Soccer Players' Agility: Complex Laboratory Testing for Differential Training

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Keywords: Soccer Players, Agility, Laboratory Testing, Agility Structure.

Abstract: The aim of the proposed study was to evaluate parameters of quickness, coordination and speed that influence the specific agility in soccer. Twenty-four young healthy male soccer players born in 2004 (mean age 14.7 ± 0.7 years) underwent complex laboratory testing including anthropometric measurements, simple and complex visual-motor reaction (VMR), Tapping test, cycling Wingate test and FitLight-trainer tests. Obtained data allowed to estimate speed and power abilities of soccer players, as well as establish interrelations between the measured parameters throughout the tests. Six soccer players demonstrated excellent ability to work in conditions that require high concentration and speed of switching attention (complex VMR < 270 ms) and 4 athletes (complex VMR > 320 ms) – poor level. Results of Wingate test showed, that studied athletes had sufficient power abilities of lower extremities for soccer players in respect to their age (PP/kg – 12.56 ± 3.38 W/kg). 16.7 % (n=4) of athletes showed high results in all FitLight tests. The suggested system of laboratory tests for evaluation of agility structural components so important in soccer, allowed to emphasize athlete's weaknesses in order to improve it. Thus, testing of non-planned agility should include at least simple and complex reaction rate, coordination tests and speed-and-strength abilities evaluation.

1 INTRODUCTION

Agility is recognised as one of the most important ability in team sports. Athlete's speed, coordination and ability to act fast are interrelated and together they provide such complex quality as agility.

Agility is an important quality in soccer which significantly contributes to success in sports achievements (Sekulic, 2015; Young, 2015). In soccer, as in many other team sports, constant changes in the environment (alterations in the ball position, co-players and opponents) require particular actions from the players, such as pre-planned motor responses, coordination of body segments and anticipating actions coming from rapidly changed complex sensorial information (Lage, 2011).

Based on mention above it is critically important for a soccer player to have a constants readiness to motor response to unpredictably occuring signals.

A number of experimental studies have reported sufficient cognitive and motor abilities in elite team sports athletes, who are able to modulate their cognitive and motor resources in response to task demands (Zwierko, 2014). Meanwhile, there is lack of data on evaluation of this quality in young soccer players, as well as methods of complex testing for further application in training process amendments.

According to N.A. Bernshtein, 1991 agility (or coordination) is a complex, reliable and universal quality which is in close connection with speed, motor inventiveness and mental quickness.

Based on mentioned above, the aim of the proposed study was to design a number of diagnostic tests to determine agility structure components in young soccer players in order to improve their soccer performance.

An ability to act quickly in unpredictable conditions depends upon reaction time in response to visual or other stimuli, speed of mental analysis and following decision making, locomotion start and speed-and-strength ability to move as fast as necessary. So in our research we were focused on

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those parameters of quickness, coordination and speed that influence the specific agility in soccer.

2 ORGANIZATION AND METHODS

Subjects: Twenty-four young healthy male soccer players born in 2004 (mean age 14.7 ± 0.7 years, height 171.05 ± 6.08 cm, weight 60.65 ± 11.7 kg) were recruited for the study. Participants were members of junior soccer team "Sinara" (Yekaterinburg, Russia) that was the winner of the youth futsal championship of Russia in 2018.

2.1 Anthropometric Measurements

Estimation of anthropometric data, body composition, height, lean muscle mass (absolute and relative values), body fat component and BMI are widely used in practical training practice and research.

Weight and detailed segment body composition data were measured with the use of MC-980MA Plus Multi Frequency Segmental Body Composition Monitor (TANITA, Japan) based on the advanced Bioelectric Impedance Analysis (BIA) technology. The following parameters were analyzed: body mass (kg), body mass index (BMI, kg/m^2), muscle mass – absolute and relative values (kg; %), absolute and relative fat mass (kg; %), fat free mass (kg), bone mass (kg), separately lean mass of the trunk, upper and lower extremities (kg).

2.2 Psycho-physiological Tests

The computer complex "NS-PsychoTest" ("NeuroSoft", Russia) was used for evaluation of psychophysiological features of the athletes' nervous system. The choice of diagnostic psycho-physiological methods was determined by the nature of sports agility. For latent simple reaction time simple visual-motor reaction test was conducted. For evaluation of an ability to act in situation of choice test of complex visual-motor reaction was selected.

Tapping-test was conducted to assess the ability of nervous system to perform frequent movements and intensive quick work.

