

Change of direction ability test differentiates higher level and lower level soccer referees

AUTHORS: Yanci J^{1,2}, Los Arcos A¹, Grande I³, Casajús JA⁴

¹ Department of Physical Education and Sport, Faculty of Physical Activity and Sports Science, University of the Basque Country, UPV/EHU, Vitoria-Gasteiz, Spain

² Soccer Referee Association of Navarra, CNAF, Pamplona, Spain

³ Faculty of Physical Activity and Sport Science, Politecnica University, Madrid, Spain

⁴ Faculty of Health and Sport, University of Zaragoza, Huesca, Spain.

ABSTRACT: This report examines the agility and level of acceleration capacity of Spanish soccer referees and investigates the possible differences between field referees of different categories. The speed test consisted of 3 maximum acceleration stretches of 15 metres. The change of direction ability (CODA) test used in this study was a modification of the Modified Agility Test (MAT). The study included a sample of 41 Spanish soccer field referees from the Navarre Committee of Soccer Referees divided into two groups: i) the higher level group (G1, n = 20): 2ndA, 2ndB and 3rd division referees from the Spanish National Soccer League (28.43 ± 1.39 years); and ii) the lower level group (G2, n = 21): Navarre Provincial League soccer referees (29.54 ± 1.87 years). Significant differences were found with respect to the CODA between G1 (5.72 ± 0.13 s) and G2 (6.06 ± 0.30 s), while no differences were encountered between groups in acceleration ability. No significant correlations were obtained in G1 between agility and the capacity to accelerate. Significant correlations were found between sprint and agility times in the G2 and in the total group. The results of this study showed that agility can be used as a discriminating factor for differentiating between national and regional field referees; however, no observable differences were found over the 5 and 15 m sprint tests.

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Corresponding author:

Javier Yanci
Faculty of Physical Activity and Sports Science,
University of the Basque Country,
UPV/EHU,
Lasarte 71, 01007,
Vitoria-Gasteiz, Spain
E-mail: javier.yanci@ehu.es

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INTRODUCTION

Soccer field referees (FRs), supported by two assistants, are responsible for supervising and judging the action of the players and penalizing offending individuals [1]. The FR has responsibility for implementing the rules of the game and guaranteeing that players abide by its regulations [2]. The economic importance of football matches has increased enormously, as have the physical and psychological demands on referees [1, 3]. It has been reported that during a competitive match, FRs cover an average distance of between 9 and 13 km [4]. These values appear to be dependent on the level of competition, especially between national and regional levels of the game [4]. As well as the distance covered, unorthodox movements such as backing or shuffling sideways have also been recorded [2]. The FR usually adopts backward running in order to withdraw from the action while still controlling it [4].

Different studies have analysed these unorthodox movements [5-7] and also 1268 activity changes during an average competitive match in elite FRs [8]. An exercise mode change has been registered every 4.3 seconds [8], while in an earlier study [6] the frequency was every 6 seconds. Among these unorthodox movements, backward running was involved for $5.3 \pm 2.4\%$ of the total match time [9],

equating to from 6.9 to 18.2% of the total distance covered [5, 7, 10] depending on the FR's level and the year of the study. With respect to the sideways movements the values were lower and ranged from 1 to 1.3% [5, 7] of the total distance covered, while the percentage of total time was recorded to be as low as $0.2 \pm 0.2\%$ [9]. Sprint movements are important because at higher competitive levels of the game, the speed of match play is significantly quicker [11], which may thus increase the physiological/running demands on refereeing [12]. Furthermore, velocity helps FRs to be closer to the play for better observation and analysis [13]. During competitive matches, FRs cover from 1.7 to 11.8% of the total distance in sprints [5, 7, 10], corresponding to $0.4 \pm 0.2\%$ of total play time [9]. Given the high rate of activity changes recorded, the variety of movements, and the qualitative value of unorthodox movements, it would appear necessary to test the change-of-direction ability (CODA) [14] in FRs, similarly to a research study carried out by Castagna et al. [15], which was implemented with assistant referees (ARs).

Therefore, the aim of the study was to examine the CODA and acceleration ability of Spanish soccer referees and analyse differences between soccer referees of different categories, namely "high-

er level (G1) or lower level (G2)" referees, in agility and sprint performance. The supposed high performance in the CODA of the elite group was adopted as the study hypothesis.

