and rest between trials.

In the current literature, there is no standard agreement on the number of trials completed by participants during agility testing and how many of those trials are used during analysis. The number of trials performed by each participant typically ranges from 1-3 (Cronin et al., 2003; Delextrat & Cohen, 2008; Gabbett, Kelly, & Sheppard, 2008; Jarvis et al., 2009; Jones, Bampouras, & Marrin, 2009; Pauole et al., 2000). The number of trials completed increases in importance when a researcher calculates reliability scores. The 505 agility test often involves participants completing 2-3 trials with a single trial being used for correlation purposes (Gabbett et al., 2008; Jones et al., 2009). Although there is much variation among the protocols used for running the shuttle run test, most of the studies in this review had participants complete 1-2 trials with all trials being used for analysis (Jullien et al., 2008; Kaplan et al., 2009; Lidor et al., 2007). For the Illinois agility test 2-3 trials were completed in all studies with 1 and 2 trials being used in analysis (Caldwell et al., 2009; Jarvis et al., 2009; Vescovi & McGuigan, 2008). In the current literature, few studies involving the Illinois agility test have been carried out using the same combination of trials performed versus trials used during statistical analysis. The T-test is by far the most commonly used test for measuring agility in the current literature. Researchers in the current literature had participants complete 1-3 trials (Chaouachi et al., 2009; Cronin et al., 2003; Delextrat & Cohen, 2009; Gabbett et al., 2008; Haj Sassi et al., 2009; Pauole et al., 2000). With regards to the T-test, the literature appears to be split between whether to use the fastest trial (Delextrat & Cohen, 2009; Gabbett et al., 2008; Pauole et al., 2000) or all trials (Chaouachi et al., 2009; Cronin et al., 2003; Haj Sassi et al., 2009; Pauole et al., 2000) for analysis purposes. One study used an average score of 3 trials for analysis purposes (Miller et al., 2006). Although there is little agreement on the number of trials used during analysis, it is evident that at least 2 trials should be collected in order to provide the researcher with multiple options when it comes to final statistical analysis.

Similarly, the amount of rest is also important when considering repeatability of an agility protocol. Rest time becomes extremely important when completing maximum effort testing. A participant must be able to perform the protocol at a maximum effort and then repeat this effort on subsequent trials. If the participant is unable to fully recover, then he/she will most likely yield less reliable results. The most commonly used rest period in agility testing is 3 minutes (Haj Sassi et al., 2009; Pauole et al., 2000; Sporis et al., 2010; Vescovi & McGuigan, 2008). Alternatively, several researchers have also used 1 minute of rest in between trials (Barnes et al., 2007; Cronin et al., 2003; Meylan et al., 2009). Therefore, based on the current literature, at least 1 minute of rest should be observed by participants in between maximum effort trials.

Modifications to agility testing.

In order to continually improve performance assessment protocols, it is sometimes necessary to modify the test in order to improve reliability and validity. Cronin, McNair, and Marshall (2003), modified the total distance travelled during the T-test to be 11m instead of 36.6m in order to better represent the on-court conditions found in sports such as badminton and squash. Haj Sassi et al. (2009) argue that most distances and duration of sprints during field and court sports take 10-20m and last 2-3 seconds. They modified the total distance travelled during the T-test to 20m in order to make the test more specific to field and court sports (Haj Sassi et al., 2009). McMillan, Moore, Hatler, & Taylor (2006) modified the T-test by making the forward and backward running portions of the test 5m in length instead of 10m in order to place more emphasis on the lateral portion of the test. Vescovi and McGuigan (2008) used a modified version of the Illinois agility test in order to increase specificity and decrease the chance of metabolic limitations due to the original test protocol taking 16-18 seconds to complete. They eliminated two out of four straight sprinting sections in order to place an increased emphasis on agility and not repeated sprint ability (Vescovi & McGuigan, 2008). In 2008, Gabbett et al. modified the 505 agility test in order to see how decreasing the distance travelled during the test would affect the reliability of the results. They found the modified 505 agility test increased reliability over the standard 505 agility test (Gabbett et al., 2008). The modification of many testing protocols in the current literature indicates a need to develop new protocols which measure agility.

Reliability and Validity

Reliability and validity are important aspects of any measurement tool. The following sections will discuss reliability and validity in detail. When evaluating the reliability and validity of a measurement tool, it is first important to understand the relationship that these two concepts share. First, it is possible for a measurement to be reliable but not valid, however, it is not possible for a measurement to be valid if it is not also reliable (Trochim, 2005). The reasoning behind this will become evident in the following sections.

Reliability and Agility Testing

Trainers, coaches, and researchers are always looking for reliable and valid techniques that can be used to assess athletic performance. In order to determine which agility test is most appropriate, the reliability of the test must be considered. Reliability is the degree to which a measuring instrument yields consistent results (Thorndike, 2001). Thorndike (2001) also stated that “a reliable measure is one that is free from random variation” (p.14). In order to assess the reliability of a measurement tool, it is important to understand measurement error.

Measurement error causes the observed value of a measure to be different than the true value (Hopkins, 2000). Classical true score theory maintains that each measurement is the sum of two components, the true score of the participant and random error (Trochim, 2005). Classical true score theory can be represented by the simple yet powerful equation: $X = T + e$, where $X =$

observed score, T = true score and e = random error. For example, a measure which has no random error, and is therefore all true score, is perfectly reliable. Conversely, a measure which is composed entirely of random error, and therefore has no true score component, has zero reliability (Trochim, 2005). Hopkins (2000) stated that random error is the most important measurement error to come out of a study and that the smaller the random error, the better the measure. An example of random error could include inconsistent posture control while completing agility testing from trial to trial. This type of error can be difficult to control if it is inherent to the measurement tool (Atkinson & Nevill, 1998). One method used to manage the occurrence of random error in measurements is to make sure that a large sample size is acquired. In a large sample, random error from individual measurements will tend to cancel out once added together in calculating the mean. In addition to random error, it is possible for error to occur systematically across all participants in a sample, this is known as systematic error (Trochim, 2005). Systematic error therefore refers to a general trend for measurements to be different in a particular direction (Atkinson & Nevill, 1998). An example of systematic error would include a learning effect where agility protocol retests are faster than prior trials. An example of systematic error trending in the opposite direction would occur where inadequate rest time is allowed between trials for all participants and this increased trial time across the entire sample. In order to include systematic error in the classical true score theory equation, the error component is divided into random error systematic error. The classical true score theory equation can then be revised as follows: $X = T + e_r + e_s$, where X = observed score, T = true score, e_r = random error, and e_s = systematic error. The difference between random error and systematic error is in how they affect the central tendency within a sample. Random error adds variability to a distribution but does not affect the central tendency as long as the sample is large enough. Systematic error does affect the central tendency of a distribution positively or negatively (Trochim, 2005). Systematic and random errors are therefore the two components associated with the assessment of measurement error (Atkinson & Nevill, 1998).

It is important to question whether a set of measurements of agility remain the same over time or over repeated measurements. Test-retest reliability is used often to assess the consistency of a measure from one time to another (Trochim, 2006). This will confirm for the researcher that the agility test is stable over time and that any measured change is a result of a true change in the trait and not the result of systematic or random error. However, the time interval between testing sessions will have an effect on the scores with a shorter interval resulting in higher correlation between the two sets of scores (Trochim, 2006). Reliability is often measured using intraclass correlation coefficient (Barnes et al., 2007; Chaouachi et al., 2009; Cronin et al., 2003; Gabbett et al., 2008; Haj Sassi et al., 2009; Jullien et al., 2008; Pauole et al., 2000; Sporis et al., 2010). Safrit and Wood (1995) have stated that an intraclass correlation coefficient (ICC) score of 0.90 is high, between 0.80 and 0.90 is moderate, and less than 0.80 is too low to be considered acceptable in physiological field-testing. However, within the sports medicine testing literature, there is no consensus regarding intraclass correlation cut off levels. Regardless, it has been suggested that an intraclass correlation coefficient closer to 1 indicates excellent reliability and a coefficient closer to 0 indicates poor reliability (Atkins & Nevill, 1998). Agility tests in the current literature have varying reliability scores and it is important to examine each one prior to selecting a test for use in a study or team evaluation (Table 9).

Many agility tests are currently found in the literature. Overall, the T-test showed the highest individual reliability however varied widely with ICC scores ranging from 0.82-0.98.

The 505 agility test was also reported to have high reliability with ICC scores between 0.90 and 0.92 for the standard and modified protocols respectively. Contradictory results were found within the literature for the shuttle run test with both a high score of 0.91 and an extremely low score of 0.69. This is most likely due to the large variability in shuttle run testing protocols. To the author's knowledge, no study has been completed evaluating the reliability of the Illinois agility test. All of the tests evaluated in this paper with the exception of the Illinois agility test scored moderate to high in terms of reliability and therefore serve as good candidates for testing participants assuming they have been properly validated.

Table 9
Reliability of common agility tests

Study	Agility test	ICC
Barnes et al., 2007	4 × 5 shuttle run test	0.69
Chaouachi et al., 2009	T-test	0.96
Cronin et al., 2003	Modified T-test	0.88
Gabbett et al., 2008	505 agility test	0.90
	Modified 505 agility test	0.92
Haj Sassi et al., 2009	Modified T-test	
	Males	0.95
	Females	0.92
Jullien et al., 2008	2 × 11 shuttle run test	0.91
Munro & Herrington, 2011	T-test	
	Males	0.82
	Females	0.96
Pauole et al., 2000	T-test	
	1-trial	0.94
	2-trial	0.97
	3-trial	0.98
Sporis et al., 2010	T-test	0.93

Validity

In order to determine that an agility test is valid, a researcher must be certain that the test is measuring exactly what he/she thinks it does (Thorndike & Dinnel, 2001). Trochim (2005) stated that a valid measure provides "the best available approximation of the truth of a given proposition, inference, or conclusion" (p. 16). In addition to the preceding definitions, there are many varying definitions of validity. There are many different types of measurements and therefore many different types of validity (Thorndike & Dinnel, 2001), this includes but is not limited to face, criterion, content, and construct validity (Leedy & Ormrod, 2010).

Face validity is the simplest form of validity (Leedy & Ormrod, 2010). It is subjective in nature and represents how much the test in question measures what it claims to (Sim & Arnell, 1993). Trochim (2005) defined face validity as "a type of validity that assures that "on the face" the operationalization seems like a good translation of the construct" (p. 51). The T-test measures a participant's ability to sprint forwards, backpedal, and shuffle side-to-side at speed (Semenick, 1990). Using Trochim's definition of face validity, the operationalization is the T-test and the construct would be agility. The movements contained within the T-test are all present in the sport of soccer and therefore the T-test would appear to have strong face validity and be a valid measurement tool for testing soccer players.

Criterion validity can be broken down into 2 types of validity: predictive validity and concurrent validity. Construct validity can also be broken down into 2 types of validity: convergent validity and discriminant validity. These four types of validity will be discussed in the following sections.

Predictive validity.

Predictive validity assesses the test's ability to predict something it should theoretically be able to predict (Trochim, 2005). Thorndike and Dinnel (2001) described predictive validity as involving the collection of predictor data, followed by an elapsed period of time, after which the same series of tests are re-administered and the criterion data collected. For example, if the T-test has high predictive validity, it should be able to predict based on test scores which participants will perform better in match play. This however requires an initial measurement, agility trials, followed later by a criterion measure against which those scores are compared to. This was not feasible in the case of this study where all data was being collected in a short timeframe due to team scheduling. Therefore predictive validity was not used in order to validate the measurement tools used in this study.

Concurrent validity.