2.2.1 Simple Visual-motor Reaction

During testing of a simple visual-motor reaction 30 red light signals were activated consistently to athletes. The signals appear at a different time interval. When a signal appears, the examinee must press the button with a finger as soon as possible, trying to avoid mistakes such as a prematurely pressing of the button or a skip of the signal.

The following indicators were determined:

1. Time of visual-motor reaction and subject's quality of the reaction to the stimulus (M, ms);
2. Equilibrium of nerve processes and stability of sensorimotor reactions (SD, ms).

2.2.2 Complex Visual-motor Reaction

During testing of a complex visual-motor reaction 30 red and green light signals were activated randomly to athletes. The athletes were instructed to react only to red light with pressing the button and do nothing in case of green signal occurrence. Average time of complex visual-motor reaction (M, ms) and standard deviation (SD, ms) were determined as well as a number of mistakes (missed signals or prepressing of button).

2.2.3 Tapping Test

Express-method Tapping test is reflecting overall performance and strength of the nervous processes. The test was carried out using two special instruments: "pencil" and "a rubber platform". The athlete was instructed to tap the platform with the maximum possible frequency for 30 seconds.

Processing of the results was made by counting the number of movements performed in each of the five-second intervals of the test.

Two indicators obtained in the test were taken for analysis: the number of taps made during 30 seconds and the maximal number made in any five second interval.

2.3 Cycling Wingate Test

Cycling Wingate test was performed with the use of the ergometer Monark Ergomedic 894E Peak Bike (Monark, Sweden). Power and speed abilities were evaluated during leg cycling Wingate anaerobic test by means of the device producer protocol provided.

Before the test athletes were familiarized with the technique of the test and given comprehensive instructions on the procedure. The positions of handlebar and cycle seat were adjusted in accordance with athletes' height and length of the extremities. Foots were fixed in the pedals with straps. Based on recorded data on the age, gender and weight of tested player the required weight of the basket was calculated automatically by the system (7.5 % of body weight). The protocol of the test allowed to set the moment of basket drop. Each test started from the pre-test warming-up pedaling with recommended cadence of 50 rpm. After the command “Go!” an athlete had to speed-up and at reaching 80 rpm, the basket dropped and test started. Before the test all subjects had sufficient for power testing warming up.

From the beginning of the test power and speed parameters were fixed automatically in the PC with pre-installed Monark software, connected with the ergometer through a serial cable. The following parameters were selected for ongoing analysis: peak power (PP, W), average power (AP, W) and their relative values PP (PP/kg, W/kg) and AP_{30}/kg, W/kg), maximum attained cadence (rpm) and time of PP attained.

2.4 Fitlight-trainer Test

For soccer players agility estimation a FitLight TrainerTM (FitLight Sports Corp., Canada) was used. Two different test protocols were designed for the research.

The first one was created for goalkeepers: 12 wireless light discs with a diameter of 10 cm were placed on the wall in the square of 3000x2000 as the area of the futsal or handball gate (Fig. 1). The light disks were grouped into 4 sectors, 3 lamps in each according to the scheme shown in the Figure 1. Participants were instructed to deactivate the lights as fast as possible by placing a hand or a leg in close proximity (deactivation distance was set at 20 cm) to the activated light (Fig.2). Maximum duration of the light stimulus (time out of light if light was not de-activated as required) was programmed for 2 seconds for this test. Light disks activated randomly during 30 seconds during the trial. The analysis concerned the amount of deactivated light disks and the average response time to stimuli in the test as well as average response time to each square sector.

The second test was designed for soccer players and included 8 light disks placed on two neighbor walls (Fig. 3 and 4) deactivated with legs only. Parameters of test protocol were as in the described above test 1: duration 30 seconds, 20 cm and 2 sec were deactivation distance and time out of light respectively. Average response time to stimuli and amount of deactivated light were under analysis.

The soccer players performed 3 trials. Results of the best one were under consideration.

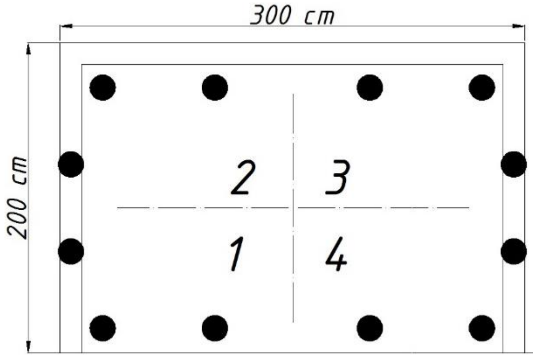

Figure 1: Light disk layout for FitLight trainer test 1.

Figure 2: Station for the FitLight trainer test 1.

