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Department of Health Sciences
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"The development of a new reactive agility test for soccer"

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Abstract

Soccer is an intermittent sport with offensive and defensive actions that requires a large number of different high-intensity actions (e.g., sprints, turns) in response to an external stimulus which emphasises the importance of agility training and testing in soccer. The aims of the current study were three-fold: to a) construct a new soccer-specific reactive agility test; b) evaluate the reliability and validity of the new tests; c) investigate the relationship between physical capacities (speed, power, strength) and pre-planned (CODS) and reactive agility (RA) performance. Twenty young male soccer players (age: 17.0 ± 0.9 years; body height: 1.81 ± 0.03 m; body mass: 70.0 ± 7.4 kg; body fat: 11.3 ± 2.0%) were divided into two groups (10 players each group) based on their age and performance level (U17 & U19). The reliability data showed high consistency of the new tests, both CODS and RA with ICC coefficients 0.92 and 0.70-0.88, respectively. Within-subjects variability ranged from 3.6% to 5.8%. A moderate correlation between the CODS and RA protocols indicated small common variance shared between them. The regression analyses demonstrated that tested physical capacities could not be used to predict results in CODS and RA. Independent samples t-test showed that a higher performance level group were better in CODS and two other RA tests. In conclusion, the newly designed agility tests showed to be reliable and valid testing tools for young soccer players. Moreover, the CODS and RA were demonstrated to be independent qualities, so they should be trained and tested separately.

Keywords: power, reliability, speed, strength, validity.

Abstrakt

Fotboll är en intermittent sport med både offensiva och defensiva aktioner som kräver ett flertal höghastighetsrörelser (sprint, vändningar) som respons till yttre stimuli vilket betonar betydelsen av att träna och testa agility (kvickhet). Syfte med denna studie var att a) konstruera ett nytt fotbollspecifikt reaktivt agility-test, b) utvärdera reliabiliteten och validiteten av de nya testerna och c) undersöka eventuellt samband mellan fysiska egenskaper (snabbhet, effektutveckling/explosivitet, styrka) och snabbhetstest med riktningsförändringar (CODS) och förmåga till reaktiv agility (RA). Tjugo unga manliga fotbollsspelare (ålder: 17,0 ± 0,9 år; kroppslängd: 1,81 ± 0,03 m; kroppsvikt: 70,0 ± 7,4 kg; kroppsfett 11,3 ± 2,0 %) delades upp i två grupper (10 spelare per grupp) baserat på ålder och fotbollsprestation (U17 & U19). Reliabilitetsdata visade hög tillförlitlighet för de båda CODS och RA-testerna (ICC-koefficienter 0,92 och 0,70-0,88). *Within-subject* variabiliteten hade en variationsvidd emellan 3,6–5,8 %. Ett moderat samband mellan CODS och RA-protokollen indikerar på en låg samhörighet. Regressionsanalyserna visade att de testade fysiska kvaliteterna inte kunde användas för att förutsäga resultaten i CODS och/eller de andra RA-testerna. Oberoende t-test visade att den högre rankade gruppen var bättre i både CODS och två andra RA-tester. Sammanfattningsvis, påvisade de nykonstruerande testerna god reliabilitet och validitet för test av unga fotbollsspelare. I tillägg, visade sig CODS och RA vara två oberoende kvaliteter och bör tränas och testat separat.

Nyckelord: explosivitet, reliabilitet, snabbhet, styrka, validitet.

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1. Introduction

Soccer is an intermittent physically demanding sport with many defensive and offensive actions that require players to repeatedly engage in sequences of intense activities (sprinting, turns, cuts, etc.) on the soccer field (Bloomfield et al., 2007; Rampinini et al., 2009). A player performs approximately 1300-1400 activities during a game (Rampinini et al., 2009), 800 high-intensity turns (Bloomfield et al., 2007) and 15-20 sprints every game with a duration of 3-4 seconds (Carling et al., 2012 & Andrezejewski et al., 2013). It was reported that these high-intensity actions influence the outcome of games, preceding 83% of all goals that were made (Faude et al., 2012). In that regard, it has been suggested that agility is one of the key performance indicators and therefore a fitness skill-related component that should be a part of standard physiological testing for soccer players (Svensson & Drust, 2005). Before discussing different tests developed to test agility in general and specifically in soccer, the definition of agility will be specified.

Agility is defined as “a rapid whole-body movement with change of speed or direction in response to a stimulus” (Young & Sheppard, 2006). This definition is based on a model which separates agility into two components, change-of-direction-speed (CODS) and perceptual and decision-making processes. The definition and the model have been generally accepted for agility-based sports with some exceptions and additions (Brughelli 2008; Chauachi et al., 2012 & Sekulic et al., 2012). The physical factors of CODS in the model include running technique, linear sprinting speed, static balance, dynamic balance, coordination, anthropometry and leg muscle qualities such as power, reactive strength and concentric and eccentric strength. The perceptual and decision-making part includes visual scanning, anticipation, pattern recognition and knowledge of situation (Young & Sheppard, et al., 2006; Young & Sheppard, 1996; De Hoyo et al., 2012, Castillo-Rodrigues et al, 2012; Sekulic et al., 2012; Keiner et al., 2014). Although soccer play requires a fast reactiveness or responsiveness to a visual stimulus (movement of opponent, teammate or a ball), after which a player must make a good decision and efficiently perform a single or several movements (Moreno et al., 1995; Sekulic et al., 2012). Most agility testing in soccer has been researched in CODS, in a pre-planned movement patterns scenario. Typical CODS tests being used are T-test, shuttle run 10 x 5 m test, zig-zag test (Kapidzic et al., 2011; Sporis et al., 2009; Kaplan et al., 2009; Mirkov et al., 2008) or tests that combine agility with protocols that stimulates different bioenergetics systems responsible for successful play of soccer (e.g., Yo-Yo tests; repeated sprint tests) (Bullock et al., 2014; Bradley et al., 2016; Bangsbo et al., 2008).

Furthermore, previous cross-sectional and intervention studies commonly investigated determinants of CODS and the ways to improve agility by improving CODS' components. Those interventions aimed to improve CODS through improved force-velocity relationship (e.g., strength, speed) have ended up with mixed findings (Darren et al., 2013). It appears that when complexity of CODS tasks increased due to multiplied change of direction, the relationship with strength qualities and speed becomes more negligible (Chaucahu 2012; Brughelli et al., 2008; Matlak et al., 2016). The relationship with physical factors becomes even more trivial when basic perceptual cognitive factors (e.g., simple reaction time) were added in agility tests (Sheppard et al., 2006; Darren et al., 2013 & Young et al., 2015).

As mentioned earlier, soccer is a team sport where players are required to constantly perform changes of direction and speed in response to external stimulus, which actually represent the manifestation of reactive or non-planned agility (Lockie et al., 2013; Young et al., 2015 & Sekulic et al., 2016). Unfortunately, reactive agility (RA) has not been tested frequently in team sports and soccer. One of the reasons is the lack of the RA tests that are both valid and reliable on one hand, and that simulate real game situations on the other hand.