MATERIALS AND METHODS

Participants. The study included a sample of 41 Spanish soccer referees from the Navarre Committee of Soccer Referees (Comité Navarro de Árbitros de Fútbol) divided into two groups: the higher level group (G1, $n = 20$): 2ndA, 2ndB and 3rd division referees from the Spanish National Soccer League (age: 28.43 ± 1.39 years; height: 177.40 ± 0.04 cm; body mass: 73.52 ± 7.78 kg; body mass index (BMI): 23.48 ± 0.61); and the lower level group (G2, $n = 21$): Provincial League soccer referees (age: 29.54 ± 1.87 years; height: 176.84 ± 0.04 cm; body mass: 77.72 ± 10.75 kg; BMI: 24.83 ± 0.57 kg.m⁻²). Before the beginning of the study, written informed consent was obtained from all the participants after they were informed about the nature of the research. Consent was obtained from Navarre Committee of Soccer Referees. An option was given for the referees to withdraw from the test at any point during the research. The study was conducted according to the Declaration of Helsinki (2013), and the study protocol was approved by the local ethics committee.

Procedures

After the analysis of the matches, as covered above, the CODA [15] and sprinting ability of the FRs were tested due to the importance of these types of movements during competition. To evaluate sprinting quality and the CODA, 5-15 m sprints [16] and the Modified Agility T-test (MAT) were selected respectively. Taking into account the type of unorthodox movements, including backwards and sideways, and as well as forwards sprinting that the FRs performed during a match, the CODA test used in this study was a modification of the MAT proposed by Sassi et al. [17]. The MAT conserved the same directive protocol and included all movements described above. Only one modification was proposed to the original MAT, namely that the participants touch the top of the cone instead of the base [18]. Therefore, the reasons for selecting the MAT were its short duration, the variety of movements to perform that the FRs executed during matches (forwards, backwards and sideways running), and the fact that they did not need to touch the floor with the hand. During competition, sprint bout duration ranges between 2-4 seconds in elite soccer referees [7] and exactly 1.9 ± 0.6 seconds in international games [9]. Moreover, sprint distance rarely exceeds 30 m [7]; therefore, in our study we used 5 and 15 m sprints to examine the FRs' sprint capacity, given that this method has been used with soccer players in a separate study [16].

Sprint testing

The sprint test consisted of 3 maximum acceleration stretches of 15 metres with a 180-second rest between each one, giving enough time to walk back to the start, as previously described by Yanci [19].

The participants were placed at 0.5 m from the starting point, and began when they felt ready. Running time was recorded using photocell gates (Microgate, Polifemo Radio Ligth, Bolzano, Italy) [15] placed 0.4 m above the ground, with an accuracy of ± 0.001 m. The timer was activated automatically as the volunteers passed the first gate at the 0 m mark and split times were then recorded at 5 and 15 m [16].

Agility test

The participants began with both feet together at 0.5 m from cone A, and completed the circuit as follows (Figure 1): A-B distance (5 m): At his own discretion, each subject sprinted forward to cone B and touched the top with the right hand. B-C distance (2.5 m): Facing forward and without crossing the feet, they shuffled to the left to cone C and touched the top with the left hand. C-D distance (5 m): The participants then shuffled to the right to cone D and touched the top with the right hand. D-B distance (2.5 m): They shuffled back to the left to cone B and touched the top. B-A distance (5 m): Finally, the participants ran backwards as quickly as possible and returned to line A. All participants performed the test 3 times with at least 3 minutes of rest between all trials. The total distance covered was 20 m, and the height of the cones was 0.3 m.