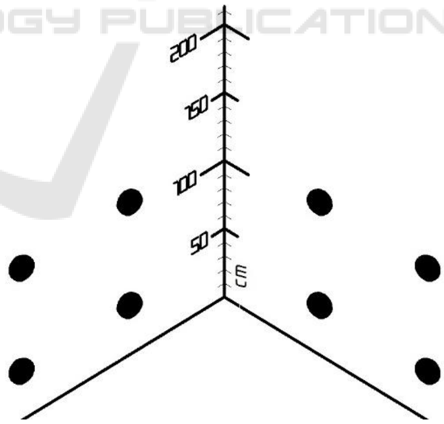

Figure 3: Light disk layout for FitLight trainer test 2.

Figure 4: Station for the FitLight trainer test 2.

2.5 Statistical Analysis

Statistical analysis was performed with the use of statistic software package "SPSS Statistics 23.0" (IBM). We used descriptive analysis of the obtained data in order to estimate basic functional status of athletes. Normality of distribution was assessed by the Shapiro-Wilk test. Mean value (M), standard deviation (SD), minimum and maximal values of the measured parameters were calculated. To estimate possible interrelations between measured parameters in different tests correlative analysis (Pearsons correlations) was applied.

As the FitLight trainer test is a new technology supporting "testing and training" in sport there were lack of data of optimal results. To establish the levels of FitLight test agility (Table 5), level criteria was calculated using the value of the normal M and the deviation equal to ± 2/3 SD:

- Average level – the indicators in the range M ± 2/3 SD;
- Level above the average (high) the indicators are greater than M + 2/3 SD;
- Level below the average (poor) – the indicators are less than M - 2/3 SD.

3 RESULTS AND DISCUSSIONS

The obtained results of anthropometric measurements of young soccer players (Table 1) show that studied subjects had appropriate physical status in reference to sports age and gender norms. In particular, high values of lean mass and low values of fat component were found. Taking into consideration specific character of soccer, this type of body composition is undoubtedly beneficial for athletes.

Table 1: Anthropometric and body composition data of young soccer players.

Parameters	M±SD	min-max
Height, cm	171.1±6.1	158-182
Weight, kg	60.7±11.2	42-92
Muscle mass, kg	47.93±7.3	35-66
Muscle mass, %	79.5±3.3	71-84
Fat, kg	10.3±4.3	5-23
Fat, %	16.5±3.9	12-26
BMI, kg/m^2	20.6±2.7	17-28

BMI – body mass index.

Assessment of the level of speed abilities of young soccer players was initially started with studying of an elementary form of speed and agility – the latent time of simple visual-motor reaction (simple VMR) characterizing efficiency of activity of the neuromotor mechanism (Platonov, 2004). In group of the studied soccer players (n=24) the average value of simple VMR on a red colour signal was 197.18±15.64 ms (Table 2). 5 subjects (20.8 %) had excellent VMR (quicker than 180 ms). Optimum results for sports activity in soccer (181<simple VMR <210 ms) showed 14 athletes that is 58.24 %.

The research of complex visual-motor reaction (Table 2) associated with simple VSR and mental abilities to effective actions in limited time revealed that average value of complex VMR (295.75 ms) was within age norm as well as the reaction stability (24.57). Six soccer players demonstrated excellent ability to work in conditions that require high concentration and speed of switching attention (complex VMR < 270 ms) and 4 athletes (had complex VMR time more than 320 ms (poor level).

Table 2: Simple and complex visual-motor reaction in young soccer players.

Parameters	M±SD	(min-max)
Simple VMR t, ms	197.18±15.64	175 -239
Complex VMR t, ms	295.75±24.57	236-342

The nervous system workability by Tapping test revealed that 16.67 % of soccer players had an excellent ability to maintain the movement pace, which means the effectiveness of the speed activity for a long time. 79.17 % of the subjects showed a good level and only 1 athlete (4.16 %) was distinguished by rapid fatigue of the nervous system.

Analysis of cycling Wingate-test data allowed to estimate power abilities of soccer players (Table 3). On average, demonstrated peak power was higher than one in 15 years old soccer-players (11.2 ± 0.76 W/kg reported by Jastrzębski, 2011), and 17 years old soccer players (11.1 ± 0.9 W/kg – by Chtourou, 2012). Although, relative values of PP varied within a wide range. This proves essential difference in the level of preparedness of players and/or inherent power abilities. Really only 3 soccer players demonstrated PP higher than 13.5 W/kg (high level) while 5 had poor level (less than 11.6 W/kg). The obtained results show, that generally, studied athletes had sufficient power abilities of lower extremities for soccer players in respect to their age.