Concurrent validity examines the degree to which the measurement tool in question correlates with a “gold standard” test which has previously been validated (McIntire & Miller, 2005). Concurrent validity involves the collection of both the predictor and criterion data at the same time and therefore can be completed in a shorter time frame than predictive validity (Thorndike & Dinnel, 2001). Pauole et al. (2000) completed a study in which they investigated the reliability and validity of the T-test as a measure of agility, leg power, and leg speed. They compared the standard T-test protocol outlined by Semenick (1990) to the hexagon test, as it was another agility measurement protocol commonly used to assess tennis players at the time. The two testing protocols were compared using Pearson’s r correlation. Pauole et al. (2000) determined that the T-test appears to be “a reliable and valid measure of leg speed and secondarily of leg power and agility” (p. 449). During the study, the researchers had participants perform both the T-test and hexagon test and then compared the criterion data. They found that the T-test had high to moderate correlations with the hexagon test which indicated that both tests were measuring the same construct. Since the hexagon test was stated to measure agility, they concluded that the T-test also measures agility (Pauole et al., 2000). Pearson's r correlation has previously been used to assess the relationship between two testing protocols (Wong, Chan, & Smith, 2011). Concurrent validity will be one of the focuses of this study.

Convergent validity.

Convergent validity examines the degree to which the test in question is similar to other tests which it should theoretically be similar to (Trochim, 2006). The difference between concurrent and convergent validity is that concurrent validity is concerned with the criterion data of both measurement tools which are being compared and convergent validity is concerned with the relationship of the constructs being measured including their shared variance. If the T-test was being validated using convergent validity, it would be compared to other agility tests and the results would be compared to examine the overlapping variance which might occur. Convergent validity was not used in this study since the researcher was satisfied with the statements from the current literature describing the T-test as measuring the construct of agility (Pauole et al., 2000; Sporis et al., 2010).

Discriminant validity.

Discriminant validity is the degree to which the item in question is not similar to other items which it theoretically should not be (Trochim, 2005). For example, if the T-test is a valid measure of agility, it should have a low correlation to tests which measure skills not related to agility. This can be difficult to assess accurately since agility has many components and therefore should theoretically demonstrate a correlation with many of the existing performance tests such as the 40m sprint and maximal countermovement jump. An agility testing protocol which measures agility, should also be able to discriminate between skill groups which should theoretically be different. Ben Abdelkrim and colleagues (2010) found that both senior and under-20 basketball players performed better than under-18 players when tested using the T-test. Gabbett and Georgieff (2007) found that junior national and state volleyball players performed significantly faster in the T-test than novice volleyball players. Discriminant validity has previously been evaluated using a factorial ANOVA in order to test for significant differences (Coelho E Silva et al., 2010; Wong et al., 2011). Discriminant validity will be one of the focuses of this study.

Development of a New Testing Protocol

To date, there has been no agility testing protocol developed specifically to test soccer players. This warrants the development of soccer specific agility tests (Chaouachi et al., 2011). A new testing protocol must meet the theoretical and empirical descriptions of agility found in the current literature, provide a reliable and valid measurement of agility performance, and apply directly to the sport being tested. Therefore, the test must include all three portions of Jeffreys' (2006) theoretical concept of agility, initiation, transition, and actualization, as well as the basic locomotor movements described by time motion analyses in the current soccer agility literature. This includes movements such as short sprints, rapid acceleration or deceleration, turning, jumping, kicking, and tackling (Kaplan et al., 2009). The new protocol must be based on the new definition of agility outlined as follows: "agility is the process of coordinating appropriate parts of the body in a rapid and functional manner in the face of environmental constraints."

New soccer agility test.

A new test of agility was developed based on the criteria outlined in the preceding section entitled "Development of a New Testing Protocol" (F*igure* 10). The test is self-initiated with the participant starting when ready. The participant begins the test from a prone position with a soccer ball directly above his/her head. Upon starting the test, the participant gets up from the ground and jumps over the soccer ball. He/she then sprints around cone A to cone B. Upon reaching cone B, he/she side-shuffles to cone C. The participant then manoeuvres around cone D and sprints to cone E. Upon touching the base of cone E, the participant then backpedals back to cone D. Upon reaching cone D, the participant turns inwards and navigates between cones B and C and around cone A. He/she then sprints towards the timing gates and kicks the soccer ball into the net to complete the test. The total distance covered is 36.5m.

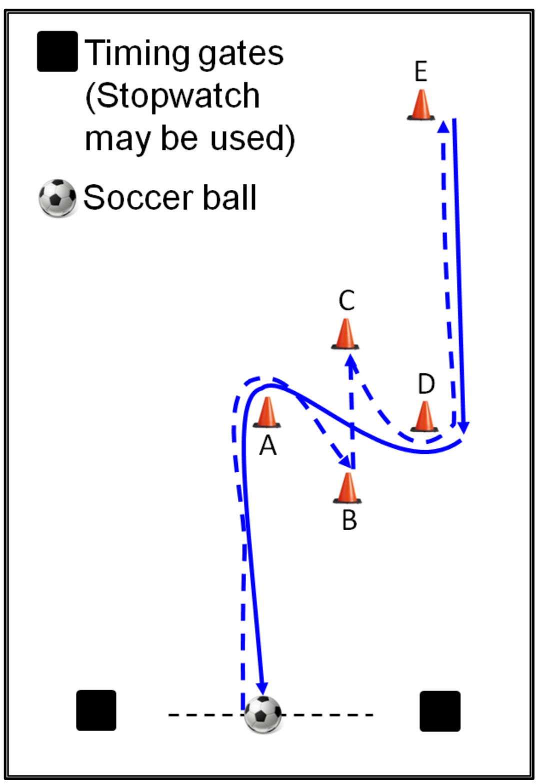

Figure 10. New soccer agility test.

The new soccer agility test represents an improvement over previous agility tests because it accurately reproduces a large portion of movements found in the sport of soccer as well as other sports. The test includes straight sprints, getting up from the ground, jumping, turns, rapid cuts, backpedalling, and a sport specific task which will help develop face validity for the new agility test. The test also meets the requirements of the new definition of agility which is the process of coordinating different parts of the body in a functional manner as quickly as possible in the face of different environmental constraints. In this case, the participant is constrained by the cones and ball during the test. The t-test is the only other test of agility which contains initiation, transitional, and actualization target functions as set forth by Jeffreys (2006), however, this new test of agility uses all of the initial and transitional target functions in order to place the participant in position to perform the actualization target function of kicking the ball as opposed to simply running to a final location. Therefore, the new test of agility in soccer represents an improvement over the traditional methods of testing agility with regards to soccer.

Significance

To date, there have been many studies utilizing the T-test as a measure of agility or change of direction speed (Chaouachi et al., 2009; Cronin et al., 2003; Delextrat & Cohen, 2008; Delextrat & Cohen, 2009; Gabbett et al., 2008; Haj Sassi et al., 2009; Jarvis et al., 2009; Miller et al., 2006; Pauole et al., 2000; Sporis et al., 2010). A few studies have attempted to modify agility tests (Gabbett, Kelly, & Sheppard, 2009; Vescovi & McGuigan, 2008) including the standard T-test protocol (Cronin, McNair, & Marshall, 2003; Haj Sassi, Dardouri, Haj Yahmed, Gmada, Elhedi Mahfoudhi, & Gharbi, 2009) in order to closely replicate the requirements of the sport in which the participant competes. However, the development of a new agility test based on the theoretical basis of agility in combination with the locomotor requirements of soccer may lead to a more valid soccer agility assessment tool. This new tool must include sprinting, backpedalling, shuffling side-to-side, turning, and getting up from the ground quickly.

Purpose

The purpose of this study was to evaluate the reliability and validity of a new agility testing protocol designed to measure agility in competitive male soccer players.

Hypothesis

The new soccer agility test was developed based on the physical requirements of soccer and on agility theory. Accordingly, three hypotheses were made regarding its reliability and validity:

1. The new soccer agility test will demonstrate a satisfactory degree of both between-day and within-day reliability.
2. The new soccer agility test will demonstrate a satisfactory degree of concurrent validity with the T-test for each team.
3. The new soccer agility test will demonstrate a satisfactory degree of discriminant validity among the three teams.

Method

Participants

A sample of 54 competitive male soccer players was recruited to take part in this study. All participants were members of the Thunder Bay Chill soccer organization. Participants were recruited from 3 teams, each which plays at a different level of competition: Premier

Development League (PDL), Reserve, and Elite. Players from the PDL team compete in the Heartland division of the Central conference of the United Soccer Leagues which consists of teams from Canada, the United States, and Bermuda. Both the Reserve and Elite teams compete locally at a high level of play. Players of all positions took part in testing including forwards, midfielders, defenders, and goaltenders. Prior to the commencement of agility testing, age, height, and mass were collected using the sports experience questionnaire (See Appendix A). The mean and standard deviation for each team can be found in Table 10.

Table 10
Descriptive statistics for age, height, and mass by group

Group	Age (years)	Height (cm)	Mass (kg)
PDL (*n* = 16)	22.1 ± 2.7	178.1 ± 6.2	76.3 ± 7.0
Reserve (*n* = 17)	15.5 ± 1.5	172.3 ± 7.4	64.8 ± 10.4
Elite (*n* = 21)	10.9 ± 0.8	138.4 ± 21.5	39.7 ± 7.7

Note. Values are shown as mean ± SD.

Positional data was also collected prior to testing using the sports experience questionnaire. An analysis of frequencies was run using positional data and can be found in Table 11. Several players from the PDL team were injured and therefore did not participate in testing. The PDL and Elite teams were both equally distributed among the forward, midfield, and defence positions, however, the Reserve team had an uneven distribution with the number of defence equalling the number of forwards and midfielders combined.

Table 11
Player position frequency by team

Team	Forward	Midfielder	Defence	Goaltender
PDL	5	5	4	2
Reserve	5	3	8	2
Elite	6	7	6	2
All teams	16	15	18	6

Instrumentation

Two agility tests were used in this study: the T-test and the new soccer agility test. The T-test is the most commonly used agility testing protocol found in soccer literature (Chaouachi et al., 2009; Cronin et al., 2003; Delextrat & Cohen, 2008; Delextrat & Cohen, 2009; Gabbett et al., 2008; Haj Sassi et al., 2009; Jarvis et al., 2009; Miller et al., 2006; Pauole et al., 2000; Sporis et al., 2010). The new soccer agility test was developed to measure agility in soccer players specifically. Players had no previous experience involving either of the testing protocols prior to testing. Both testing protocols involved the use of pylons and a Brower timing system. The new soccer agility test used a regulation size 5 soccer ball for both the PDL and Reserve teams and a youth regulation size 4 soccer ball for the Elite team.

T-test.

The T-test was setup according to the original protocol outlined by Semenick (1990) (Figure 11). Timing gates were placed at the start/finish line at a height of 0.75m with a distance of 3m between them. The participant started the test in a staggered two point stance with feet approximately shoulder width apart. Participants were allowed to start with the preferred foot forward. The start of the test was self-initiated. Participants were instructed to always face the top of the T and to not cross their feet when shuffling between cones.

The T-test

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The T-test is a measure of four-directional agility and body control. It measures the ability to change directions rapidly while maintaining balance without loss of speed.

The equipment necessary to conduct the T-test includes the following:

1. Four cones
2. Stopwatch (1/10 second)
3. Basketball gymnasium floor
4. One timer, one spotter, one person to record times

The four cones should be arranged as shown in **Figure 1**. The distance between points A and B is 10 yards, the distance between points C and D is 10 yards. There should be a cone placed at points A, B, C and D.

Each athlete should warm up and stretch properly before participating in the T-test. The test administrator or a nonparticipant should demonstrate proper procedure for the T-test, and then the athletes should be allowed to take up to two submaximal trial runs to familiarize themselves with the test procedures.