The best time recorded was used for statistical analysis. A photocell (Microgate Polifemo Radio Light, Bolzano, Italy) located over cone A was used to record the time. Time measurement started and finished when the subject crossed the line between the tripods. The calculated margin of error was ± 0.001 m, and the sensors were set approximately 0.40 m above the floor. Previously, one extra session was planned where all the referees could practice the test. The researchers explained to all the participants the correct way to perform the MAT. All participants were able to practise the execution of the test between 6 and 8 times. The same warm-up was performed on

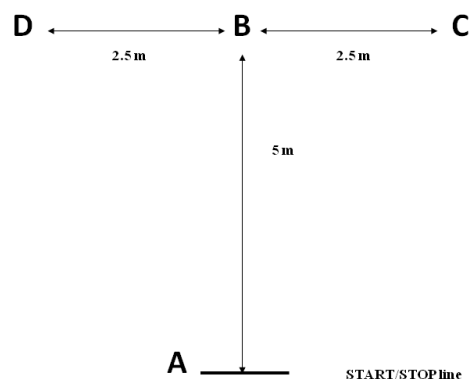


FIG. 1. Modified Agility T-test (MAT).

every occasion: 3 min jogging, followed by a skipping and scalping exercise, strides and three accelerations with change of direction. The participants were instructed to perform the test at maximum intensity. The tests were carried out outdoors on a synthetic pitch, in the usual training space and in the same time slot, between 18:00 and 19:00 hours. No strenuous exercises were performed within the 48 h immediately prior to the tests, and the study was supervised by the researchers at all times.

Statistical analysis

Results are presented as means ± standard deviations. The intra-class correlation coefficient (ICC) and coefficient of variation (CV) [20] were used to assess MAT reproducibility. Descriptive statistics were calculated for all experimental data. The normal distribution of results for the variables applied was tested using the Kolmogorov-Smirnov test, and statistical parametric techniques were used because variables showed normal distributions. Statistical significance was set at $p \leq 0.05$. An independent Student t test was used to determine the differences between groups in sprint and agility tests. Pearson product-moment correlation (r) coefficients were calculated for the two groups (G1 and G2) and used to determine the strength and directionality of relationships between the MAT and acceleration over 5 and 15 m. The threshold values for the Pearson product-moment used by Salaj and Marcovic [21] were used to interpret the results: low ($r \leq 0.3$), moderate ($0.3 < r \leq 0.7$) and high ($r > 0.7$). Data analysis was performed using the Statistical Package for the Social Sciences (version 20.0 for Windows, SPSS Inc, Chicago, IL, USA).

RESULTS

The MAT test showed good CV (4.23%) and ICC values (0.89, $p < 0.001$, 95%, range 0.82-0.91). Table 1 shows the sprint results over 5 and 15 m for the two groups taking into account the competition category.

The result in the MAT for all the soccer referees was 5.94 ± 0.25 s. After inter-group analysis with respect to each category we found significant differences ($p < 0.001$) between G1 (5.72 ± 0.13 s) and G2 (6.06 ± 0.30 s) in the MAT test (Figure 2). However, during the sprint tests both over 5 m and 15 m, no observable differences were found between these two groups.

TABLE 1. 5 m and 15 m sprint results according to each group (mean ± SD).

Group	5 m (s)	15 m (s)
GNAC (n = 20)	0.98±0.02	2.33±0.45
GINF (n = 21)	0.97±0.23	2.33±0.56
Mean dif. (%)	1.02	0.00
TOTAL (n = 41)	0.97±0.18	2.33±0.48

Note: G1 = higher level group soccer referees; G2 = lower level group soccer referees.

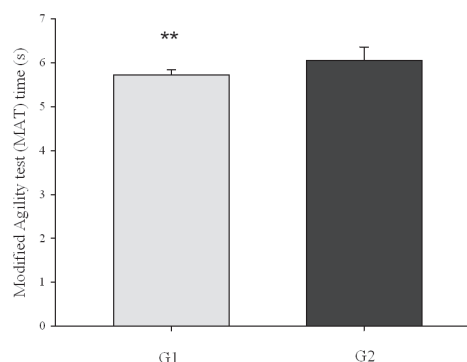


FIG. 2. Modified Agility T-test (MAT) results according to each group (mean ± SD).

G1 = higher level group soccer referees; G2 = lower level group soccer referees.

**Significant differences between G1 and G2 ($p < 0.01$).

Table 2 shows the correlation results among variables where significant correlations were found between sprint and agility times in the G2 and in the total group. No significant correlations were found between sprint and agility times in the G1.