Table 3: Wingate-test parameters of soccer players.

Parameters	M±SD	min-max
PP, W	748.33±153.33	513-1661
PP/kg, W/kg	12.56±3.38	9-15
AP, W	512.43±96.64	366-772
AP/kg, W/kg	8.59±0.67	7-10
t_{pp}, s	2.48±1.06	1-5

PP – peak power; AP – average power; t_{pp} – time of PP attainment.

Average power (AP, W/kg) in studied soccer-players was within athletic norm (Zakharova, 2016) and as high as it was revealed in soccer players aged 17 by Chtourou, 2012. Thus, we may conclude that soccer-players demonstrated satisfied strength endurance which is typical in team sports.

FitLight trainer test 1 (deactivation of signals with hands and feet) revealed that average time of reaction was considerably higher (Table 4) than in complex VMR testing (Table 2).

Table 4: FitLight trainer test results in young soccer players.

Parameters	M±SD	(min-max)
Test 1 reaction time, ms	896±52.14	802-995
Number of deactivated lamps	27±2.71	23-30
Test 2 reaction time, ms	919±91.78	739-469
Number of deactivated lamps	27±2.11	22-32

As these FitLight trainer tests were designed especially for the research no results were at our disposal. To establish the levels of FitLight test agility (Table 6), level criteria was calculated using the value of the normal M and the deviation equal to ± 2/3 SD as depicted in statistic methods description.

Table 5: Levels of FitLight agility tests results for soccer-players 14-15 years old.

	High	Middle	Poor
Test 1 reaction time, ms	< 680	680-930	> 930
Test 2 reaction time, ms	< 680	680-980	> 980

FitLight trainer test 1 results revealed a high reaction rate in 29.2 % (n=7) athletes. The average and low reaction rates were registered in 50.0 % (n=12) and 20.8 % (n=5) of the subjects, respectively. Most athletes (54.2 %, n=13) showed the best result during the second attempt.

According to the results of test 2, the data were distributed as follow: high reaction rate in 25.0 % (n=6), average reaction time in 62.5 % (n=15), low reaction rate in 12.5 % (n=3) athletes. During this test, the majority of athletes (58.4 %, n=14) showed the best result during the third attempt.

Also, 16.7 % (n=4) of athletes have high results in both tests.

The FitLight trainer software allowed to calculate a segmental reaction time, that is, the response time of the right and left hands and feet.

Observation of athletes during the FitLight trainer tests allow to suggest that the differences between the reaction rate of the right and left feet and as well as hands induced by (i) motor asymmetry, (ii) low and/or dissimilar flexibility in the right and left hip joints, (iii) a violation of natural technique of performing light deactivation (segment 1 by left foot, segment 2 by left hand, segment 3 and 4 –by right hand and foot, respectively).

Often the subjects tried to perform all the touches with one hand, generally right. In addition, during the test they oriented the body mainly to the left, thereby losing sight of the sensors on the right. Subjects were not specified how to fulfill the FitLight trainer test as agility is the ability to move in an efficient and effective manner.

Results of correlative analysis revealed significant interrelations between athletes' height and time of complex VMR in psycho-physiological test (r = -.532, P < 0.01), response time in FitLight-trainer test (r = -.431, P < 0.05), as well as number of deactivated signals (r = .454, P < 0.05). Additionally, we found significant correlations between measured parameters within the obtained tests: time of complex VMR correlated well with time of reaction time in FitLight-test 1 (r = .423, $P < 0.01$) and number of deactivated signals in FitLight-test 2 (r = -.462, $P < 0.01$).

Thus, the studied structural components of agility in general are independent as they are associated with different body structures and their functions. So each of the component may limit the agility and in turn require specific types of exercise to provide agility development.

To demonstrate the agility structure of soccer players we determined the most substantial indicators measured throughout all laboratory tests. The individual soccer player's agility profile includes (Figure 5) innate parameters of nervous system (time of simple and complex visual-motor reaction), general and specific coordination (reaction time in FitLight trainer test 1 and 2 respectively), low extremities motor symmetry/asymmetry (t FitLight 2 right and left leg), anaerobic power characteristics (PP and time to PP attained) and a number of frequency indicators: maximum attained cadence (rpm) in cycling Wingate test and Tapping test data (the maximal number of taps made in any five second interval associated with motion rate performance and number of taps made during 30 seconds).