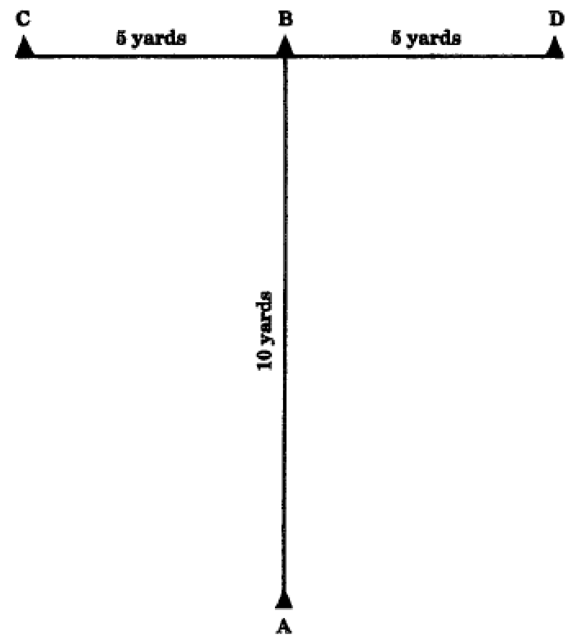

Figure 1. T-test Diagram

Figure 11. T-test protocol setup (Semenick, 1990).

Upon commencing the T-test, the participant sprinted forward and touched the central cone with a hand. The participant then shuffled 4.57m laterally to the left and touched the far left cone with a hand. This was followed by a lateral shuffle 9.14 m to the right. Upon touching the far right cone, the participant then reversed direction and shuffled 4.57 m laterally back to touch the centre cone. Lastly, the participant backpedalled as quickly as possible through the finish line 9.14 m away. Trials were disqualified if the participant fell, failed to face the top of the T, or crossed his feet while shuffling.

New soccer agility test.

The new soccer agility test was setup as outlined below in Figure 12. Similar to the T-test, timing gates were setup 3m apart at a height of 0.75m at the start/finish line. A soccer ball was placed in the centre of the start/finish line such that the beam of the timing gates would be split upon contact with the ball and the subsequent follow through of the participant's body. The participant started the test prone with his head behind the soccer ball. The beginning of the test was once again self-initiated. If a stopwatch were used however, a countdown would have to be used to start the test.

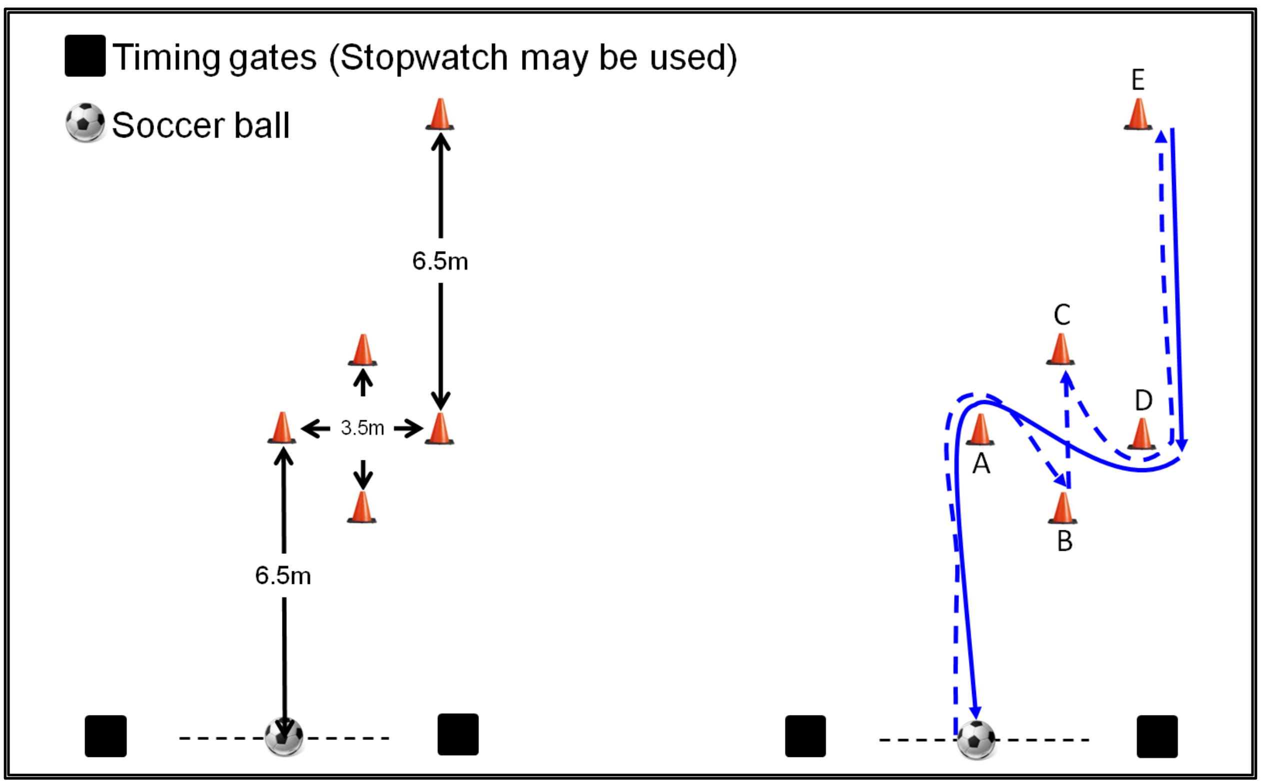

Figure 12. New soccer agility test setup.

The start of the test is self-initiated with the participant starting when ready. The participant begins the test from a prone position with a soccer ball directly above his/her head. Upon starting the test, the participant gets up from the ground and jumps over the soccer ball. He/she then sprints around cone A to cone B. Upon reaching cone B, he/she side-shuffles to cone C. The participant then manoeuvres around cone D and sprints to cone E. Upon touching the base of cone E, the participant then backpedals back to cone D. Upon reaching cone D, the participant turns inwards and navigates between cones B and C and around cone A. He/she then sprints towards the timing gates and kicks the soccer ball into the net to complete the test. Trials were disqualified if a participant fell or if they failed to score a goal upon kicking the ball at the conclusion of the test.

Procedures for Testing

Testing took place on 2 days in late spring and all trials were completed on a grass surface during sunlight hours. All three teams attended separate testing sessions. All teams completed testing on similar natural grass fields that were used by the teams for training purposes. Each team completed testing on the same field for both sessions. All players wore their practice uniforms and shoes with rubber or plastic cleats. The sports experience questionnaire was completed on day 1 along with the informed consent form and a physical activity readiness questionnaire (PAR-Q) (See Appendix B). Days 1 and 2 were otherwise identical in format.

Testing sessions.

The schedule of testing was dictated in part by weather and in part by the team schedule for all teams. PDL team testing sessions took place on Monday at 3:00pm and on Saturday of the same week at 10:00am. The Reserve team testing sessions took place on Monday at 8:00pm and on Saturday of the same week at 1:00pm. The Elite team testing sessions took place on Tuesday at 5:00pm and on Saturday of the same week at 11:30am. The PDL team's testing sessions took 45 minutes to complete not including time to fill out forms on day 1. The Reserve and Elite teams' testing sessions each took 60 minutes to complete not including time to fill out forms on day 1.

Day 1 and 2 testing protocol.

Prior to the start of testing, all participants completed a standardized warm-up consisting of dynamic stretching and light jogging. Following the warm-up, the T-test and the new soccer agility test were demonstrated by the researcher (See Figures 11 and 12). Participants were allowed to complete a single submaximal practice trial of each agility protocol prior to the commencement of testing. At least 2 minutes of rest followed the warm-up and subsequent practice trials.

Both the T-test and the new soccer agility test were setup adjacent each other on the same soccer field. The order in which participants would complete the agility trials was randomized at the beginning of each testing session. Participants were randomly split into 2 groups and then completed the testing protocols according to their randomized order. Each participant completed 2 trials for both the T-test and the new soccer agility test and was required to rest at least 2 minutes between trials. If a participant fell, knocked over a cone, or did not touch a cone, the trial was disqualified and another trial was completed after at least 2 minutes of rest.

Dependent Variable

This study involved only a single dependent variable, time to completion, which was measured as the time from the beginning of the test until the participant crossed the finish line.

This was measured in seconds using timing gates setup for both the T-test and the new soccer agility test.

Independent Variable

Three independent variables were identified for this study, competition level, agility test, and testing day. Competition level was used to divide the study sample into three subgroups: PDL, Reserve, and Elite. The two tests used in this study were the T-test and the new soccer agility test. The third independent variable, testing day, was represented by testing day 1 and testing day 2.

Statistical Analysis

All statistical analyses were performed using SPSS Statistics 17.0 for Windows. The mean and standard deviation were calculated for all variables. A frequency analysis was run on the positional data.

Two-way random intraclass correlations for absolute agreement were run in order to assess reliability. Within-day reliability was calculated for both day 1 and day 2 using the faster of 2 trials for the corresponding agility tests. Between-day reliability was calculated using the fastest trial from day 1 and day 2 for the corresponding agility tests. Intraclass correlations were evaluated whereby scores greater than .90 were considered high, between .80 and .90 considered moderate, and less than .80 considered too low to be acceptable in physiological field-testing (Safrit & Wood, 1995).

Concurrent validity was evaluated using Pearson's r correlation. The T-test was selected as the "gold standard" test and compared to the new soccer agility test. The fastest trials from each testing session were used for the correlation. Magnitude of each correlation was evaluated using a modified scale developed by Hopkins (2000): trivial: $r < 0.1$; low: 0.1–0.3; moderate: 0.3–0.5; high: 0.5–0.7; very high: 0.7–0.9; nearly perfect > 0.9; and perfect = 1. The coefficient of determination was also calculated as r^2.

Discriminant validity was evaluated using a 3 x 2 x 2 (Team x Test x Day) mixed factorial ANOVA with repeated measures on the final two factors. A 3 x 2 factorial ANOVA was then run in order to assess the Team x Test interaction on both Days 1 and 2. This was followed by pairwise comparisons of the Team factor under all combinations of the Test and Day variables in order to test for significant differences. This analysis was performed using the fastest day 1 trial and fastest day 2 trial for each participant on each test. The significance level (α) was set at the .05 level.

Results

Agility Scores

Means and standard deviations were calculated using the fastest trial for each participant on day 1 and on day 2, for the PDL, Reserve, and Elite teams (Table 12). See Appendices C, D, and E for all trial data collected from the PDL, Reserve, and Elite teams respectively.

Table 12

Descriptive statistics for fastest agility scores on day 1 and day 2

Protocol	Team	Day 1 (s)	Day 2 (s)
T-test	PDL	9.44 ± 0.41	9.36 ± 0.30
	Reserve	10.10 ± 0.60	9.59 ± 0.47
	Elite	11.61 ± 0.52	11.07 ± 0.63
New soccer agility test	PDL	10.70 ± 0.52	10.16 ± 0.53
	Reserve	11.01 ± 0.64	11.03 ± 0.47
	Elite	12.62 ± 0.66	11.93 ± 0.56

Assessment of Reliability

The two-way random intraclass correlation testing for absolute agreement was run in order to assess reliability of both the T-test and the new soccer agility test. Table 13 outlines the results of the intraclass correlation procedure.

Table 13
Intraclass correlation for T-test and new soccer agility test

Team	Protocol	Within day 1	Within day 2	Between day 1 & day 2
PDL	T-test	.79	.73	.40
	NSAT	.90	.88	.52
Reserve	T-test	.91	.92	.83
	NSAT	.91	.92	.98
Elite	T-test	.87	.87	.55
	NSAT	.89	.88	.22

Note. NSAT = New soccer agility test.

Relatively low-moderate ICCs were found for the PDL team within-days 1 (.79) and 2 (.73) respectively for the T-test. A very low reliability score was found between-days 1 and 2 (.40) for the T-test. The new soccer agility test received higher reliability scores with high to moderately high reliability scores being found within-days 1 (.90) and 2 (.88) respectively. A low reliability score was once again found between-days 1 and 2 (.52) for the new soccer agility test.

