# RELIABILITY AND VALIDITY OF THE NEWLY DEVELOPED TESTS OF FOOTBALL SPECIFIC CHANGE OF DIRECTION SPEED AND REACTIVE AGILITY IN YOUTH PLAYERS

Nikola Foretic[1], Barbara Gilic[1, 2], Damir Sekulic[1]

[1]*University of Split, Faculty of Kinesiology, Split, Croatia*
[2]*University of Zagreb, Faculty of Kinesiology, Zagreb, Croatia*

## ABSTRACT

*Purpose*: Agility is an important determinant of success in football (soccer), but there is a lack of reliable and valid tests applicable in the evaluation of different agility components in youth football players. In this study we evaluated the reliability and factorial validity of the two newly developed tests of agility in male youth football players.

*Methods*: The sample comprised 44 youth football players (all males, 14–15 years of age) who were tested on anthropometrics (body height and mass), newly developed tests of football specific reactive agility (FS-RAG) and change of direction speed (FS-CODS), one standard test of CODS (20-yards), and sprinting over 20-m distance (S20M). The relative reliability is evaluated by calculation of Intra-Class-Correlation coefficients (ICC), while the absolute reliability was evaluated by calculation of the coefficient of variation (CV). Further, systematic bias was checked by analysis of variance for repeated measurements (ANOVA). The associations between studied variables were evidenced by Pearson's correlation. Finally, factor analysis was calculated to define the factorial validity of agility tests (FS-RAG, FS-CODS, 20-yards).

*Results*: The newly developed football-specific tests were found to be reliable, with better reliability of FS-CODS (ICC: 0.81, CV: 6%), than of FS-RAG (ICC: 0.76, CV: 9%). The ANOVA evidenced significant ($p < 0.05$) learning effects for FS-RAG, but post-hoc analysis indicated stabilization of the results until the third testing trial. Factor analysis extracted one significant factor under the Guttmann-Kaiser criterion (Explained Variance: 1.67), showing the appropriate factorial validity of newly developed tests in comparison to standard agility indicator 20-yards. Meanwhile, the significant correlations between all agility performances with S20M (Pearson's R: 0.52–0.63; all $p < 0.01$) revealed that sprinting capacity significantly influence agility performances and that conditioning capacities of youth football players are not yet discriminated.

*Conclusion*: Results showed appropriate reliability and validity of the newly developed tests of football specific change of direction speed and reactive agility. Therefore, here proposed FS-CODS and FS-RAG can be used as reliable and valid measures of agility components in youth football players. Further studies should evaluate the discriminative validity of the here proposed tests (i.e. identification of position-specific or performance-related differences), as well as reliability in younger players than those studied herein.

**Keywords**: soccer; agility; sport-specific tests; reliability; validity

**Introduction**

Agility is a motor ability that directly influences successful performance in majority of team sports (Freitas et al., 2019). It is defined as a performance quality of an athlete to rapidly change direction and speed of movement (Gabbett, 2006). Agility has two main components: *change of direction speed component* and *perceptual and decision making component* (Sheppard & Young, 2006).

Football is a team sport characterized by short sprints, rapid acceleration or deceleration, turning, jumping, kicking, and tackling (Wisloeff, Helgerud, & Hoff, 1998). Following this, it is clear that most important abilities for successful football performance are those connected with speed and force production such as; power, speed and agility. Agility in football is often described as a player quality to fast change direction or speed of movement, to start and stop quickly, with or without the ball (Sporis, Jukic, Milanovic, & Vucetic, 2010). Time-motion analysis show that football player changes direction every 2–4 seconds and makes 1,200–1,400 changes of direction during a game (Bangsbo, 1992).

In football, agility appears in two forms dependable on game situations; *non-reactive* (CODS) – pre-planned players change of direction that is not conditioned by any external factor and *reactive* (RAG) – non-planned change of direction that is influenced by opponent action. Both forms appear with or without the ball. CODS depends on: technique of movement, straight sprinting speed, anthropometry, reactive strength, concentric strength and power & left-right leg muscles imbalances. On the other side RAG depends on completely different qualities: visual scanning, knowledge of given situations, pattern recognition and anticipation (Sheppard & Young, 2006). Although the nature of the football game produces many unexpected situations and puts reactive agility on very important place in player's ability setup, both CODS and RAG should be trained and developed from the youth categories.