Some of the well-known examples of RA tests is so called "Y-shaped" test. Basically, the test was been developed for rugby players to test their ability to quickly change direction in response to external visual stimulus (Serpell et al., 2010; Sheppard et al., 2006), which provides a high ecological validity of the test in rugby. The subject is asked to sprint linearly and after the visual signal (right or left) to react accordingly changing a direction without stopping. Therefore, a subject has to change direction only once. The test provides a subject with only two options, left or right, which is one of the main disadvantages of this test, along with the fact that the test is performed in "non-stop running pattern". Similar testing of RAG in soccer with only two reaction options was conducted by McGawley and Andersson (2013), Di Mascio et al. (2015) & Fiorolli et al., (2017). In the first study, they used a modified T-agility test with an experimenter either signalling to the right or left for a subject sprinting toward him/her. The other study used a soccer-specific reactive repeated-sprint test with the lights showing a change of sprint direction.

However, in many team sports (e.g., basketball, volleyball, soccer, handball) players are required to react to external visual signal decelerating, stopping and then changing direction, executing so called “stop-and-go” manoeuvre. In order to test RAG in combination with this “stop-and-go” movement scenario and multiple reaction options (more than two), Sekulic et al. (2014) developed reliable and valid “stop-and-go” reactive agility test. Briefly, a subject is required to cross a distance of 1.5 m as fast as possible, after which s/he goes through an infrared timing gate that starts the stopwatch and lights one of four LED lights placed within four a 30-cm high cones. The subject has to spot the lit cone, run to the cone (≈ 2 m), touch it and run back through the timing gate as quickly as possible. Two front cones are position at the angle of 45° to the starting line, while two side cones are positioned at an the angle of 90° to the starting line. Using this test set-up, the researchers provided four-response options, “stop-and-go” and multiple turn’s direction movement scenario.

Furthermore, studies confirmed Young & Sheppard´s (2006) model of agility, with RAG and CODS being considered as independent components (Gabbett and Benton, 2009; Sekulic et al., 2014; Sattler et al., 2016), so testing them separately is recommended. Moreover, knowing that soccer is unique as a team sport, which includes combination of controlling the ball by legs and movement on pitch (Bullock et al., 2014), it seems logical to include a ball when testing agility. In that regard, Bullock et al. (2014) developed an integrative test of agility, speed and passing accuracy in soccer with the ball being incorporated in the test. The final section of the test includes RA testing, similar to the Y shape RA test providing only two choices for a subject to change direction in response to unpredictable visual stimulus projected on a screen (a soccer player dribbling the ball and changing direction; left or right). In order to develop a reactive agility test that would include a “stop-and-go” movement scenario, the ball presence and soccer related situation, we decided to construct a new test and to evaluate its reliability and validity. Therefore, **the aims** of the current study **we**re three-fold: a) to construct a new reactive agility test in soccer; b) to evaluate the reliability and validity of the new test; c) to investigate the relationship between physical capacities and agility performance.

2. Methods

Experimental approach to the problem

Previous studies emphasised the importance of testing RA, but specifically RA that includes multiple reactions and change of direction options (Sekulic et al., 2014). Sekulic et al (2014) created are liable and valid reactive agility test for team sports called "Stop-and-go" test that was used to test RA in agility sports (e.g., basketball, handball, volleyball, soccer etc.) with such stop and go movement pattern. They designed the test so that it provides four-response options and "stop-and-go" and multiple turn's direction movement scenario. However, as all sports are specific in their own way, with a number of specific factors that characterise them, e.g., soccer being unique as it is played by feet. In this study the "stop-and-go" test was modified from touch cone by hand, to touch ball with foot. That specific change involves an eye-foot synchronisation and coordination instead of eye-hand synchronisation coordination. The movement pattern that includes linear sprint, turns (45, 90 and 180°) in response to a signal, touching a ball with foot and sprinting back to starting position. It might be relevant in situation when defender or midfielder wants to intercept a pass, or in a situation when defender or midfielder wants to stop dribbler who has just received a ball. In the both situations, defender or midfielder tries to adjust his/her position after touching a ball sprinting in response to specific situation (e.g., ball position/possession, position offensive/defensive players etc.). Additionally, turning angles (from 45-180°) in soccer reported to be the most frequent way of changing direction in a soccer game (Bloomfield, 2012).

In the current study, within-subject, between-subject and cross-sectional experimental designs were used to determine the reliability and the validity of the newly constructed "stop-and-go" RA soccer test and the relationship between physical capacities and the test. The study design consisted of several phases. In the first phase, we tried to design the RA test for soccer players that would have a good ecological validity in terms of used movement patterns. In the second phase, the test was checked for reliability. In the third phase, the test was analysed for its discriminative validity comparing a different level soccer players. In the last phase, the relationship between selected physical capacities (e.g., speed, strength, power) and the new soccer RA test was analysed.

Participants

Twenty young male soccer players voluntarily participated in this study (age: 17.0 ± 0.9 years; body height: 181.0 ± 0.3 cm; body mass: 70.0 ± 7.4 kg; body fat percentage: 11.3 ± 2.0). They were recruited from a soccer academy that belongs to male team that plays at the highest league in Sweden. All participants competed at the highest level for their age group. They were healthy without any reported injury or neuromuscular diseases in the previous six month. The participants were divided in two different groups based on their age and performance level evaluated by their coaches (n=10, U17 & n=10, U19). The inclusion criterion was that the player had to belong in the group for a minimum time of 6 months to be included in the study. Additionally, they had to have at least 1 month of training time after being back from the injury. The higher performance group had in general two more years of experience. Goal keepers were excluded from the study. The both groups had similar training volume with training frequency of 6-10 sessions per week, (approximately 10-12 training hours each week). The players were in preparations phase and had approximately 4-6 weeks of regular soccer training before testing started.

All players signed a written consent to participate in this study after had been provided a verbal and written explanation of the study goals, potential risks and benefits. They were informed that they were free to withdraw the study without any consequences. Players under 17 years were also required to have parents´ or guardians´ consent to take a part in the study. The study was conformed to the principles of the Declaration of Helsinki. The study was approved by the regional ethical review board of the University of Umeå (No: 2016/457-31).

Review of the study protocol

The participants were tested from the end of January to the middle of March, 2017. To minimize variation in the climatic and other conditions, the testing took place in an indoor soccer stadium on artificial grass (turf) and in a gym. Participants were asked to come on four separate occasions; one familiarization and three testing sessions. During the familiarization session players were familiarised with selected tests, equipment and data collection protocols. On the same session the anthropometric characteristics were measured. During the first testing day, the speed and whole body acceleration ability was assessed. On the second day, maximal leg strength (back squat) and explosive power were tested using back squat and vertical jumps. The third testing day, agility performance was assessed (both CODS and RA). All testing was preceded by standardised warm-up (Pojskic et al., 2015).The testing days were separated by 48 hours rest. To avoid diurnal variation, the testing sessions were performed between 10 and 12 A.M. Participants were provided with verbal encouragement and asked to use as much effort as possible during all tests.