The T-test demonstrated high reliability scores within-days 1 (.91) and 2 (.92) respectively for the Reserve team. A moderate reliability score of .83 was found between days for the T-test. For the new soccer agility test, high ICC scores were found once again demonstrating a high level of reliability. Between-day reliability was found to be very-high for the new soccer agility test.

The Elite team had moderate-high reliability scores for the T-test within-days 1 and 2. Between-day reliability was low for the T-test. The new soccer agility test demonstrated similarly moderate-high reliability scores within-days 1 and 2 respectively. However, between-day reliability was very low.

Assessment of Concurrent Validity

Pearson's r correlation analyses were run in order to evaluate the concurrent validity between the T-test and new soccer agility test for each team on day 1 and each team on day 2. Table 14 displays the results for the Pearson's r analysis, including effect sizes (r^2). Using a modified magnitude of correlation scale (Harris, Cronin, Hopkins, & Hansen, 2010), on Day 1, the magnitude of the correlation between the T-test and the new soccer agility test was found to be low for the PDL team (*Figure 13*), high for the Reserve team (*Figure 15*), and high for the Elite team (*Figure 17*). On Day 2, the magnitude of the correlation between the T-test and the new soccer agility test was found to be moderate for the PDL team (*Figure 14*) and high for both the Reserve (*Figure 16*) and Elite teams (*Figure 18*).

Table 14
Pearson's r correlation for the T-test and new soccer agility test for days 1 & 2

	Day 1		Day 2	
Team	r	r^2	r	r^2
PDL	.21	.04	.48	.23
Reserve	.75	.56	.55	.30
Elite	.68	.46	.60	.36

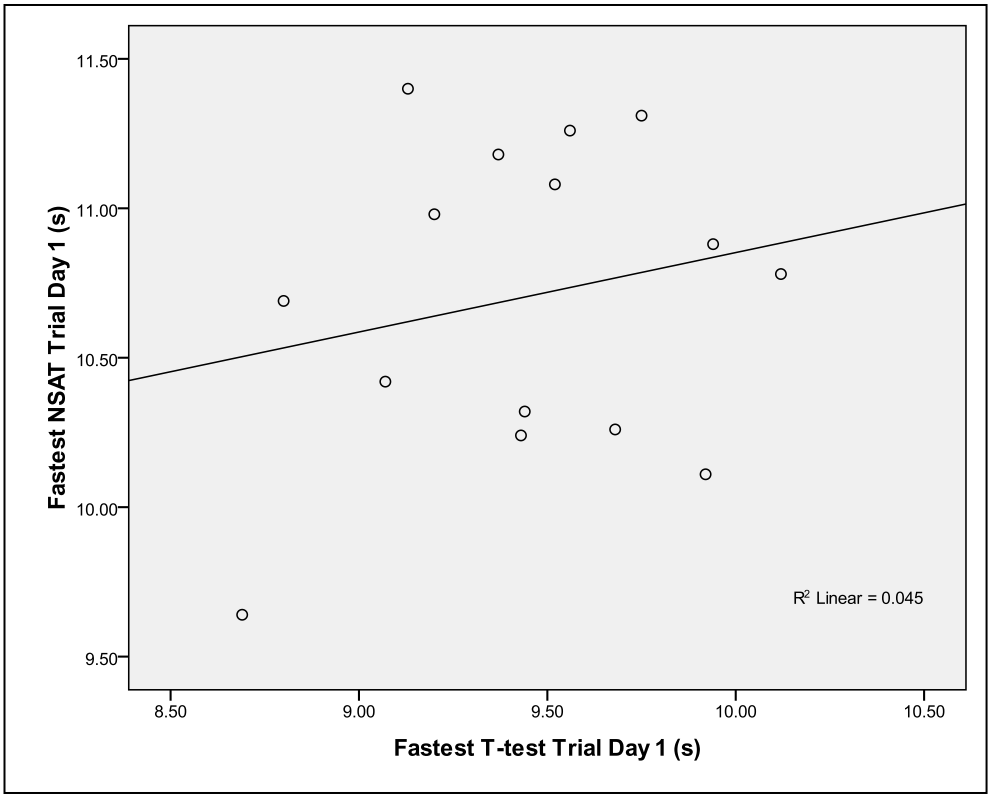

Figure 13. NSAT vs T-test on Day 1 for PDL team.

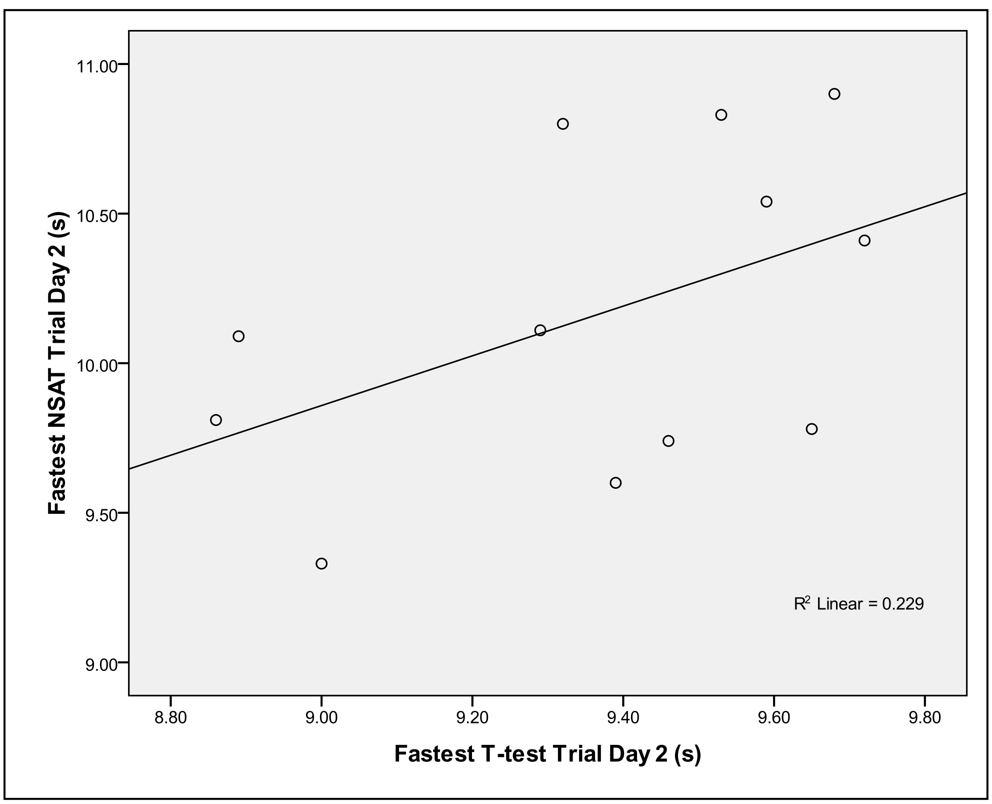

Figure 14. NSAT vs T-test on Day 2 for PDL team.

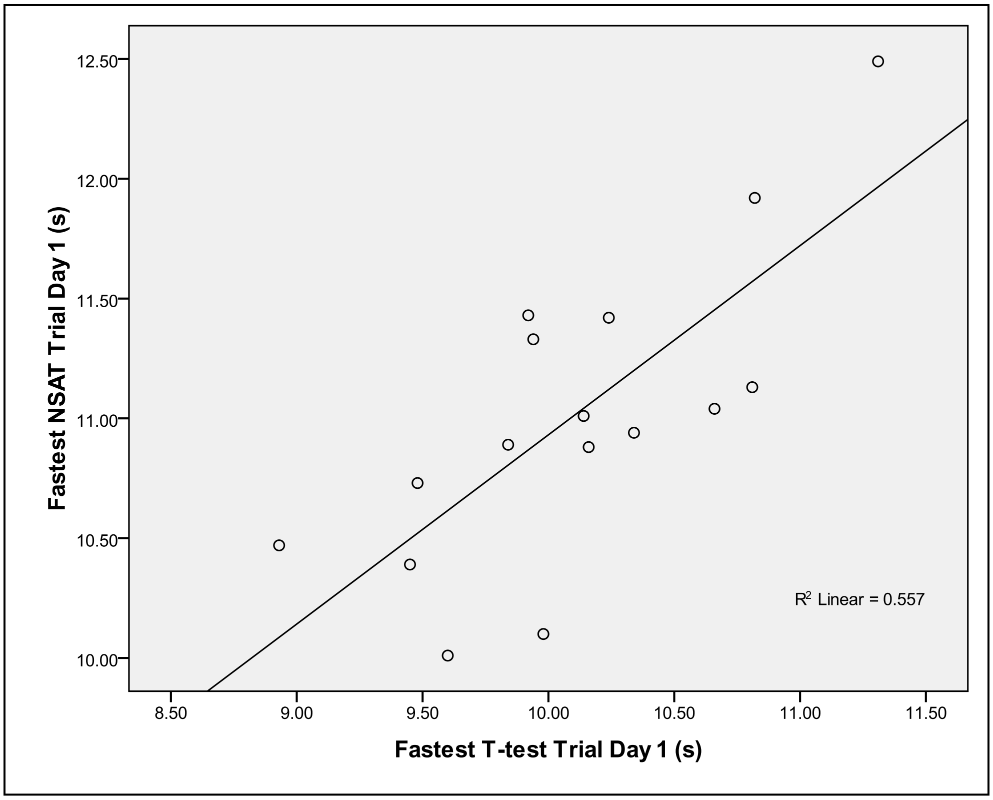

Figure 15. NSAT vs T-test on Day 1 for Reserve Team.

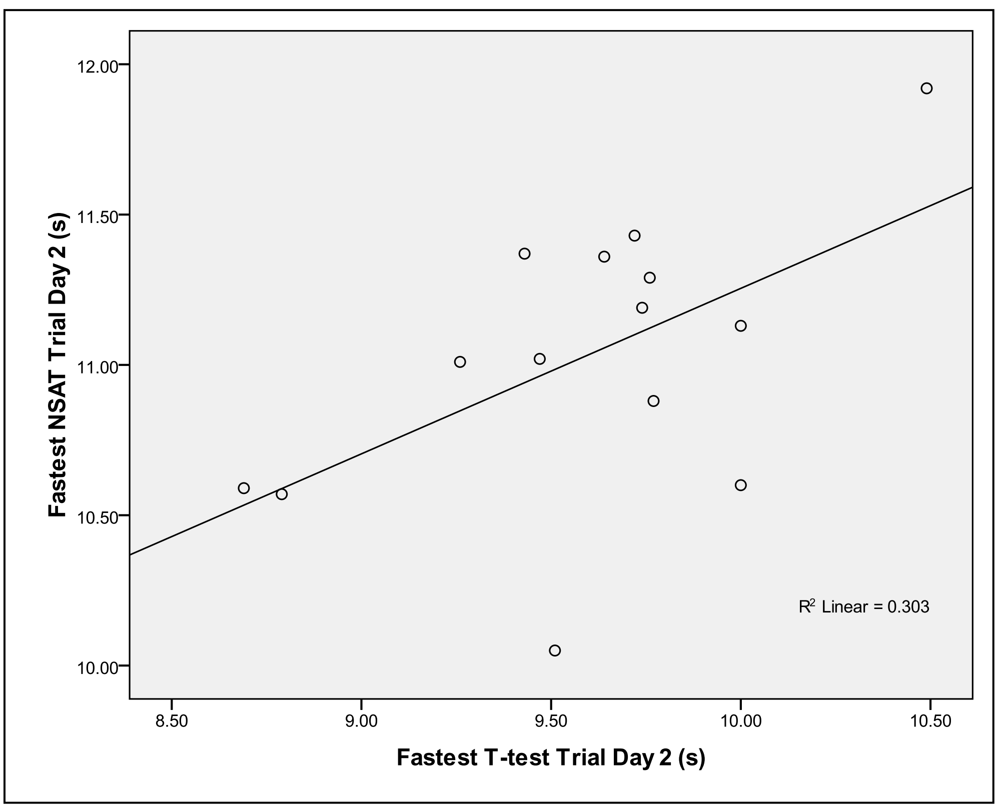

Figure 16. NSAT vs T-test on Day 2 for Reserve Team.