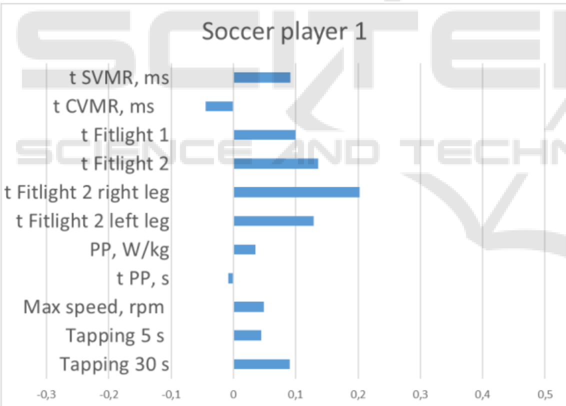

Figure 5: Individual soccer player 1 agility profile.

The linear graph with deviation depicts positive deviation (better than average value) and the degree of excellence in the right part or backwardness and its degree in the left part. So, one can see the strengths and weaknesses of the athlete's agility.

For example, soccer player 1 (Figure 5) have low reaction rate in complex VMR while soccer player 5 (Figure 6) demonstrated poor simple reaction and insufficient level of power abilities in legs (Wingate test).

If you know the athlete's weaknesses you are able to amend it.

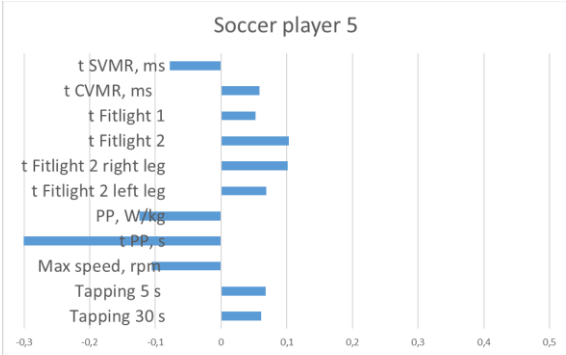

Figure 6: Individual soccer player 5 agility profile.

To improve simple reaction rate table tennis, aero-hockey, various ball catching, reaction game and motor tasks should be used.

To accelerate the complex reaction rate it is advisable to read as fast as possible, watch videos at 1.25/1.5/2x speed, comment everyday events, just like a TV commentator. The main idea of these tasks promoting the brain to work intensively in time trouble. Computer games also may be used for the development of speed of reaction and thinking rate.

To show better results in FitLight trainer tests it is necessary to analyze the reasons of poor performance (hand-eye coordination, foot-eye coordination, coordination of the body segments' movement in cooperation with the body's sensory functions or other issues) and use the problem orientated exercises to improve it along with FitLight training.

Detailed control of soccer players during FitLight test 2 allowed to conclude that agility ladder in its traditional format (laying on the floor) does not develop 3d (space) coordination. So it is necessary to design 3d agility ladder – to locate ladders on the walls or to use the idea of FitLight – fix the targets in accordance with the sports specifics.

In case of motor asymmetry in legs in football players as shown in Figure 7 (marked out in ellipse) it is important to work with non preferred leg. For example, start strength exercises with it, pay more attention to non preferred leg in agility motor tasks, use it for shots and ball transition, etc.

So the suggested system of laboratory tests for evaluation of agility structural components so important in soccer, allowed to emphasize athlete's weaknesses in order to improve it thus developing agility.

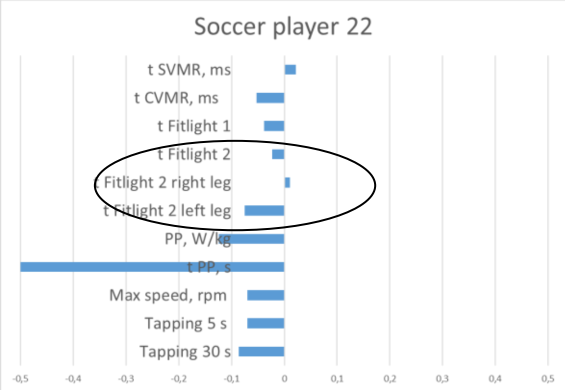

Figure 7: Individual soccer player 22 agility profile.

4 CONCLUSIONS

As agility performance is underpinned by physical and cognitive attributes the following conclusions may be done from the research:

1. Testing of non-planned agility should include at least simple and complex reaction rate, coordination tests and speed-and-strength abilities evaluation.
2. FitLight trainer is an effective training system at the same time providing with accurate data on reaction rate in close to competitive environment.

To compare FitLight trainer test results of athletes all over the world it is necessary to standardize the scheme of lamp locations according to sports specifics.

3. Structuring of soccer players' agility through laboratory tests allowed to determine athlete's strengths and weaknesses to enhance agility performance.

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