Familiarization procedure

All participants performed familiarization with all test and test equipment. Moreover, they did three trials of each test, except the new agility test which they did two trials each of the four protocols. The main reason for the familiarization was to reduce the learning effect during testing. Another aim was to ensure that participants had appropriate technique during the tests' execution. Especially for all jumps, sprint and agility test. The idea for the familiarization with back squat was to find an appropriate starting weight in the maximal back squat test (see appendix, A).

Familiarization with agility tests

Because the main aim was to develop the new RA test, it was important that participants were familiarised with the test as much as possible. They were asked to do the test as fast as possible and to find the best movement strategies for themselves, i.e.**,** find the best way to accelerate, make a turn, decelerate, touch a ball, and sprint and so on. This is because a participant usually finds a preferable movement repertoire that would be the fastest way to move for him/her (Sekulic et al., 2014). It could be shuffle running, sidestep, backward running, lateral displacement grapevine steps etc. (Sekulic et al., 2014). In this way we tried to reduce the learning effect during the test day.

Testing procedure

The testing procedure included measurements of body mass (BM), body height (BH), body fat percentage (BF%), CODS, reactive agility test, 20-m sprint, squat jump, countermovement jump, drop jump, unilateral jump and back squat. The body height was measured with measuring-tape and 90° ruler. The body mass was measured with a calibrated ordinary scale (Marquant). Body fat percentage was evaluated using the skin fold method (Durnin & Womersley et al., 1976 & Sekulic et al., 2014). The procedure includes skin fold measurements of four sites of body (biceps, triceps, scapular & suprailiac) using a Harpenden calliper. Before the measurements all measuring sites were marked using a pen with water soluble ink. These areas were then sum up and calculated in order to obtain a body density (BD) according to following formula: (BD = 1.162 – 0.063 x log Σ4KN = Sum of biceps, triceps, subscapular and suprailiac skinfolds). Body density was converted to body fat percentage: BF% = (4.95/BD – 4.5) x 100. The assessment was executed by a well experienced physiotherapist.

Agility testing

Agility performance was tested with one pre-planned (CODS) and with three non-planned courses (protocols). The both protocols used the same test set-up with a difference that participants in CODS protocol knew the movement pattern in advance, while in the non-planned (RA) protocol they performed the test in response to external light signal.

The test administration

The participant stood in a middle stance starting position behind the starting line that provides them the optimal position for a quick start. They started to run when they were ready, accelerating straight forward next 1.5 m between two cones (a gate) that were placed 65 cm apart (Figure 1). One of the two cones is an infrared (IR) cone that will detect movement. The detection starts a stop watch and triggers one of four LED lights placed in one of four cones (A, B, C, D) depending on which testing protocol have been chosen. In the pre-planned course (CODS), the lights in the cones light up in predetermined order (A, B, C, D, A) that is to say, a participant knows in advance which direction to run (1-2-3-4-1). The direction number 1 means that participant needs to make a 90º turn to the left, the direction number 2 indicates a turn of 45º to the left, the direction number 3 indicates a 45º turn to right and the direction number 4 denotes a 90º turn to right. In front of the each cone (A-D) is placed and fixed one soccer ball at a specially constructed stand which positioned the ball 3 cm above the ground.

After initiating one of the lights, the participants are required to run as fast as possible in the indicated direction, touch the ball with a foot and following a 180º turn to run back as fast as possible through the cones' gate (finishing line). Crossing the gate (IR cone) stops the time. Participants could choose which foot to use to touch the ball and which movement strategy to use to be as fast as possible. If they miss to touch the ball they had to repeat the protocol again after doing some other protocol before. The participants had 2-3 seconds to take the starting position before performing next trial. Each protocol consisted of five trials. The total time for one protocol was calculated as the sums of 5 trials. There were 3-5 minutes of recovery between the protocols. The fastest time out of 3 CODS protocols were taken for analyse.

We used 3 different non-planned reactive agility (RA) protocols with the following running direction (1-3-2-4-3), (2-3-1-4-1) and (4-3-1-4-2). The protocols were performed in the same way as the CODS protocol, with a difference that the participants did not know the movement direction (the lights ignition order) in advance. They had to spot the ignited light and react as fast as possible running in the proper direction, toward the light, touching the ball and running back through the IR gate. The best score from the three RA protocol were used for the analyses.

Each protocol, both CODS and RA were repeated 3 times, with the RA protocols being performed in the randomised order. In this way we tried to prevent the participants to remember the RA protocols. Each participant performed 12 agility trials with a total number of 240 recordings used for analyses. In the current study, the test device was plugged in to a PC with the operative system Windows 7. For the full description and information about the technical characteristics of the used testing equipment refer to Sekulic et al. (2014).

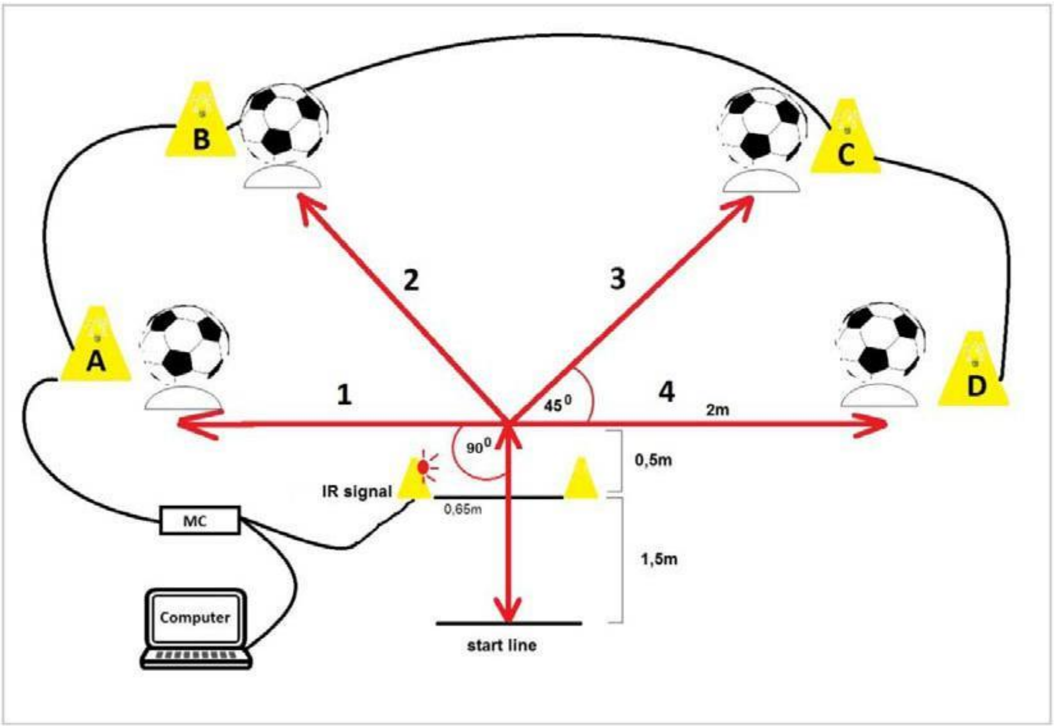

Figure 1. Set up of the new soccer agility test (CODS) and (RA)