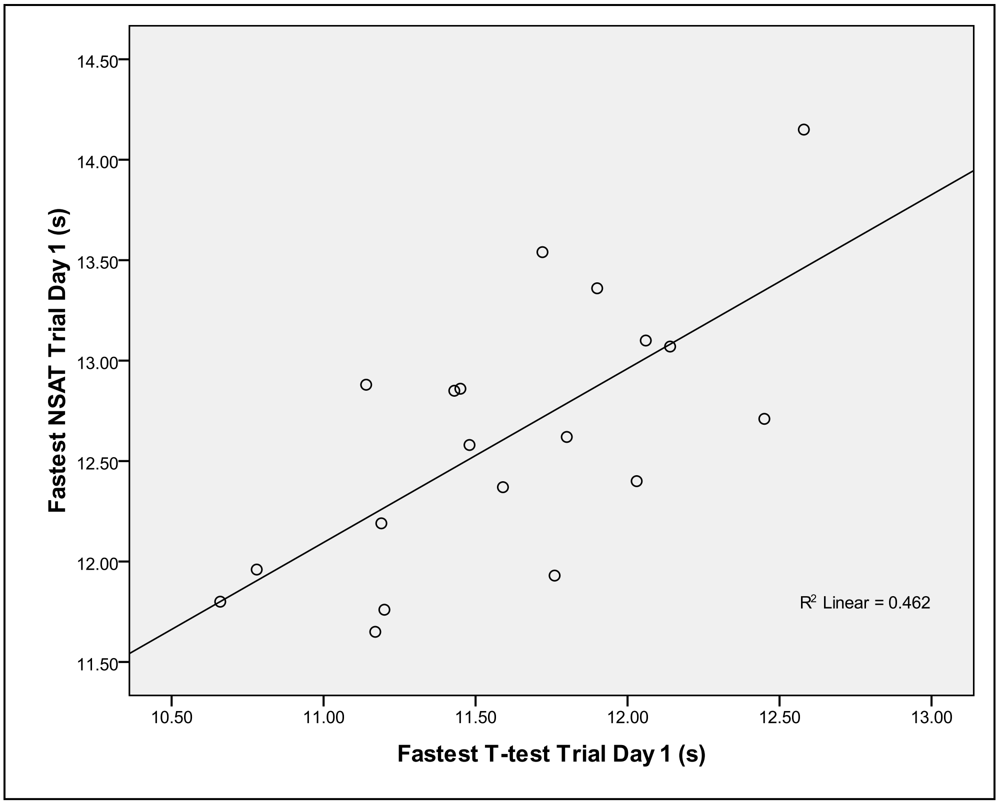

Figure 17. NSAT vs T-test on Day 1 for Elite team.

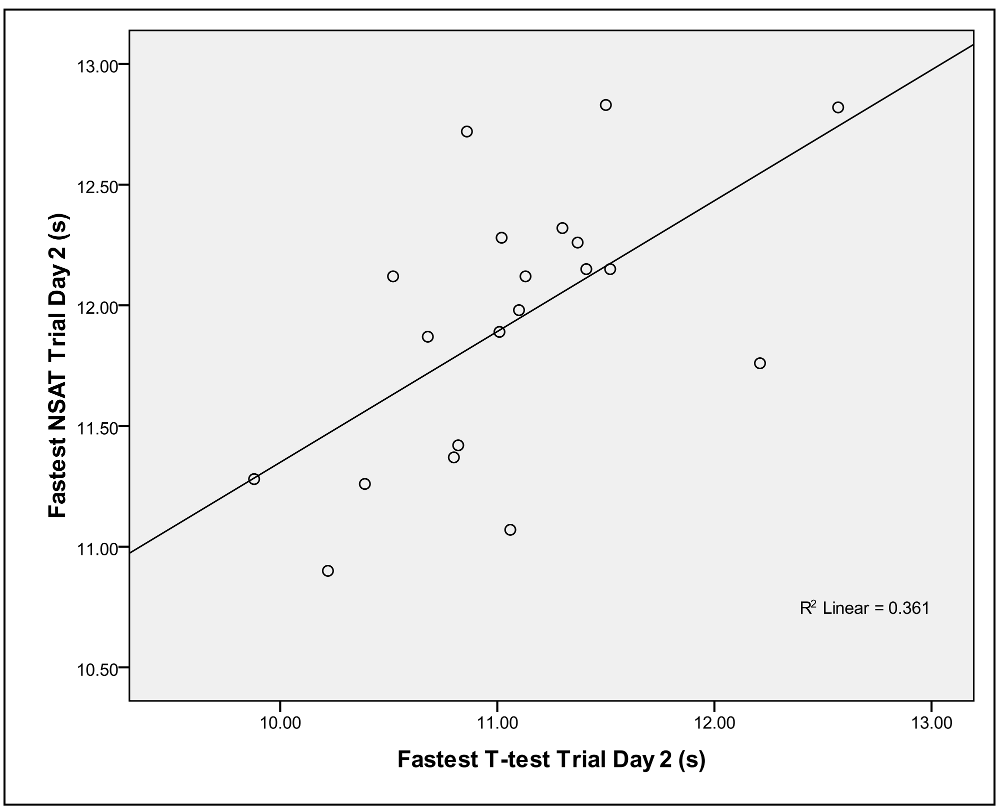

Figure 18. NSAT vs T-test on Day 2 for Elite team.

Assessment of Discriminant Validity

Main and interaction effects were calculated from the 3 x 2 x 2 mixed factorial ANOVA (Table 15). A significant three-way interaction effect was found among Team x Test x Day. The Team x Test (3 x 2) interaction was then analysed on Day 1 and Day 2 in order to assess for significant differences. This analysis is presented in *Figure 19* and *Figure 20*.

Table 15

Main and interaction effects for mixed factorial ANOVA

	df	*F*	η^2	*p*
Team	2	84.33	0.81	<.05
Test	1	267.84	0.68	<.05
Day	1	39.24	0.07	<.05
Team x Test	2	1.36	0.01	>.05
Team x Day	2	3.57	0.01	<.05
Test x Day	1	0.00	0.00	>.05
Team x Test x Day	2	6.08	0.02	<.05

The Team x Test interaction effect [$F_{3x2Day1}(2,47) = 1.96$, $p > .05$] was found to not be significant on Day 1 (*Figure 19*).

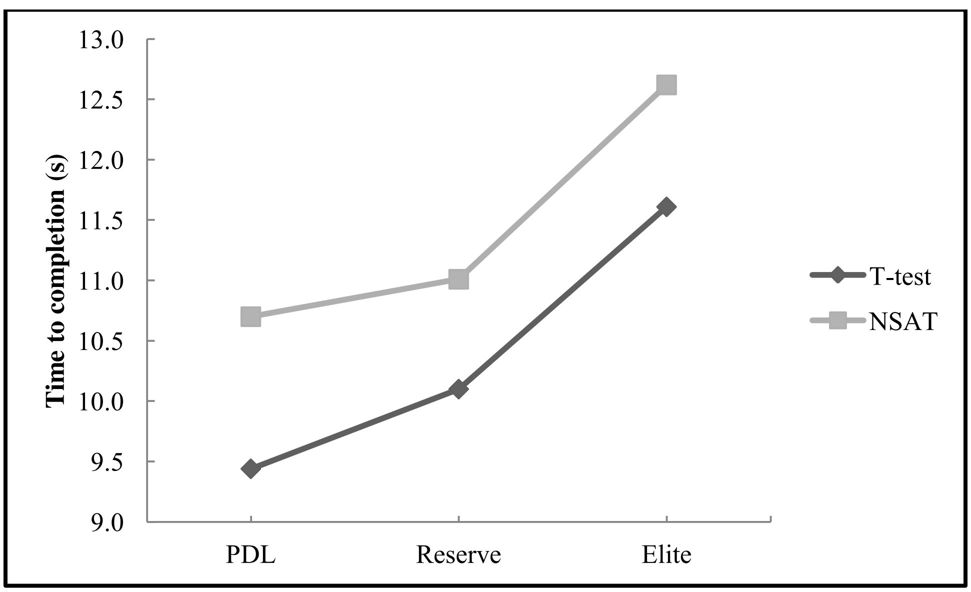

Figure 19. Team x Test interaction on Day 1

In contrast, the Team x Test interaction effect [$F_{3x2Day2}(2,43) = 7.37$, $p < .05$] was found to be significant on Day 2 (*Figure 20*).

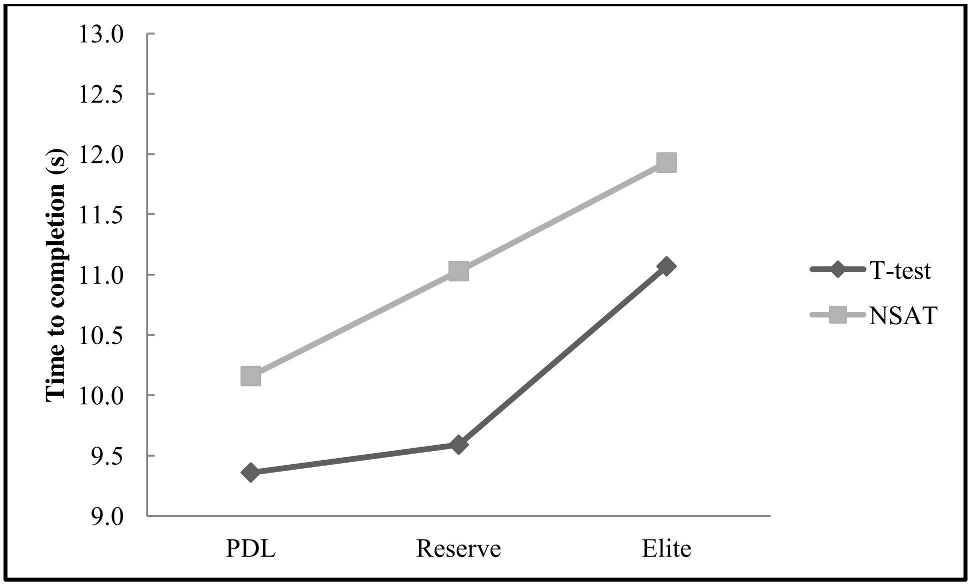

Figure 20. Team x Test interaction on Day 2

Pairwise comparisons were then run on the Team x Test x Day interaction in order to assess for any differences among the Teams on all levels of Test and Day. The PDL team was found to differ significantly (p <.05) from both the Reserve and the Elite teams with differences between the mean fastest scores on day 1 of 0.48s and 2.06s respectively for the T-test. A significant difference (p <.05) was also found between the Reserve and Elite teams with the difference between the mean fastest scores on Day 1 being 1.58s for the T-test. With regards to the new soccer agility test, the Elite team was found to differ significantly (p <.05) from both the PDL and Reserve teams with differences between the mean fastest scores on Day 1 of 1.98s and 1.66s respectively.

For the T-test on Day 2, significant differences (p <.05) were found between the Elite team and both the PDL and Reserve team with differences in the mean fastest scores on Day 2 of 1.79s and 1.57s respectively. With regards to the new soccer agility test, significant differences

(p <.05) were found between all teams. The PDL team differed significantly from both the Reserve and Elite teams with difference scores of 0.79s and 1.81s respectively. The Reserve team was found to differ significantly (p <.05) from the Elite team with a difference score of 1.02s being found for Day 2.

The mixed factorial ANOVA procedure also found significant differences ($F(1,39) = 18.59$, p <.05) between Days 1 and 2 across the entire sample with differences in the mean fastest agility score of 0.34s for both the T-test and the new soccer agility test.