As a fundamental physical trait, agility should be regularly monitored and assessed, if possible, in sport-specific conditions. Sport-specific tests are developed to simulate basic movement patterns in real-sport situations. It is overall opinion that these tests better asses players capacities for successful performance in given sport than general fitness tests (Uljevic, Spasic & Sekulic, 2013). Football coaches, trainers, and players continually search for simple and effective tests that may help to revel deficiency in agility. Along with simplicity and efficiency those tests must have acceptable metric characteristics. Most of all tests must have satisfying reliability and validity.

Since there is a lack of reliable and valid tests applicable in the evaluation of different agility components, especially in youth football players, we have developed new tests of football specific change of direction speed and reactive agility. In regard to this, main goal of the study was evaluation of the reliability and factorial validity of these two newly developed tests.

**Methods**

*Subjects*

Subjects in this study were 44 youth male football players, 14–15 years old. Only participants who had no injuries and/or illnesses for 30 days before the experiment were included in this investigation. The ethics board of the author's institution provided approval of the research experiment. Participants voluntarily took part in the testing after they provided written consent. All players had been playing football for at least 4–6 years. The average training frequency of all players ranged from 10 to 14 hours per week, with an average of 5–6 sessions weekly.

*Procedures*

Players were tested on 2 basic anthropometric variables; body height (BH) and body mass (BM). Body height was measured with GPM anthropometer (*Siber Hegner*, Zurich, Switzerland) while body mass was assessed using the *Tanita BC-418* device (Amsterdam, Netherlands).

The agility variables included 2 newly developed tests of football specific reactive agility (FS-RAG) and change of direction speed (FS-CODS), one standard test of CODS (20-yards), and sprinting over 20-m distance (S20M).

For the S20M test, the participants were placed 1 meter behind the start line with their body leaned forward. The first timing gate (*Powertimer, Newtest*, Finland) was on the start line (0 m), and the second at the finish line (20 m), reflectors were at 1 m height. The participants were told not to include backward movements at the start and to sprint at maximal speed the whole distance with avoiding a "dive finish." The athletes had three trials with a rest period of 2 minutes between each sprint. The best score was used for the analyses.

For the 20-yards (CODS) three marker cones are placed along a line five yards apart. The player stands 50 cm from the middle line and starts moving with 90° full body rotation by going to the left direction. When passing the middle line he activates timing gate (*Powertimer, Newtest*, Finland). After coming to the first cone on 5 yard, player turns and runs 10 yards to the right side. He turns again and finishes by running back through the start/finish timing gate.

The specific football agility performances were tested with one protocol that evaluated the FS_CODS and three protocols for the FS_RAG, and the testing was performed on plastic turf grass. All performances were tested with the same equipment and test set-up, with the difference that the participants in the FS_CODS protocol were aware of the movement pattern in advance. In contrast, the participants had no advanced knowledge of the testing scenario when they performed the FS_RAG testing protocols. Each protocol consisted of 5 trials.

Measurements were performed using a hardware device system based on an ATMEL micro-controller (model AT89C51RE2; ATMEL Corp, San Jose, CA, United States) as the core of the system. A photoelectric infrared (IR) sensor (E18-D80NK) was used as an external time triggering input, and LEDs were used as controlled outputs. The photoelectric IR sensor has been shown to be as reliable as high-speed sensors, with a response time of less than 2 ms (500 Hz) and a digital output signal. The sensor's detection distance ranged from 3 to 80 cm and was capable of detecting transparent or opaque objects. Because it has a digital output (high-low state) with an NPN transistor open collector, the sensor is connected through a microcontroller IO port. For the purposes of our study, this device was connected to a laptop PC operated on Windows 7. This equipment has previously been used and proven to be both valid and reliable for reactive agility and CODS assessments (Sekulic et al., 2017; Sisic, Jelicic, Pehar, Spasic, & Sekulic, 2016).