Construction of the wooden stands for four soccer balls and four cones

Every ball was fixed on a wooden construction, with 10 m steel around it, to avoid the ball from moving. To avoid the construction from moving, screws of 8 cm were penetrated through the construction and 2.5 cm through the plastic turf grass. It was also needed to put plates of 30 kg on the construction. 2). When the change was made from touch a cone, to touch ball, the location of cone needed to be changed. It felt important to have the cone centred approximately 5 cm behind ball. Therefore was the cones attached to a secondly wooden construction visible above ball.

Testing jumping performance

The explosive strength components were tested using parts of Bosco jumping protocol which included squat jump, countermovement jump, drop jump and with additional of unilateral (single leg) CMJ. These jumps have showed good reliability and considered to have a high validity in measuring lower body explosive power (Markovic et al., 2004). All jumps had some instructional similarities. The participants were required to hold hands on hips during each of jump attempt to avoid contribution of arm swing and emphasize only leg power evaluation. They were instructed to land on their toes at the same spot as take-off. All jumps were performed 3 times with 1.5 min rest between the attempts. The best score was used for the analyses. The jumps measurements were performed using a contact mat (Muscle Lab, Norway).

Jump squat (SJ)

The jump is performed from a starting position of 90-100° in knee angle. A participant is asked to stand still in this position approximately two seconds before executing the jump. They are required jump as high as possible by rapidly extending the legs and the hips. Any countermovement is not allowed before the jump. This was checked by visual observation of experienced tester. The test is used to measure only execute a maximally concentric strength of lower body extensor musculature.

Countermovement jump (CMJ)

The participants started from an upright position. They were instructed to perform a countermovement movement to the depth and with a speed that would elicit the highest possible jump height. The downward movement were then immediately followed by a fast upward movement. The jump is used to test the stretch-shortening-cycle (SSC) utilisation.

Eccentric utilisation ratio (EUR)

The eccentric utilisation ratio presents the ability of the neuromuscular system to utilise the effects of the stretch shortening cycle (SSC). It is expressed as difference (in percentage) between SJ and CMJ height.

Single leg countermovement jump (SL-CMJ)

The SL-CMJ was performed in the same way as CMJ, but with a single leg jump. The participants alternately did the jumps 3 times at each leg, starting with dominant leg. The best of three attempts was used for the analysis. The index of asymmetry (IA) was calculated as a difference (expressed in percentage) in jump height between the legs.

Drop jump (DJ)

The DJ test was used to evaluate the participants´ reactive strength (Tanner and Gore, 2013). A participant started in an upright position standing on a wooden drop box (25 cm). They were instructed to step forward off the box without stepping down or jumping up. Upon the contact with the ground they were asked to shorten the contact time (CT) and to maximize the jump height (JH) as much as possible. The reactive strength index (RSI) was calculated as JH / CT (m/s) and the highest score was used for the analysis.

Testing acceleration and speed performance

The 20-m sprint (S-20 m)

The 20-m sprint test was used to measure acceleration and speed qualities. The participants stood 1m behind the first timing gate in a middle stance starting position with the body leaned forward. They were instructed not to make any backward movement before the start. They started to sprint in their own time when they were ready. The participants were instructed to perform the test maximally sprinting the whole distance. The "dive finish" was not allowed when they were approaching the finish line, the second timing gate. The time was recorded with two timing gates (Muscle Lab, Norway) with reflectors at 1m in height separated with 20-m distance. The participants performed 3 attempts with the best score used for the analyses.

Testing maximal lower body muscular strength - one repetition maximum (1RM) back squat

A free-weight back squat exercise was performed to predict the maximal dynamic lower body muscular strength (1RM). The aim for the participants was to find out the load they could lift between 1-6 times, with the last repetition considered to be to the failure as described earlier (Chtara et al., 2008). After the warm-up, participants performed the specific warm-up starting with weight of either 50% or 75% of 1RM (6 reps) that was prescribed individually for every participant. The percentage was determined based on the load they lifted during familiarization session. If participant performed more than 6 reps the load was increased after a protocol. In next to attempts, participants were required to find the targeted number of reps. The obtained number of repetitions and a load were then used for 1RM prediction using the equitation by Brzycki (1993). Recovery between sets was 3 min (Wisløff et al., 2004). A repetition was considered valid when the participants lowered the weight to required depth (hips and thighs below the parallel position) and then extended to full leg extension. The barbell was held in a high bar position over the shoulders on trapezius muscles. The Olympic barbell (20 kg) and free weights (Eleiko Sport, Inc., Halmstad, Sweden) with different increments from 0.5 to 20 kg were used. There were 3 assisters who took care of safety consideration being prepared to take the bar in each moment if needed. Two of them were on the sides and one stood behind a participant. The test leader was standing 1.5 m away on one side from the participant checking the proper technique execution during the assessment.

Warm-up protocol before jumping, sprinting and agility tests

A standardised warm-up proceeded all testing days. This included a general warm-up, dynamic stretching and specific warm-up exercises (see Table 1). The general warm-up consisted of 800 metres running that was progressively increased in running speed at 90 seconds, 70 seconds, 60 seconds and 45 seconds every 200 m (8 km/h, 10 km/h, 12 km/h and 16 km/h). The dynamic stretching included front and lateral lunges, squats with dynamic exercise for the legs adductors, and exercises for the gluteus and the gastrocnemius muscles. This was followed by a specific warm-up with high-intensity exercises; six vertical jumps (performed from lower than 90º in the knee flexion angle) and two sub-maximal (70%) and maximal (95-100%) sprints. After the warm-up there was an active rest of 3-5 min before the testing. The total time for the whole warm-up was approximately 10 min.

Table 1. Warm-up protocol which includes increased speed of jogging, dynamic stretching and high-intensity specific exercises.