Discussion

Standardized testing is common in competitive sports. Players are tested at various stages in their development and this may qualify them for recruitment to elite teams and leagues. This study included soccer teams from three different competitive levels: Premier Development League (PDL), Reserve, and Elite. The United Soccer Leagues' PDL is considered the highest level of amateur soccer in North America. The Reserve team acts as a feeder team for the PDL. The Elite team is a foundation level competitive team for players who want to begin training on a regular basis with the hopes of eventually making the Reserve and later on PDL team.

The new soccer agility test was specifically developed in order to test agility in soccer players. This distinguishes the protocol from other agility tests which were developed for a general populace. In addition, the new soccer agility test has previously been shown to be reliable when testing healthy active males (Leon-Carlyle & Kivi, 2011). Face validity represents how much the test in question measures what it claims to (Sim & Arnell, 1993). While many of the tests found in the current literature, including the T-test, may measure agility or its components, they do not necessarily encompass all the physical movements found in the sport of soccer. In addition, current studies (Cronin et al., 2003; Gabbett et al., 2008; Haj Sassi et al., 2009; McMillan et al., 2006; Vescovi and McGuigan, 2008) have modified existing protocols in order to make them more specific to the requirements of certain sports. This suggests the need for the development of entirely new tests. The sport of soccer is comprised of short sprints, rapid changes in acceleration, turning, jumping, kicking, and tackling (Kaplan et al., 2009). In addition, mean agility scores for all three teams for the new soccer agility test were completed in less than 14 seconds, which is an important aspect of testing soccer players (Vescovi & McGuigan, 2008). The new soccer agility test encompasses the majority of the physical requirements and movements specific to soccer and therefore represents an agility testing protocol which is specific to testing soccer players' agility. This provides the new soccer agility test with strong face validity.

Reliability is an important factor when it comes to developing a new testing protocol. A practitioner will require a test to demonstrate consistent scores when he/she is going to be tracking an athlete's performance over time. It is important to determine that any differences found are the result of a "real and worthwhile change to the measured variable" (Brughelli et al., 2008, p. 1051). Many agility testing protocols have been developed; however, the reliability scores found for them vary. In the case of the shuttle run test, for example, ICC scores ranging from .69 (Barnes et al., 2007) to .91 (Jullien et al., 2008) have been reported related to agility testing. This range was likely due to the high variability found in the number of sprints performed for the respective shuttle run protocols. The 505-agility test showed more consistent high reliability scores with ICCs of .90 and .92 (Gabbett et al., 2008) for both the original and a modified protocol, respectively. Part of the reason the T-test is considered the "gold standard" for agility testing is its reliability. The T-test has been previously shown to have within-day ICC scores of .92 to .98 (Haj Sassi et al., 2009; Pauole et al., 2000; Sporis et al., 2010). The within-day T-test reliability scores found in this study fell just below this range for the Reserve and Elite teams with scores ranging from .88 to .92. The within-day T-test reliability scores for the PDL team were found to be slightly lower with scores of .73 and .79 for days 1 and 2 respectively. A possible explanation may be that the T-test is less specific to the physical requirements found in elite soccer and therefore the PDL players displayed less consistent scores. It is also possible that the PDL players may have been fatigued due to a busy schedule prior to a lengthy set of road games. This would introduce further error into the results. The new soccer agility test was found to have high within-day 1 intraclass correlation scores for the PDL, Reserve, and Elite teams with scores of .90, .91, and .89 respectively. Similar within-day 2 intraclass correlation coefficients were found for the PDL, Reserve, and Elite teams with scores of .88, .92, and .88 respectively. These scores compete well with the T-test and all of the other agility testing protocols found in the current and past literature. Between-day reliability was mixed with low scores found for both the PDL and Elite teams and high reliability found for the Reserve team for the new soccer agility test. This may be the result of differences in motivation to perform well during the performance testing. The PDL team had already been recruited to a high level team and therefore may have felt like they had less to prove. The Elite team was still in the developmental stages and had many years before trying to reach the highest echelons of soccer. In contrast, the players on the Reserve team were trying to be recruited for the PDL team as soon as the following season and therefore may have been motivated to perform better on the tests.

If a tool is not found to be reliable, it cannot be valid. In addition to reliability, validity is a critical step in the development of a new agility testing protocol. Markovic et al. (2004) stated that “the use of reliable and valid testing procedures is beneficial for monitoring the effects of training and for talent selection purposes" (p. 551), which means ensuring that the test in question measures exactly what the researcher thinks it does. In the case of this study, the researcher was concerned with ensuring that agility was being measured accurately.

In order to validate the new soccer agility test, both theoretical and statistical methods were used. At the beginning of this study, a new definition of agility was proposed: "agility is the process of coordinating appropriate parts of the body in a rapid and functional manner in the face of environmental constraints." An agility testing protocol must also consider the theoretical foundation underlying that construct. Jeffreys (2006) suggested that agility was composed of initiation, transition, and actualization movements which when chained together formed an agility movement. Most agility testing protocols were found to include only initiation and actualization movements. The T-test was found to be the only test which followed both agility definitions and theories, albeit in a slightly different order of movements. The new soccer agility test follows the definition as well as the theory set forth by Jeffreys (2006) by encompassing initiation, transition, and actualization movements by replicating movements which would normally be performed during a match in the correct order they would normally occur ending with a sport specific kick.

The primary method which is used to validate performance testing protocols involves comparing the test in question to an existing protocol which has already been validated and which measures the construct in question, in this case agility. In many cases, the currently accepted "gold standard" will be indentified in the current literature for this purpose. The T-test may be considered the "gold standard" when testing agility in many sports as it is one of the most commonly used agility assessment tools found in the current literature (Hoffman, Ratamess, Cooper, Kang, Chilakos, & Faigenbaum, 2005; McBride, Triplett-McBride, Davie, &

Newton, 2002; Miller et al., 2006). Pauole et al. (2000) validated the T-test in this manner by comparing it to the hexagon test which measured quickness when changing direction over a relatively short distance. At the time, there was no gold standard agility test in the literature. They found that the T-test was significantly correlated to the hexagon test (Pauole et al., 2000). This indicated that the T-test measured a large portion of the same construct as the hexagon test. The construct was assumed to be agility (Pauole et al., 2000).

Low correlations ($r_{\text{PDLDay1}} = .21$) were found between the T-test and the new soccer agility test for the PDL team on Day 1. This may be explained by several factors. The participants from the PDL team were observed to place an initial emphasis on speed over control while navigating the course during testing on Day 1. This caused the PDL team to complete the course using a less efficient path and thus increasing trial time. Agility involves a combination of both speed and control in order to be efficient. This was not the case with the Reserve team who used a more conservative combination of speed and control to navigate the new soccer agility test. This was evident in the form of decreased or better agility trial scores demonstrated by players from the PDL team on the second day of testing decreasing their mean fastest new soccer agility score from 10.70 ± 0.52s to 10.16 ± 0.53s. Also, the PDL team appears to represent a homogeneous sample of highly skilled soccer players who all scored similarly on the two different tests. As a result, the magnitude of the correlation found may be artificially low. This might be remedied by recruiting several teams from the PDL league in order to increase the variance found within the sample.

The Reserve team's scores, in contrast to those of the PDL and Elite teams, stayed almost the same from Day 1 to Day 2 with mean fastest scores of 11.01 ± 0.64 s and 11.03 ± 0.47 s respectively. Similar to the PDL team, the Elite team's scores were found to decrease or improve from Day 1 to Day 2 with mean fastest scores of 12.62 ± 0.66s and 11.93 ± 0.56s. It is also possible that the T-test is simply not specific enough to test players at the PDL skill level as was previously mentioned. The T-test places a large bias on backpedalling (25%) and sideshuffling (50%). Only 25% of the T-test total distance takes place in a forward direction. While the new soccer agility test contains similar components, they are broken up into sections of no more than 6.5m. The T-test components are all performed consecutively in larger sections. For example, the participant completes the entire sideshuffling section, a distance of 18.28m, in a single segment instead of performing many smaller segments interspersed with the other movements. The large backpedalling section also biases the T-test in favour of defenders who spend more time backpedalling than players in other positions. Sporis et al. (2010) found significant differences ($p < 0.01$) between defenders and the other positions when evaluating the T-test. The defenders were faster and completed the T-test with a mean score of 8.06 ± .27 s whereas the midfielders finished with a mean score of 8.35 ± 0.26 s and the attackers finished with a mean score of 8.38 ± 0.28 s (Sporis et al., 2010). The new soccer agility test, which was developed to be specific to soccer, may be a more valid measure of agility in soccer players. This may explain the low correlations found between the two protocols for the PDL team as well as the low within-day correlations found. Contrary to the results of the PDL team, the new soccer agility test was found to be highly correlated to the T-test when testing the Reserve ($r_{\text{ReserveDay1}} = .75$) and Elite ($r_{\text{EliteDay1}} = 0.68$) teams on Day 1 using the fastest overall trials. However, on Day 2, these correlations dropped down to the moderate level ($r_{\text{ReserveDay2}} = .55$, $r_{\text{EliteDay2}} = .60$). These different findings may indicate that a learning effect may have been present between-days. In addition, the moderate correlation suggests that the T-test and new soccer agility tests, while measuring to a degree the same construct, may in fact be measuring distinct skills. Therefore, it may be stated that the new soccer agility test measures agility in a similar fashion to the T-test when testing competitive soccer of the same calibre as the Reserve team. If the T-test is in fact not specific enough to test high-performance soccer players and the two protocols appear to measure slightly different constructs, the new soccer agility test may indeed be more valid when testing competitive soccer players of all ages.

Prior to testing, none of the players indicated that they had prior experience with either agility test. This allowed both protocols to be evaluated starting from the same level for all participants. There is no clear consensus within the current literature whether to introduce testing protocols during the same session as data collection or in a separate session. Several studies have used a familiarization day prior to testing during which participants were able to perform maximum effort trials which would not be collected and thereby familiarize themselves with the different protocols being used during testing (Barnes et al., 2007; McMillian et al., 2006; Sheppard et al., 2006). Cronin et al. (2003) included a familiarization session which included several 1-rep maximal measurements which were not associated to the agility testing protocol being introduced. In contrast, many studies from the current literature complete familiarization and testing within a single session (Caldwell & Peters, 2009; Haj Sassi et al., 2009; Little & Williams, 2005; Meylan et al., 2009; Miller et al., 2006). The inclusion of a familiarization session might help to eliminate systematic error caused by the learning effect. This type of error would occur whereby a systematic bias was seen with regards to the central tendency of the scores from Day 1 to Day 2 across all participants in the sample. Significant differences [$F(1,39) = 18.59$, $p < 0.05$] were found between Days 1 and 2 for both T-test and the new soccer agility test with faster mean agility scores being recorded on testing Day 2. The mean difference between Day 1 and Day 2 was found to be 0.34s for both protocols. This indicates that a learning effect may have been present between Days 1 and 2 and that a familiarization session may have helped reduce this systematic bias. Munro and Herrington (2011) found that the T-test had a learning effect between-day when testing recreational athletes.

In addition to the inclusion of a familiarization session, there is also no clear consensus on whether to have participants complete practice trials at submaximal or maximal effort. Vescovi and McGuigan (2008) included submaximal practice trials within a single session which additionally included the maximal testing trials. However, given the length of time taken to complete most agility testing and an appropriate rest period, maximal practice trials should not influence the testing effort put forth by a participant.