DISCUSSION

The present study compared running speed and agility performance in two groups of soccer referees at different levels of competition. To our knowledge no scientific articles have been published about 5 and 15 m sprints and MAT measurements in soccer referees. We found differences between lower level and higher level soccer field referees with respect to the CODA performance (MAT), but not in sprinting speed (over 5 and 15 m). The analysis of the reproducibility of the MAT showed good values (ICC=0.89 and CV=4.23%), as has been described with other T-design agility tests [17, 21, 22].

With respect to the results in the MAT, significant differences ($p < 0.001$) were obtained in the change of direction ability between

TABLE 2. Correlation (r) between MAT test and 5 or 15 m sprint.

	Category	5 m	15 m
MAT	Total	0.608** (0.000)	0.768** (0.000)
	GNAC	-0.252 (0.482)	0.173 (0.633)
	GINF	0.617** (0.005)	0.735** (0.000)
5 m	Total	-	0.747** (0.000)
	GNAC	-	0.139 (0.701)
	GINF	-	0.760** (0.000)

Note: MAT= modified agility test; G1 = higher level group soccer referees; G2 = lower level group soccer referees.

G1 and G2 groups. This finding confirmed the hypothesis that the CODA can be used to discriminate between the competitive level of the FRs, specifically between national and regional referees. However, in a study carried out on Italian assistant referees (ARs) where agility was evaluated in professional ARs of Series A-B and Lega Pro levels, no significant differences were found in the 10-8-8-10 agility test between these two groups [15]. The contradictory results may be due to the different activity profile in FRs and ARs and the use of different CODA tests. Therefore, it would be interesting to use the MAT to evaluate the CODA ability in elite FRs that belong to different categories to find out if there are differences in these competitive levels using the MAT. Moreover, we proposed the application of the MAT test, which includes two sideways movements in ARs, due to the importance of this unorthodox movement during the matches [9, 23, 24]. The differences found with respect to CODA in FRs between different competition levels have also been found between amateur and professional soccer players [25], with respect to the positional role in professional soccer players [26], and between selected and non-selected young footballers [27]. In contrast, in a separate study on 13-14 year old soccer players, no differences were found between selected and non-selected individuals [28].

In acceleration capacity, measured over a 5 m and a 15 m sprint, no noteworthy differences were recorded to distinguish between G1 and G2 groups. Sprint without change-of-direction appears not to be a discriminating factor between national and regional FRs. It is difficult to compare these results, because no other velocity studies on FRs have been found, despite exhaustive searches of the literature. Nevertheless, in other studies carried out on soccer players, differences between professionals and amateurs have been found [3, 25]. Therefore, the CODA ability may be more important than sprint capacity for comparing national and regional FRs. In future studies, it would be interesting to test these two qualities at higher refereeing levels.

The relationships between sprinting and the CODA have been studied in other sports, with controversial results [29-31]. In this study, no significant correlations were obtained in G1 between the MAT and the capacity to accelerate. Nevertheless, significant cor-

relations were found between sprint and agility times in the G2 and in the total group. It should be noted that all correlations were moderate ($0.3 < r \leq 0.7$) or high ($r > 0.7$). The contradictory results between G1 and G2 may be due to the different training specifications. However, it is difficult to compare our data, since no other studies have been found correlating acceleration, velocity and agility in FRs. As Salaj and Marcovic [21] stated, the use of principal component factor analysis (PCA) proposes the specificity and the independence of agility and acceleration motor abilities. Thus, the issue of the relations among the sprinting and CODA abilities in FRs remains unresolved. Further studies are necessary to determine the presence or absence of correlation between agility and acceleration in FRs. Moreover, it would also be very interesting to obtain more data with other FR and AR groups, to compare with this current study.

Various investigations have reported that agility can be improved by a proper practical progression [13, 32]. Therefore, taking into account the possible importance of this ability in matches and its trainability, physical trainers should emphasize the training of this quality. Moreover, the inclusion of a CODA test in the battery of tests used to assess the FRs' physical conditioning could be very interesting. Future research in this area will involve using the MAT test to evaluate the change-of-direction ability in ARs and in elite FRs.

CONCLUSIONS

The results of this study showed that agility can be used as a discriminating factor for differentiating between higher level and lower level FRs; however, no observable differences were found over 5 and 15 m sprint tests.

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