The FS_CODS and FS_RAG were performed in the testing area shown in Figure 1. The participants commenced from the start line, and the timing was initiated when they crossed the IR signal. At this particular moment, a hardware module (microcontroller – MC) lit one of the two LEDs placed inside the 30-cm-high cones (labelled A and B). When tested on the FS_RAG, the participant had to assess which cone was lit, run to the particular cone, kick (rebound) the ball in front of the cone placed at the specially constructed stand positioned 3 cm above the ground, and return to the start line as quickly as possible. When a participant crossed the IR signal on their way back, the timing stopped. Testing of the FS_RAG was performed over three protocols and the participants had no advanced knowledge of the testing scenario. The participants performed the protocols in a random order. Following the reliability analysis (refer to the results on reliability), the best achievement for each of the three protocols was employed as the final result for each participant. The rest period between attempts was 10–15 s with 3 min of recovery between the protocols. The testing of the FS_CODS was similar to the testing of the FS_RAG performances; however, a participant had advanced knowledge of which cone would light up and only one protocol that consisted of five attempts was performed (scenario: A-B-A-B-A). Following the reliability analysis, the best achievement was retained as the final result for each participant.
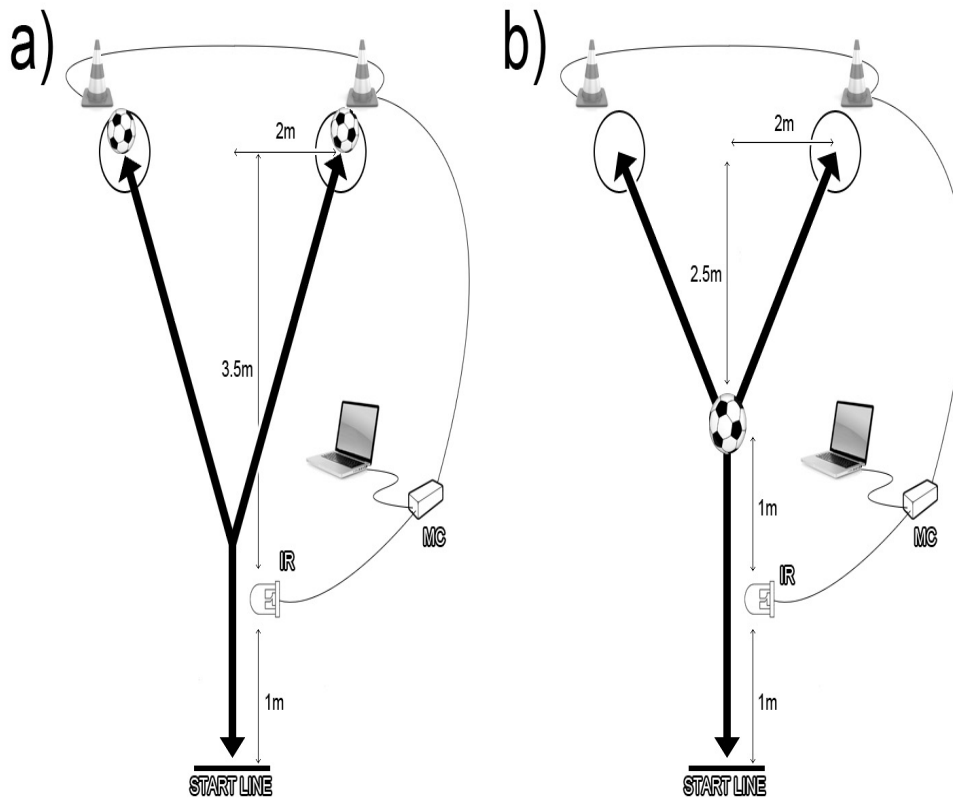
**Figure 1** *Tests of specific football agility (FS_CODS and FS_RAG)*

*Statistical analysis*

The relative reliability is evaluated by calculation of Intra-Class-Correlation coefficients (ICC), while the absolute reliability was evaluated by calculation of the coefficient of variation (CV). Further, systematic bias was checked by analysis of variance for repeated measurements (ANOVA). The associations between studied variables were evidenced by Pearson's correlation. Finally, factor analysis was calculated to define the factorial validity of agility tests (FS-RAG, FS-CODS, and 20-yards).

## Results

The reliability of the FS_RAG and FS_CODS is presented in Table 1. The newly developed football-specific tests were found to be reliable, with better reliability of FS-CODS (ICC: 0.81, CV: 6%), than of FS-RAG (ICC: 0.76, CV: 9%). ANOVA indicated significant differences between testing trials for RAG, but post-hoc analysis revealed significant differences between first trial and remaining two trials, indicating stabilization of the results until the third testing trial.