In addition to concurrent validity, a new protocol should be able to discriminate between skill levels which should theoretically be different. Previous studies have found that a faster agility score is indicative of a better agility performance and therefore a more highly skilled participant would be expected to have a faster time to completion score than a less skilled participant (Gabbett et al., 2008; Pauole et al., 2000). The T-test was previously found to differentiate between different skill levels in basketball (Ben Abdelkrim et al., 2010), rugby (Gabbett et al., 2008) and volleyball (Gabbett and Georgieff, 2009). The T-test was also found to discriminate among intercollegiate athletes, recreational athletes, and non-athletes (Pauole et al., 2000). In the current study, a significant three-way interaction was found among the three factors, Team x Test x Day [$F(2,39) = 6.08$, $p < 0.05$]. Although the Team x Test interaction was found to be non significant on Day 1 [$F_{3x2Day1}(2,47) = 1.96$, $p > .05$], it was found to be significant on Day 2 [$F_{3x2Day2}(2,43) = 7.37$, $p < .05$]. Pairwise comparisons for the T-test results showed significant differences among all three teams on Day 1. Similarly, pairwise comparisons for the new soccer agility test on Day 1 revealed that differences were found in the mean agility scores between the Elite and PDL teams and the Elite and Reserve teams. However, no significant difference in the mean agility scores was found between the PDL and Reserve teams on Day 1. These results are not surprising given the developmental difference between the Elite team and the other two teams. The Reserve team feeds directly into the PDL team whereas the Elite team feeds into another competitive level before reaching the Reserve team. On Day 2, pairwise comparisons revealed significant differences between the Elite and PDL teams and the Elite and Reserve teams. All three teams were found to differ significantly when using the new soccer agility test on Day 2. A possible explanation for the difference between the pairwise results found for Day 1 and Day 2 is the fact that this study lacked a formal familiarization session. It is possible that this may have resulted in significant differences being found among all teams on both testing days. Overall, the results of the discriminant validity evaluation indicate that the new soccer agility test is capable of discriminating between players from different levels of competition and thus different skill levels.

Conclusion

The new soccer agility test was developed to be specific to the physical requirements of soccer and the construct of agility. The purpose of this study was to evaluate a new agility testing protocol designed to measure agility in soccer players at three different competitive levels. Within-day reliability was found to be high based on an analysis of the fastest trials performed by each participant for all teams. However, between-day reliability was found to be low for the PDL and Elite teams which may warrant the introduction of a formal familiarization session in order to account for possible learning effects. Concurrent validity was only confirmed for the Reserve and Elite teams with moderate to high correlations being found between the T-test and the new soccer agility test. These results may suggest that the new soccer agility test is more specific than the T-test for the assessment of agility in soccer players, based on the results found when evaluating concurrent validity for the PDL team. The new soccer agility test was also shown to discriminate among the three different teams on testing Day 2 with regards to time to completion.

Practical Applications

The evaluation of agility in soccer may provide coaches and trainers with important information regarding a player's ability to keep his/her body in the proper position to read and react to a play. To the author's knowledge, no soccer-specific agility test has been developed to date. The new soccer agility test includes many movements which are required in competitive play and therefore offers a means of assessing overall agility performance specific to soccer. In addition, this new test also requires minimal equipment and can be performed with a stop watch where cost prohibits the use of timing gates. The test has been shown to discriminate among players of different competitive levels; therefore the test can be used to collect normative data and used for player selection purposes. Testing can also be repeated over the season to track changes in agility performance. It is important to remember that agility involves the combination of several distinct skills. Coaches and trainers must therefore identify and train the individual components in order to improve agility performance.

Limitations

This study was limited by the following:

1. Testing had to be organized around a busy competition schedule and this dictated intervals between testing sessions and testing times.

2. The loss of several PDL participants between testing Day 1 and 2 may have influenced the results for that particular team.
3. Course conditions were observed to degrade as testing progressed on both days possibly randomly influencing the results of the following trials.

Delimitations

This study was delimited to the following:

1. 55 competitive male soccer players.
2. Only players from the PDL, Reserve, and Elite competitive levels were used.
3. Participants were evaluated using two agility testing protocols, the T-test and the new soccer agility test.

Assumptions

The following assumptions were made:

1. The T-test is a valid and reliable measure of agility in soccer players.
2. The participants responded truthfully and accurately to the questions posed in the sports experience questionnaire.
3. Participants understood instructions given to them regarding the agility testing protocols including: providing a maximal effort and the running of the protocols themselves.

Future Research

There is a need for the development of new sport specific testing techniques. This should include a stronger theoretical basis, whether that pertains to agility or another performance factor, in addition to the empirical foundations found within the relevant literature. Future research involving the new soccer agility test should include the use both male and female participants in order to further validate the protocol for all soccer players. Additionally, the test should be evaluated in a mirrored format to test for any bias in turning to one side. Also, testing on artificial turf where the course may degrade less though the testing session may help control extraneous error. It is suggested that future studies in the area of agility also involve the continued modification of current testing protocols and the research and development of other sport specific testing techniques.

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Appendix A – Sports Experience Questionnaire

Sports Experience Questionnaire

Name: ____

Birth Date: ______________________ (MM/DD/YYYY)

Height: ______________________ (m)

Weight: ______________________ (kg)

Primary position played:

Secondary position played:

Years of experience and level of play:

(YOU HAVE THE RIGHT TO SKIP ANY QUESTION WHICH YOU DO NOT WANT TO ANSWER)

Appendix B – Physical Activity Readiness Questionnaire (PAR-Q)

Physical Activity Readiness
Questionnaire - PAR-Q
(revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO		
☐	☐	1.	**Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
☐	☐	2.	**Do you feel pain in your chest when you do physical activity?**
☐	☐	3.	**In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	4.	**Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	5.	**Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	6.	**Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	7.	**Do you know of any other reason why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME ____

SIGNATURE ____ DATE ____________________

SIGNATURE OF PARENT ____ WITNESS ____________________
or GUARDIAN (for participants under the age of majority)

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

continued on other side...

Appendix C – PDL Team Scores

Table 16

Agility scores, mean agility scores, and standard deviations for all PDL team trials

	Day 1				Day 2			
Team	T-test F (s)	T-test S (s)	NSAT F (s)	NSAT S (s)	T-test F (s)	T-test S (s)	NSAT F (s)	NSAT S (s)
PDL	9.92	10.33	10.11	10.27	9.65	10.07	9.78	9.96
	9.37	9.44	11.18	11.30	9.59	9.68	10.54	10.74
	9.75	9.75	11.31	11.50	9.53	9.85	10.83	11.11
	9.94	10.25	10.88	11.07	9.29	9.58	10.11	10.61
	9.52	9.68	11.08	11.23	DNP	DNP	DNP	DNP
	8.80	8.88	10.69	10.98	8.89	8.96	10.09	10.31
	9.20	9.43	10.98	10.99	9.32	9.53	10.80	10.90
	9.56	9.58	11.26	11.39	DNP	DNP	DNP	DNP
	9.44	10.02	10.32	10.65	9.72	9.99	10.41	10.78
	9.07	9.21	10.42	10.90	9.46	9.86	9.74	10.02
	9.68	9.75	10.26	10.53	9.00	9.09	9.33	9.58
	9.43	9.47	10.24	10.41	8.86	9.07	9.81	10.06
	10.12	10.24	10.78	10.91	9.68	10.17	10.90	11.07
	9.13	9.54	11.40	11.54	DNP	DNP	DNP	DNP
	8.69	9.24	9.64	9.93	DNP	DNP	DNP	DNP
	DNP	DNP	DNP	DNP	9.39	9.71	9.60	9.82
Mean ± SD	9.44 ± 0.41	9.65 ± 0.42	10.70 ± 0.52	10.91 ± 0.47	9.36 ± 0.30	9.62 ± 0.40	10.21 ± 0.53	10.47 ± 0.52

Note. F = Fast, S = Slow, and DNP = Did not participate.

Appendix D – Reserve Team Scores

Table 17

Agility scores, mean agility scores, and standard deviations for all Reserve team trials

	Day 1				Day 2			
Team	T-test F (s)	T-test S (s)	NSAT F (s)	NSAT S (s)	T-test F (s)	T-test S (s)	NSAT F (s)	NSAT S (s)
Reserve	10.24	10.64	11.42	11.87	9.64	10.12	11.36	11.54
	10.82	11.35	11.92	12.20	10.49	10.71	11.92	12.3
	10.34	10.41	10.94	11.33	10.00	10.04	11.13	11.35
	11.31	11.63	12.49	12.56	DNP	DNP	DNP	DNP
	9.48	9.94	10.73	11.45	9.26	9.45	11.01	11.13
	9.92	10.08	11.43	11.53	9.43	9.86	11.37	11.65
	10.14	10.44	11.01	11.40	9.47	9.74	11.02	11.28
	9.60	9.98	10.01	10.32	DNP	DNP	DNP	DNP
	9.94	10.86	11.33	11.72	9.74	10.14	11.19	11.19
	9.45	9.48	10.39	10.43	8.69	8.79	10.59	10.85
	9.84	10.03	10.89	11.13	10.00	10.26	10.6	10.81
	9.98	10.00	10.10	10.53	9.51	9.79	10.05	10.19
	8.93	9.06	10.47	10.68	8.79	8.80	10.57	10.68
	10.16	10.38	10.88	11.21	9.77	9.82	10.88	11
	10.66	10.71	11.04	11.26	DNP	DNP	DNP	DNP
	10.81	10.85	11.13	11.46	9.76	10.19	11.29	11.82
	DNP	DNP	DNP	DNP	9.72	9.80	11.43	12.06
Mean ± SD	10.22 ± 0.77	10.48 ± 0.78	11.13 ± 0.78	11.43 ± 0.75	9.76 ± 0.79	10.03 ± 0.96	11.16 ± 0.66	11.41 ± 0.75

Note. F = Fast, S = Slow, and DNP = Did not participate.

Appendix E – Elite Team Scores

Table 18

Agility scores, mean agility scores, and standard deviations for all Elite team trials

	Day 1				Day 2			
Team	T-test F (s)	T-test S (s)	NSAT F (s)	NSAT S (s)	T-test F (s)	T-test S (s)	NSAT F (s)	NSAT S (s)
Elite	11.20	11.79	11.76	12.10	10.80	10.89	11.37	11.84
	11.45	11.66	12.86	13.12	11.13	11.53	12.12	12.26
	10.66	10.79	11.80	11.81	9.88	10.29	11.28	11.43
	11.90	12.10	13.36	13.36	11.06	11.22	11.07	11.32
	12.45	12.66	12.71	13.01	12.21	12.40	11.76	12.03
	11.19	11.67	12.19	12.43	11.01	11.02	11.89	12.23
	11.76	11.84	11.93	12.13	11.41	11.79	12.15	12.42
	11.80	12.04	12.62	13.03	10.52	10.72	12.12	12.40
	12.06	12.33	13.10	13.14	10.86	11.22	12.72	12.82
	12.14	12.53	13.07	13.12	11.50	11.80	12.83	12.83
	11.59	11.65	12.37	12.68	11.30	11.45	12.32	12.88
	11.72	12.06	13.54	13.54	10.82	10.94	11.42	11.72
	10.78	10.80	11.96	12.31	10.68	10.77	11.87	11.92
	12.58	12.90	14.15	14.88	12.57	12.74	12.82	13.01
	11.43	11.83	12.85	13.04	11.37	11.54	12.26	12.51
	11.17	11.44	11.65	12.48	11.10	11.42	11.98	12.19
	11.14	11.45	12.88	12.91	11.52	11.72	12.15	12.64
	12.03	12.21	12.40	12.51	DNP	DNP	DNP	DNP
	11.48	11.57	12.58	12.70	11.02	11.18	12.28	12.51
	DNP	DNP	DNP	DNP	10.22	10.75	10.90	11.26
	DNP	DNP	DNP	DNP	10.39	11.25	11.26	11.43
Mean ± SD	11.61 ± 0.52	11.86 ± 0.55	12.62 ± 0.66	12.86 ± 0.67	11.07 ± 0.63	11.33 ± 0.58	11.93 ± 0.56	12.18 ± 0.55

Note. F = Fast, S = Slow, and DNP = Did not participate.

Appendix F – 18+ Cover Letter

Lakehead
UNIVERSITY

School of Kinesiology

Reliability and validity of a new test of agility in male soccer players

Dear prospective participant,

I would like to extend an invitation to participate in a research study being conducted by myself, Carlos Leon-Carlyle, a graduate student in the School of Kinesiology at Lakehead University School of Kinesiology, supervised by Dr. Derek Kivi. You are being asked to participate because you are a competitive male soccer player.