The warm-up protocol	
General part	***Volume***
Jogging	90, 70, 60 and 45 sec / 200 m
Squat sit + adductor opener	20 seconds
Lunges Forward	5 reps each leg
Lunges Lateral	5 reps each leg
Gluteus stretch	20 seconds each leg
Gastrocnemius	20 seconds each leg
Specific part	
Vertical Jump	6 reps
Linear sprints (75% & 95%)	2x1(20 m)

Statistical analysis

Descriptive data (means, standard deviation, range and coefficient of variation) were calculated for all dependent variables. The Shapiro-Wilks test used to check normal distribution of the data. The homoscedasticity was tested with Leven's test. Independent samples t-test was used to investigate the differences between U17 and U19 players in the applied tests. Effect size of the differences was calculated with Cohen's d with the conventional operational definitions as trivial = < 0.2, Small = 0.2-0.6, moderate = 0.6-1.2, large = 1.2-2.0 and very large >2.0 (Cohen, 1988; Sawilowsky, 2009). The Pearson's product-moment correlation was used to investigate the correlation between RA and CODS. To analyse the relationship between the RA and CODS and other physical capacities the linear regression was used. The reliability (within-subjects and between subjects) was evaluated by calculation of intraclass correlation coefficients (ICC), coefficient of variation (CV) and Cronbach's alpha (α). Repeated measures analysis of variances was used to check for systematic bias between the trials in the agility tests. Statistical analyses were performed with both SPSS (Windows version 24.0, USA) and Microsoft excel 2010 (Windows Version 12.0, USA).

3. Results

Descriptive statistics

Table 2 shows descriptive parameters for U17 and U19 group. The results showed that U17 and U19 group had higher variability in playing experience, body fat percentage, the eccentric utilisation ratio and index of asymmetry between single leg CMJ jump heights. The results of Shapiro-Wilk's test showed that all data were normally distributed for both groups (Appendix).

Reliability data

The test-retest reliability data for the soccer-specific pre-planned (CODS) agility test and three non -planed reactive agility (RA) tests (protocols P1, P2, P3) are presented in Table 3. The newly designed soccer-specific CODS test showed to be highly reliable with the ICC coefficient 0.92. The first reactive protocol (P1-RA) showed lower, but satisfactory reliability with the ICC of 0.70. The other two reactive agility protocols P2-RA and P3-RA showed higher reliability with ICC 0.88 and 0.87, respectively.

Relationship between CODS and RA tests

The CODS test was significantly, but moderately correlated with the reactive agility tests P1-RA, P2-RA and P3-RA with the correlation coefficients $r=0.50$, $p \leq 0.05$; $r=0.56$, $p \leq 0.05$; and $r=0.63$, $p \leq 0.05$, respectively. The data show that the CODS test and RA tests share only 25%, 31% and 39% of the common variance.

Table 2. Descriptive parameters and differences in the physical capacity and agility tests between the groups (U17 and U19)

	U17					U19								
Physical capacity test	**N**	**x̄**	**SD**	**Min – Max**	**CV%**	**x̄**	**SD**	**Min - Max**	**CV%**	**t-test**	**P**	**ES**	**CI95-**	**CI95+**
Age (years)	10-10	16.5	0.70	16 – 18	4.2	17.5	0.97	16 - 19	5.5	2.631	0.01*	1.24	-1.79	-0.20
Playing experience (years)	10-10	9.3	1.88	5 – 11	20.2	11.8	2.78	6 – 16	23.5	2.352	0.03*	1.10	-4.73	-0.26
Body height (cm)	10-10	1.82	0.04	176 – 190	2.2	1.80	0.02	177 - 185	1.1	0.799	0.43	0.37	-0.021	0.047
Body weight (kg)	10-10	70.7	9.14	60 – 82	12.9	69.4	5.62	61 - 79	8.1	0.383	0.70	0.19	-5.93	8.53
Body fat (%)	10-10	11.8	2.05	6.4 - 9.6	17.3	10.8	1.99	8.4 – 13.7	18.4	1.107	0.28	0.52	-0.90	2.90
20-m sprint (s)	8-10	3.03	0.09	2.88 3.16	2.97	2.99	0.08	2.84 - 3.08	2.68	0.777	0.45	0.38	-0.05	0.12
SJ (cm)	8-8	33.3	3.87	27 – 40	11.62	35.73	2.59	30 – 38.9	7.25	1.64	0.11	0.77	-5.52	0.68
CMJ (cm)	8-8	35.8	3.75	31.3 - 43.2	10.47	37.80	2.55	34.3 – 42.1	6.75	1.37	0.18	0.64	-4.98	1.04
EUR (%)	8-8	7.01	5.20	0.32 - 18.2	74.18	5.42	4.49	0.8 – 13.6	82.84	0.733	0.47	0.34	-2.97	6.16
Asymmetry (%)	8-8	8.46	5.88	1.18 – 19.55	69.50	12.13	8.68	0.53 – 23.2	71.56	0.999	0.34	0.52	-11.62	4.28
RSI (m/s)	8-8	1.47	0.23	1.21 – 1.81	15.65	1.52	0.16	1.24 – 1.71	10.53	0.459	0.65	0.24	-0.26	0.17
1RM squat (kg)	6-8	92.9	16.0	72.0 – 112.5	17.22	99.1	11.9	82.5 – 115.0	12.01	0.853	0.41	0.47	-21.79	9.45
Relative strength (1RM/BW)	6-8	1.32	0.10	1.21 – 1.51	7.58	1.42	0.13	1.23 - 1.57	9.15	1.569	0.14	0.87	-0.24	0.03
CODS (s)	10-10	7.78	0.33	7.3 - 8.34	4.30	7.22	0.35	6.46 - 7.74	4.98	3.614	0.00*	1.7	0.23	0.88
P1-RA (s)	10-10	9.73	0.44	9.18 - 10.50	4.55	9.38	0.24	8.98 - 9.82	2.58	2.141	0.05*	1.1	-0.00	0.68
P2-RA (s)	10-10	9.67	0.42	9.22 - 10.68	4.35	9.38	0.44	8.73 - 10.26	4.79	1.469	0.16	0.6	-0.12	0.69
P3-RA (s)	10-10	9.77	0.44	8.97 - 10.43	4.57	9.34	0.35	8.77 - 9.81	3.79	2.417	0.02*	1.4	0.05	0.81

n = number of participants from U16 and U19 groups; x̄= mean value; SD = standard deviation; Min. = minimal value; Max. = maximal value; CV% = coefficient of variation; p = p value; ES = Cohen's d effect size coefficient; CI = confidence interval; CMJ = Countermovement Jump; SJ = squat jump; EUR = eccentric utilization ratio; Asymmetry = differences between dominant and non-dominant leg in single CMJ jump height; RSI = reactive strength index; 1RM = one repetition maximum; BW = body weight; CODS = newly designed pre-planned soccer agility test; P1-RA = newly designed reactive agility test in soccer (protocol 1); P2-RA = newly designed reactive agility test in soccer (protocol 2); P3-RA = newly designed reactive agility test in soccer (protocol 3); * = Difference is significant at the level of $p \leq 0.05$(2-tailed)

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Table 3. Reliability coefficients of the newly designed soccer agility tests (CODS and RA)