**Table 1** *Reliability and descriptive parameters for the football-specific agility tests*

| | Mean | Std Dev | ICC | CV | ANOVA F test (p) |
|---|---|---|---|---|---|
| FS-CODS | | | | | |
| Trial 1 | 2.59 | 0.15 | | | |
| Trial 2 | 2.55 | 0.19 | | | |
| Trial 3 | 2.54 | 0.27 | | | |
| FS-CODS_final | 2.45 | 0.18 | 0.81 | 0.06 | 3.12 (0.14) |
| | | | | | |
| FS-RAG | | | | | |
| Trial 1 | 3.62 | 0.40 | | | |
| Trial 2 | 3.32 | 0.38 | | | |
| Trial 3 | 3.21 | 0.39 | | | |
| FS-RAG_final | 3.19 | 0.40 | 0.76 | 0.09 | 7.11 (0.04) |

Factor analysis extracted one significant factor under the Guttmann-Kaiser criterion (Explained Variance: 1.67), showing the appropriate factorial validity of newly developed tests in comparison to standard agility indicator 20-yards (Table 2)

**Table 2** *Factor analysis results (F1 – correlations with main component, Expl Var – factor variance, Prp Totl – proportion of total variance explained)*

| | F1 |
|---|---|
| FS-CODS | -0.51 |
| FS-RAG | -0.85 |
| 20 YARDS | -0.82 |
| | |
| Expl Var | 1.67 |
| Prp Totl | 0.56 |

**Table 3** *Correlation coefficients among studied variables (* indicates statistical significance of p < 0.05)*

| | FS-CODS | FS-RAG | 20 yards |
|---|---|---|---|
| FS-RAG | 0.58* | | |
| 20 yards | 0.61* | 0.60* | |
| Sprint 20 m | 0.58* | 0.52* | 0.63* |

Correlation coefficients among studied variables were statistically significant with percentage of explained variance ranging from 27–38% (Table 3).

## Discussion

Good reliability of newly developed football-specific tests is outcome of variability of the sample. It is well known that greater diversity between the subjects contribute to the higher numerical values of the correlation coefficients which produces better reliability of the given test. Since sample of this study is consisted of preadolescent boys that have different maturation status and different quality level strong correlation between particles and good reliability of the tests are not surprising.

When comparing reliability results with current research in the area of agility performance testing resemblance can be noticed. Pojskic et al. (2018) defined the reliability and validity of newly developed tests of the reactive and non-reactive agility to discriminate between the performance levels of junior soccer players. They reported ICC for CODS 0.92 and for RAG 0.70–0.88 (Pojskic et al., 2018). In another study of Spasic et al. (2014) examined sport-specific tests of reactive-agility and change-of-direction-speed to replicate real-sport environment in handball. Results showed satisfactory reliability for reactive-agility-test (ICC 0.91–0.93) and CODS-test (ICC of 0.85–0.90). Study of Sekulic et al. (2017) determined the reliability and discriminative validity of 1 standard agility test and 4 newly developed basketball-specific agility tests, in defining playing positions and performance levels in basketball. Determined reliability was very high with ICC ranging from 0.91 to 0.95 for CODS and 0.85–0.86 for RAG (Sekulic et al., 2017). Although test validated in mentioned studies are not completely similar to our test and some of them were constructed for other sports than football we can say that our results of reliability are in agreement with recent studies in the area.

Better reliability of FS-CODS than of FS-RAG is result of error of measurement. Reactive agility (RAG) is more complex motor task than non-reactive (Sheppard & Young, 2006). As so participants have much more unstandardized movements that increase possibility of testing error. Similar explanation was offered by Sekulic et al. (2017) when authors compared CODS and RAG tests for basketball players on dominant and non-dominant side of performance (Sekulic et al., 2017).

Differences between testing trials for FS-RAG revealed learning effects. However post-hoc analysis indicated stabilization of the results until the third testing trial. Therefore, it is evident that reactive agility testing demands from participant perceptual and decision making qualities. As testing continues (second and third trial) participants are becoming more focused on visual scanning and pattern recognition. This help them in learning movement pattern and perform test better (Benvenuti, Minganti, Condello, Capranica, & Tessitore, 2010).

Factor validity of newly developed football agility tests is proven by its comparison to basic agility test 20-yards. It can be stated that both FS-CODS and FS-RAG belong to the same motor ability (agility) area in this age of football player's development. Meanwhile, the significant correlations between all agility performances with S20M (Pearson's R: 0.52–0.64; all $p < 0.01$) revealed that sprinting capacity significantly influence agility performances and that conditioning capacities of youth football players are not yet discriminated.

## Conclusion

Results showed appropriate reliability and validity of the newly developed tests of football specific change of direction speed and reactive agility. Therefore, here proposed FS-CODS and FS-RAG can be used as reliable and valid measures of agility components in youth football players. Further studies should evaluate the discriminative validity of the here proposed tests (i.e. identification of position-specific or performance-related differences), as well as reliability in younger players than those studied herein.

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