The purpose of this study is to evaluate the reliability of a new agility testing protocol designed to measure agility skill in competitive male soccer players. Prior to any involvement in this study, you will be required to sign the attached consent form and Physical Activity Readiness Questionnaire (PAR-Q). If you are under the age of 18, you must obtain consent from your parent or legal guardian prior to participation in the study.

You will be asked to attend 2 testing sessions, which will take place on different days. Both sessions will include the same tests and measurements. Each session will begin with a 5 minute jog followed by a dynamic stretching warm-up led by the researcher. Following this, the agility tests will be demonstrated and you will be allowed a practice trial. You will then be asked to complete 2 testing trials for both the T-test and the new soccer agility test. Height and weight will be measured. At least 2 minutes of rest will be required between trials. Testing will be followed by a cool-down which will include static stretching and a light jog. Participants will be asked to remain on sight for 10 minutes following testing in order to ensure a proper recovery.

Potential risks of participating in this study include, but are not limited to, elevated heart rate, minor falls, and minor sprains and/or strains. Since all of the movements required in agility testing are maximal in nature, some participants may experience muscle soreness in the days following the test. This should be minimized by the fact that all of these movements are performed regularly during training and soccer matches. I have experience providing first aid at Lakehead University sporting events as a team trainer and have current CPR and First Aid certifications.

Participation in this study is voluntary; you have the right to withdraw at any time without penalty. All information will be strictly confidential. Only the researchers will have access to the recorded data and personal information, and no identifiable characteristics will be used in the final report. Data will be stored at Lakehead University, with Dr. Kivi, for a period of 5 years. The results of this study will be available to all participants upon request following the completion of the study. If you have any questions please feel free to contact Dr. Kivi or myself. This research has been approved by the Lakehead University Research Ethics Board. If you have any questions related to the ethics of the research and would like to speak to someone outside of the research team, please contact Sue Wright at the Research Ethics Board at 343-8283 or swright@lakeheadu.ca.

Thank you,

Carlos Leon-Carlyle, MSc (c), HBK, CK, CPT
☎ (647) 981-7607
💻 cleoncar@lakeheadu.ca

Dr. Derek Kivi, Graduate Supervisor
☎ (807) 343-8645
💻 derek.kivi@lakeheadu.ca

Appendix G – Parent/Guardian Cover Letter

Lakehead
UNIVERSITY

School of Kinesiology

Reliability and validity of a new test of agility in male soccer players

Dear prospective participant's parent or guardian,

I would like to extend an invitation to your child to participate in a research study being conducted by myself, Carlos Leon-Carlyle, a graduate student in the School of Kinesiology at Lakehead University School of Kinesiology, supervised by Dr. Derek Kivi. Your child is being asked to participate because he is a competitive male soccer player.

The purpose of this study is to evaluate the reliability of a new agility testing protocol designed to measure agility skill in competitive male soccer players. Prior to any involvement in this study, you will be required to sign the attached consent form and witness your child completing a Physical Activity Readiness Questionnaire (PAR-Q).

Your child will be asked to attend 2 testing sessions, which will take place on different days. Both sessions will include the same tests and measurements. Each session will begin with a 5 minute jog followed by a dynamic stretching warm-up led by the researcher. Following this, the agility tests will be demonstrated and your child will be allowed a practice trial. He will then be asked to complete 2 testing trials for both the T-test and the new soccer agility test. Height and weight will be measured. At least 2 minutes of rest will be required between trials. Testing will be followed by a cool-down which will include static stretching and a light jog. Participants will be asked to remain on sight for 10 minutes following testing in order to ensure a proper recovery.

Potential risks of participating in this study include, but are not limited to, elevated heart rate, minor falls, and minor sprains and/or strains. Since all of the movements required in agility testing are maximal in nature, some participants may experience muscle soreness in the days following the test. This should be minimized by the fact that all of these movements are performed regularly during training and soccer matches. I have experience providing first aid at Lakehead University sporting events as a team trainer and have current CPR and First Aid certifications.

Participation in this study is voluntary; your child has the right to withdraw at any time without penalty. All information will be strictly confidential. Only the researchers will have access to the recorded data and personal information, and no identifiable characteristics will be used in the final report. Data will be stored at Lakehead University, with Dr. Kivi, for a period of 5 years. The results of this study will be available to all participants upon request following the completion of the study. If you have any questions please feel free to contact Dr. Kivi or myself. This research has been approved by the Lakehead University Research Ethics Board. If you have any questions related to the ethics of the research and would like to speak to someone outside of the research team, please contact Sue Wright at the Research Ethics Board at 343-8283 or swright@lakeheadu.ca.

Thank you,

Carlos Leon-Carlyle, MSc (c), HBK, CK, CPT
☎ (647) 981-7607
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Dr. Derek Kivi, Graduate Supervisor
☎ (807) 343-8645
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Appendix H – Under-18 Cover Letter

Lakehead UNIVERSITY

School of Kinesiology

Reliability and validity of a new test of agility in male soccer players

Dear prospective participant,

I would like to extend an invitation to participate in a research study being conducted by myself, Carlos Leon-Carlyle, a graduate student in the School of Kinesiology at Lakehead University School of Kinesiology, supervised by Dr. Derek Kivi. You are being asked to participate because you are a competitive male soccer player.

The purpose of this study is to evaluate the reliability of a new agility testing protocol designed to measure agility skill in competitive male soccer players. A simple definition of agility is the ability to change direction rapidly while staying in control of your body's position. Before any involvement in this study, you will be required to sign the attached consent form and Physical Activity Readiness Questionnaire (PAR-Q). Since you are under the age of 18, you must obtain consent from your parent or legal guardian before participating in the study.

You will be asked to attend 2 testing sessions, which will take place on different days. Both sessions will include the same tests and measurements. Each session will begin with a 5 minute jog followed by a dynamic stretching warm-up led by the researcher. Following this, the agility tests will be demonstrated and you will be allowed a practice trial. You will then be asked to complete 2 testing trials for both the T-test and the new soccer agility test. Height and weight will be measured. At least 2 minutes of rest will be required between trials. Testing will be followed by a cool-down which will include static stretching and a light jog. Participants will be asked to remain on sight for 10 minutes following testing in order to ensure a proper recovery.

Potential risks of participating in this study include, but are not limited to, elevated heart rate, minor falls, and minor sprains and/or strains. Since all of the movements required in agility testing are maximal in nature, some participants may experience muscle soreness in the days following the test. This should be minimized by the fact that all of these movements are performed regularly during the training and soccer matches. I have experience providing first aid at Lakehead University sporting events as a team trainer and have current CPR and First Aid certifications.

Participation in this study is voluntary; you have the right to withdraw at any time without penalty. All information will be strictly confidential. Only the researchers will have access to the recorded data and personal information, and no identifiable characteristics will be used in the final report. Data will be stored at Lakehead University, with Dr. Kivi, for a period of 5 years. The results of this study will be available to all participants upon request following the completion of the study. If you have any questions please feel free to contact Dr. Kivi or myself. This research has been approved by the Lakehead University Research Ethics Board. If you have any questions related to the ethics of the research and would like to speak to someone outside of the research team, please contact Sue Wright at the Research Ethics Board at 343-8283 or swright@lakeheadu.ca.

Thank you,

Carlos Leon-Carlyle, MSc (c), HBK, CK, CPT
☎ (647) 981-7607
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Dr. Derek Kivi, Graduate Supervisor
☎ (807) 343-8645
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Appendix I – 18+ Informed Consent Form

Lakehead UNIVERSITY

School of Kinesiology

Reliability and validity of a new test of agility in male soccer players

1. I, ____ (PLEASE PRINT), consent to participate in this study of agility. I am aware that the purpose of this study is to evaluate a new agility testing protocol which will measure agility in male soccer players. This study is being conducted by Carlos Leon-Carlyle under the supervision of Dr. Derek Kivi.
2. I understand that I will be required to attend two testing sessions on two separate dates to be determined upon entrance in the study. I will also be required to sign a consent form and complete a Par-Q prior to participation.
3. I understand that I will be required to perform 4 trials for each of two testing protocols the T-test and the new soccer agility test. I understand that I will also complete a light warm-up including stretching before the testing and a cool down following the testing. I am aware that information including height, weight, years of soccer experience, and position played will be recorded.
4. I understand that participation in this study is entirely voluntary, and I am able to withdraw from this study at any time without penalty. I understand that all information that I provide will remain confidential. Data will be securely stored in Dr. Kivi's office at Lakehead University for a period of 5 years.
5. I have been informed of the tests that I am required to perform in this study and I am aware that with all physical activity and sports, some risk of injury does exist. I understand that risks in participating in this study may include, but are not limited to, elevated heart rate, falls, sprains, strains, and muscle soreness. I accept all of these risks by participating in this study.

____

Signature of Participant Date

____

Signature of Witness Date

Appendix J – Parent/Guardian Informed Consent Form

Lakehead UNIVERSITY

School of Kinesiology

Reliability and validity of a new test of agility in male soccer players (Parents/Guardians)

1. I, ____ (PLEASE PRINT), consent to my child, ____ (PLEASE PRINT), participating in this study of agility. I am aware that the purpose of this study is to evaluate a new agility testing protocol which will measure agility in male soccer players. This study is being conducted by Carlos Leon-Carlyle under the supervision of Dr. Derek Kivi.
2. I understand that my child will be required to attend two testing sessions on two separate dates to be determined upon entrance in the study. I will also be required to sign a consent form and witness the completion of a Par-Q prior to my child's participation.
3. I understand that my child will be required to perform 4 trials for each of two testing protocols the T-test and the new soccer agility test. I understand that my child will also complete a light warm-up including stretching before the testing and a cool down following the testing. I am aware that information including height, weight, years of soccer experience, and position played will be recorded.
4. I understand that participation in this study is entirely voluntary, and my child is able to withdraw from this study at any time without penalty. I understand that all information that my child provides will remain confidential. Data will be securely stored in Dr. Kivi's office at Lakehead University for a period of 5 years.
5. I have been informed of the tests that my child is required to perform in this study and I am aware that with all physical activity and sports, some risk of injury does exist. I understand that risks in participating in this study may include, but are not limited to, elevated heart rate, falls, sprains, strains, and muscle soreness. I accept all of these risks by allowing my child to participate in this study.

Signature of Parent/Legal Guardian   Date

Appendix K – Under-18 Informed Consent Form

Lakehead UNIVERSITY

School of Kinesiology

Reliability and validity of a new test of agility in male soccer players

1. I, ____ (PLEASE PRINT), consent to participate in this study of agility. I am aware that the purpose of this study is to evaluate a new agility testing protocol which will measure agility in male soccer players. This study is being conducted by Carlos Leon-Carlyle under the supervision of Dr. Derek Kivi.
2. I understand that I will be required to attend two testing sessions on two separate dates to be determined upon entrance in the study. I will also be required to sign a consent form and complete a Par-Q prior to participation.
3. I understand that I will be required to perform 4 trials for each of two testing protocols the T-test and the new soccer agility test. I understand that I will also complete a light warm-up including stretching before the testing and a cool down following the testing. I am aware that information including height, weight, years of soccer experience, and position played will be recorded.
4. I understand that participation in this study is entirely voluntary, and I am able to withdraw from this study at any time without penalty. I understand that all information that I provide will remain confidential. Data will be securely stored in Dr. Kivi's office at Lakehead University for a period of 5 years.
5. I have been informed of the tests that I am required to perform in this study and I am aware that with all physical activity and sports, some risk of injury does exist. I understand that risks in participating in this study may include, but are not limited to, elevated heart rate, falls, sprains, strains, and muscle soreness. I accept all of these risks by participating in this study.

____

Signature of Participant Date

____

Signature of Parent/Legal Guardian Date