Agility tests (trials)	**x̄**	**SD**	**Min.**	**Max.**	**CV%**	**ICC**
CODS	7.69	0.45	6.67	8.70	5.85	0.92
CODS-1	7.82	0.54	6.93	9.03	7.03	
CODS-2	7.66	0.46	6.62	8.74	6.12	
CODS-3	7.59	0.42	6.46	8.37	5.58	
P1-RA	9.90	0.36	9.28	10.85	3.66	0.70
P1-RA-1	10.2	0.57	9.26	11.29	5.59	
P1-RA-2	9.80	0.37	9.18	10.75	3.87	
P1-RA-3	9.69	0.40	8.98	10.50	4.19	
P2-RA	9.53	0.44	8.73	10.68	4.71	0.88
P2-RA-1	10.2	0.62	8.97	11.29	6.14	
P2-RA-2	9.81	0.45	9.14	10.81	4.65	
P2-RA-3	9.55	0.45	8.73	10.68	4.81	
P3-RA	9.99	0.49	9.14	11.03	4.94	0.87
P3-RA-1	10.4	0.63	9.09	11.94	6.09	
P3-RA-2	9.94	0.53	8.97	10.96	5.36	
P3-RA-3	9.62	0.47	8.77	10.59	4.99	

x̄ = mean value; SD = standard deviation; Min. = minimal value; Max. = maximal value; CV% = coefficient of variation; ICC = Interclass Correlation Coefficient; α = Cronbach's alpha coefficient; CODS = newly designed pre-planned soccer agility test; P1-RA = newly designed reactive agility test in soccer (protocol 1); P2-RA = newly designed reactive agility test in soccer (protocol 2); P3-RA = newly designed reactive agility test in soccer (protocol 3).

Table 4. Pearson's product-moment correlation coefficients (r).

	Reactive Agility tests		
Pre-planned agility	P1 RA	P2 RA	P3 RA
CODS	0.500*	0.558*	0.634**

CODS = newly designed pre-planned soccer agility test; P1-RA = newly designed reactive agility test in soccer (protocol 1); P 2-RA = newly designed reactive agility test in soccer (protocol 2); P 3-RA = newly designed reactive agility test in soccer (protocol 3); * = Correlation is significant at the 0.05 level (2-tailed); ** = Correlation is significant at the 0.01 level (2-tailed).

Relationship between physical capacities and agility performance

The results from Table 5 showed that only eccentric utilisation ratio index (EUR) and relative lower-body strength correlated to P2-RA ($r=0.46$, $p\leq 0.05$; $r=0.62$, $p\leq 0.05$), while there were not any other significant correlations between the tests. The results of three regression analyses showed that used predictor system of variables (physical capacity) could not explain the used criteria, the agility tests, CODS and RA (Table 6).

Table 5. Pearson's product-moment correlation coefficients (r).

Physical Performance	The Agility tests CODS	P1 RA	P2 RA	P3 RA
20-m Sprint	-0.058	-0.110	-0.165	-0.123
SJ	-0.217	0.068	-0.116	-0.054
CMJ	-0.191	0.160	0.147	0.079
EUR	0.074	0.153	0.463*	0.225
Asymmetri	-0.094	-0.246	-0.011	-0.060
RSI	0.124	-0.031	0.049	-0.180
1RM Squat	-0.214	-0.139	-0.479	-0.105
Relative strength	-0.253	-0.046	-0.622	-0.089

CMJ=Countermovement Jump; SJ = squat jump; EUR = eccentric utilization ratio; Asymmetry = differences between dominant and non-dominant leg in single CMJ jump height; RSI = reactive strength index; CODS = newly designed pre-planned soccer agility test; P1-RA = newly designed reactive agility test in soccer (protocol 1); P2-RA = newly designed reactive agility test in soccer (protocol 2) ; P3-RA = newly designed reactive agility test in soccer (protocol 3).*Statistical significance of $p \leq 0.05$.

Table 6. The relationship between physical capacities and the newly designed soccer agility tests (N = 20).

Independent predictors	Dependent variables (the agility tests) CODS		P1-RA		P2-RA		P3-RA	
	B	P value	B	P value	B	P value	B	P value
20-m sprint	-0.933	0.071	-0.637	0.252	-0.755	0.094	-0.762	.238
CMJ	-0.384	0.410	0.367	0.509	-0.063	0.875	-0.400	.532
EUR	-0.176	0.637	0.305	0.502	0.234	0.490	-0.019	.970
Asymmetry	0.348	0.548	0.380	0.586	0.068	0.894	-0.198	.804
RSI	-0.228	0.653	0.549	0.387	-0.177	0.698	-0.526	.467
1RM Squat	0.553	0.440	0.909	0.306	0.294	0.642	0.030	.976
Relative strength	-1.216	0.156	-0.928	0.340	-1.15	0.140	-0.245	.820
Model summary	R^2= .64; p = .40		R^2= .48; p = .70		R^2= .71; p = .27		R^2= .30	p = .91

Legend: R^2 = The squared multiple correlation coefficient; β = Standardized coefficient; Legend: CMJ = Countermovement J ump; SJ = squat jump; EUR = eccentric utilization ratio; A symmetry = differences between dominant and non-dominant leg in single CMJ jump height; RSI = reactive strength index; CODS = newly designed pre-planned soccer agility test; P1-RA = newly designed reactive agility test in soccer (protocol 1); P2-RA = newly designed reactive agility test in soccer (protocol 2); P3-RA = newly designed reactive agility test in soccer (protocol 3). * Statistically significant the overall relationship between the predictor variables and dependent variable ($p < .05$); ** Statistically significant contribution of a particular predictor variable to the overall relationship ($p < .05$)

Differences between the groups

Results from Table 2 showed that there were only statistical differences between groups in age, playing experience and agility performance tests, while there were not differences in body height, body mass, percentage of body fat and tested physical capacity tests. The CODS was better in U19 (7.22 ± 0.35) than in U17 (7.78 ±0.33) with a statistically significant mean difference of 0.56, 95% CI [0.23, 0.88], t(17) = 3.16, d = 1.7. The reactive agility tests P1-RA and P2-RA were also better in U19 (9.38 ± 0.24 and 9.34 ± 0.35) than in U17 group (9.73 ± 0.44 and 9.77 ± 0.44) with a statistically significant mean difference of .34, 95% CI [0.00, 0.68], t(14) = 2.14, d = 1.1 and 0.43, 95% CI [0.05, 0.81], t(18) = 2.14, d = 1.4. There were not significant differences between the groups in P2-RA test protocol.

4. Discussion

The purpose of this study was three-fold: a) to construct a new reactive agility test in soccer; b) to evaluate the reliability and validity of the new test; c) to investigate the relationship between physical capacities and agility performance (CODS and RA).

Result discussion

Tests reliability and validity

There are several important findings of this study. The first, the new designed reactive agility test showed to be reliable with high consistency coefficients. The second, the tests showed to be valid for soccer. Third, there was a significant correlation found between CODS and RA tests with less than 50% of the explained common variance, which indicates that tests should be considered to measure the independent qualities (Sekulic et al., 2014). The fourth, the tested physical capacities did not show significant relationship with the agility tests.

The reliability coefficients for the agility tests RA and CODS test in this study showed similar ICC of (0.7-0.88 and 0.92) that have been reported for the original “stop-and-go” test (0.81 and 0.87) (Sekulic et al., 2014). The high ICC were also reported in some other studies such 0.83 (Farrow et al., 2005), 0.91(Veale et al., 2010), 0.82 (Serpell et al., 2010). The reliability score (ICC) of the CODS test is in the line with some reported for pre-planned traditional CODS test such as 0.93 for T-agility (Sporis et al., 2009) and Zig-zag test (Mirkov et al., 2008), 0.82 for the 10 x 5 m shuttle run test (Kaplan et al., 2009), 0.93 for the Illinois agility test (Ducking et al., 2016). The “stop-and-go” CODS test from the current study showed also similar reliability comparing to more traditional pre-planned agility tests used in soccer.

One way to obtain the tests validity is by comparing different performance level groups. The results showed that there were differences in three of four agility tests (protocol 1, protocol 3 and CODS) between the groups having the higher level group outperforming the other group, while there were non-significant differences in the tested physical capacities. This suggests the soccer-specific agility to be an independent quality of the other physical capacities (e.g., speed, strength, power). Furthermore, the results imply that the soccer-specific agility tests can be used to differentiate the soccer players by the level of play in both CODS and RA performance. It seems that qualities needed to perform the tests at a higher level are soccer related qualities that were developed with accumulated training time. These qualities include not only the perceptual and reactive capacities such as visual scanning and reaction time speed, but also high-intensity activities (e.g., acceleration, deceleration, turns) specific to soccer. Sekulic et al. (2014) tested a discriminative validity of the "stop-and-go" test using 2 samples consisted of athletes playing in agility saturated (basketball, soccer, handball, volleyball players) and non-agility saturated (e.g., track and field, gymnastics etc.) who are not exposed to that kind of external stimulus sports. They found significant differences between the groups in the RA, but not in the CODS "stop-and-go" tests. This was understandable, because the agility saturated athletes train all the time in the environment that requires them to change the direction of speed in response to an external stimulus (e.g., a ball, teammates, or opponents movement) comparing to the athletes recruited from a non-agility saturated sports. The value of the developed test is even bigger when we know that the tests succeeded in differentiating the players in same sport who had not big differences in age and both anthropometric characteristics and physical capacities. The fact that there were differences in the both agility tests, not only in the RA, can be explained by the data that did not show a big difference in playing experience time between the groups that could affect the development of soccer-specific skills, both cognitive and physical. It means that both tests could be used interchangeably to test a soccer-specific agility performance.

Furthermore, Fiorilli et al. (2017) tested soccer players in y-shape design agility test and did not find a difference between playing positions suggesting that CODS and RA couldn't be used in assigning the players roles in soccer. It can be assumed that y-shaped test lacks in soccer-specific tasks comparing to the tests used in the current study, but we can assume that the RA test developed in the current study also lacks in some more specific stimulus that could contribute to groups discrimination. We can assume that testing groups of players with a bigger difference in the playing experience might lead to the differences between the tests results. Also, developing a test with more specific external stimulus and tasks could potentially have more discriminative and ecological validity. We tried this by including tasks that would simulate a soccer-specific movement such as the footwork in the turns and in the deceleration and acceleration movement before and the after touching a ball. To summarise this, the soccer-specific CODS and RA showed to be valid tools in assessing a specific agility in young soccer players.

The coefficient of variation (CV) for both agility test was somewhat higher (4-5% and 2-3%) than the CV reported in other studies (Sekulic et al., 2014; Ducking et al., 2016). The obtained variation seems to be in acceptable range, considering to the relatively small sample size and to some extent heterogeneous sample (U17 and U19 players).

In the current study we obtained significant and moderately strong correlations between CODS and three RA protocols with the Pearson correlation coefficients of 0.49, 0.55 and 0.63 respectively. This is somewhat lower than it has been reported by Sekulic et al. (2014) for the original "stop-and-go" test ($r = 0.62$ & 0.68), but higher than it was reported by Matlak et al. (2016) who showed a weak correlation ($r = 0.25$). On the other side, Oliver and Myers (2009) reported the correlation between CODS and RA to be a quite strong ($r = 0.92$). They explained the correlation with the Y-shape protocol used that include only a single change of direction after reacting to flashing light. This kind of stimuli lack a sport specific stimulus and clues that require perceptual qualities. Shepard et al. (2006) tested these qualities (visual scanning, anticipation, and pattern recognition) using a sport specific stimulus (a real life opponent) and they reported that high performance athletes were able to perform the RA test even better than CODS test.

In the current study, the explained variance between the CODS and RA was lower than 50%, which implies that that the tests measure independent qualities. Some part of the unexplained variance can be explained by the cognitive factors because in the CODS test does not have external stimulus that require the perceptual and cognitive processing (Lockie et al., 2014; Sekulic et al., 2016). Results from this study are in the line with some similar studies that investigated pre- and non-planned agility qualities suggesting that they are independent qualities (Sekulic et al., 2014; Sekulic et al., 2016; Matlak et al., 2016).

The relationship between the agility performance and physical capacities

The third objective of the current study was to investigate the relationship between tested physical capacities and agility performance in CODS and RA. The results showed that the physical capacities did not significantly correlate to the agility performance. These findings are in accordance with Young et al. (2015) who tried to find the association between the reactive agility performance and physical abilities (e.g., maximal strength, reactive strength, countermovement jump and squat jump performance). Moreover, the other studies found trivial to weak correlation between agility performance and power capabilities on bilateral (Matlak et al., 2016) and unilateral jump tests (Henry et al., 2015). Additionally, Sekulic et al. (2016) reported negative relationship between high speed and power capabilities and reactive agility performance. They speculated that participants who faster accelerated and then were supposed to suddenly change the direction and speed in response to an unpredictable external stimulus needed more energy to overcome their body inertia to decelerate and make the change of direction which prolonged their time comparing to those who had slower acceleration and speed before the changing of direction.

On the other side, some studies showed a positive correlation between the reactive agility tests and physical capacities. Naylor & Grieg (2015) reported a moderate correlation between eccentric hamstrings strength and deceleration task during of reactive agility test. Matlak et al. (2016) found significant correlation between foot tapping speed and turning time. High scores on foot tapping enabled participants to perform more strides while changing direction. It is believed that cognitive stimulus that is unpredictable hinder the time necessary to utilize and apply force (Darren et al., 2016).

However, CODS tests seemed to be more correlated to physical abilities (Kapidzic et al., 2009; Jones et al., 2009). Young et al. (2015) found a moderate correlation between CODS test and maximal strength, reactive strength, countermovement and squat jump when tested in rugby players. High eccentric strength was correlated with better CODS time which is understandable knowing that eccentric strength is important in deceleration movements. A higher eccentric strength was also positively associated with greater turning angles in CODS (De Hoyo et al., 2016). It is important to highlight, that the correlation between power and CODS becomes weaker when a number of directional changes is higher in a test (Chaucacu, 2012; Matlak et al., 2016). The results from the current study support this.

The results from this study imply that a soccer-specific CODS and RA share a little variance with tested physical capacities which is in line the previous cross-sectional researchers (Chauca et al., 2012; Young et al., 2015; Henry et al., 2015; Matlak et al., 2016). Additionally, Henry et al. (2015) saw that different participants had differently developed physical abilities which required them to use different movement strategies to "solve" problem of complex CODS and reactive agility tests. In regard to this, it h s been suggested that more cross-sectional studies are required to be conducted to investigate the relationship between different physical capacities and agility performance (Brughelli et al., 2008).

Method discussion

Testing protocols

The agility testing was performed in the same indoor soccer stadium on artificial turf grass with the stable conditions (temperature of 16°, no difference in humidity or wind). The testing area with all equipment was approximately 5 x 4 m. There were the same warm-up activities that preceded all testing protocols. The warm-up was controlled with prescribed intensity (speed in km/h) and duration. It was important to establish that the participants could see the LED lights when fleshing. For example, the testing outside was not possible because of too high brightness of the sun. There was also important that it was not dark either, which could influence the coordination. Because of the long testing period of 09.00-12.00 it was important that the light equipment was standardised. Professional luminaire light equipment with two different set-ups of light, the first was chosen with prescribed f or training. Another important aspect of the conditions was the surface. Turf grass has a durable and fixated surface with much friction. However, there were some diurnal differences between two testing days of participants that were tested some in the morning and some in the afternoon. The reason was due to some logistical problem.

All participants got 48 hours between testing days and no high-intensity training 48h before testing. However, 48 hours may not be enough to ensure that participants have fully recovered from strenuous exercise (Powers et al., 2012). The participants were encouraged to have a light meal before the testing and to stay hydrated during testing. Additionally they were asked to avoid any strenuous physical activity day before testing and sleep deprivation. In addition, the motivation is a factor that could differ between the participants. However, the participants were verbally encouraged to perform maximally during all attempts. Although participants had been familiarised with the tests there were the tendency of improvement in performance from the first to the third trial in the RA. It can be said that two testing trials should be recommended and the better results used for the analysis. This was not a case for the CODS, so only one testing trial could be used.

Physical capacities testing

There are three tests that should be discussed. The 20-m sprint, can be questioned for be too long because the most frequent sprint in soccer is between 10-20 m (Bangsbo et al., 1991). The 20-m test is relevant for the measurements of acceleration ability, but maybe more relevant would be 15-m sprint test or tests used with split times on 5th and 10th meter.

Drop jump, was performed in order to evaluate the participants´ reactive strength index (RSI). In the current study, a drop box of 25 cm height was used for the testing. This was asked by their coaches who were afraid that players could get injured and it was the only way to do it, if we want to test the participants for their RSI. The lower height might be insufficient for the most of the players to exert the highest possible reactive strength. In addition, it was a little bit hard to standardise the jump technique, which might have led to some small individual variation.

The back squat exercise was performed in order to get the predicted 1RM (maximal strength) of the legs extensors, which could under estimate the actual 1RM. This was performed in this way to avoid the potential injuries due to the lack of squat technique or overall strength in some players.

Limitations of the study

There were several limitations in this study. Firstly, there was a relatively small sample size which limits the generalizability of the findings and ability to do the regression analysis in a proper way. The original idea was to test 80 participants, which would be sufficient for the regression analysis. However, after logistical problems and withdrawal of younger players and professional players, 20 soccer players remained in the study. The conclusions and the interpretation from this study should therefore be considered with limitation and only applicable for a group of young, junior soccer players.

The specificity can be questioned, due to a relatively simple soccer task. Just to touch a fixed ball it may not reflect the common soccer touch and the footwork before and after the touching a ball. Usually in a game ball constantly moves which make the decision making even harder.

A light as the stimulus used for testing of cognitive responses and decision making have been criticized for being too simple, non-specific to sport. The critic consists of that only reaction time and response accuracy is tested with light being turned on or off (Sheppard et al., 2006; Oliver et al., 2009). It is minimal information to be processed, so it might be a problem to distinguish between performance level players (Abernethy, et al., 1987; Ward et al., 2003). So it might be more relevant to use a video and human movement to test the perceptual and cognitive responses (PCR). On the other side, the light was generally considered to be highly reliable and valid tool, so having a complex series of stimulus can be more beneficial (Darren et al, 2016).The three protocol of the reactive agility had some similarities on two of the five directional changes. It was a potential risk that someone of the participant could have figured out one or both of the turns. However, similar methodological flaws have been made by Sekulic et al. (2014). We tried to avoid this having the protocols in the randomised order. There were also some technical disturbances with the equipment. A couple of times the software Putty froze for a several seconds, then the equipment needed to be restarted. At a couple of moments the IR-cone did not register movement/motion. That led to re-start of the participant.

5. Conclusion

The current study has shown that the newly designed agility test for soccer is a reliable and valid testing tool for soccer-specific agility. This is a further step in progressively developing agility tests with increased specific components to soccer. It is important that perceptual and cognitive factors be included in further tests. The study has also showed the physical abilities tested in this study did not correlate with agility performance, so the further analyses should be conducted. Moreover, more research is needed to investigate whether reactive agility testing with light can distinguish playing level. There is also one very important practical implication of the study. The CODS and reactive agility were showed to be independent qualities, so they should be trained and tested separately.

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7. Appendix

Tests of Normality

	Group	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
20-m sprint	U17	.246	7	0.200*	.847	7	0.116
	U19	.271	6	0.191	.811	6	0.074
SJ	U17	.257	7	0.179	.932	7	0.566
	U19	.269	6	0.200*	.934	6	0.611
CMJ	U17	.261	7	0.161	.873	7	0.196
	U19	.298	6	0.103	.806	6	0.067
EUR	U17	.212	7	0.200*	.890	7	0.277
	U19	.246	6	0.200*	.827	6	0.102
Asymmetry	U17	.152	7	0.200*	.974	7	0.927
	U19	.187	6	0.200*	.929	6	0.572
RSI	U17	.206	7	0.200*	.897	7	0.313
	U19	.273	6	0.184	.889	6	0.312
1RM Squat	U17	.210	7	0.200*	.916	7	0.439
	U19	.235	6	0.200*	.943	6	0.682
Relative strength	U17	.188	7	0.200*	.932	7	0.564
	U19	.278	6	0.161	.825	6	0.098
CODS	U17	.234	7	0.200*	.940	7	0.635
	U19	.180	6	0.200*	.921	6	0.514
P1_RA	U17	.227	7	0.200*	.923	7	0.491
	U19	.181	6	0.200*	.963	6	0.843
P2_RA	U17	.177	7	0.200*	.952	7	0.749
	U19	.199	6	0.200*	.950	6	0.740
P3_RA	U17	.168	7	0.200*	.959	7	0.813
	U19	.269	6	0.200*	.891	6	0.323

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction