SPEED OPTIMIZATION STRATEGIES FOR U16 FOOTBALL PLAYERS: METHODS AND IMPACT

Florin SUCIU[1], Nicoleta LEONTE[2*], Teodora WESSELLY[2], Ofelia POPESCU[2], Alin Mihăiță SĂFTEL[1]

[1] National University of Physical Education and Sport, Faculty of Physical Education and Sport, Bucharest, Romania
[2] "Politehnica Bucharest" National University of Science and Technology, Bucharest, Romania
*Corresponding authors: nicoleta_leonte@yahoo.com

https://doi.org/10.35189/dpeskj.2024.63.4.2

Abstract. *Knowledge and development of speed indices have always been important concerns in the field of elite sport. Understanding the effects of specific exercises for speed optimisation has a positive impact not only on athletic performance, but also on overall health. The purpose of the present research is to make a comparative analysis of the dynamics of speed parameters following the application of intervention programmes to the players of two football clubs and then check the effectiveness of the means used to achieve the proposed objectives. The experimental research tested 36 members of two football clubs registered in the National Championship, namely Concordia Chiajna Football Academy (18 players) and FC Voluntari (18 players). The effects produced by the application of speed optimisation programmes were checked using the Witty System Speed Test (5 m, 20 m, 30 m) and the Illinois Agility Test. The data were collected at both the beginning and end of the training period (pretest-test). The research results highlight the dynamics of speed indices in the football game for U16 juniors. Thus, the independent variable used in the research produced significant improvements in the physical training of junior players for the 5 m sprint event and the Illinois Agility Test. For the 20 m and 30 m running events, there were no significant increases, but between the two testing sessions, the experimental group recorded some improvements. The data obtained from the research can be of practical use in the training of both elite and school teams.*

Keywords: *speed test, agility test, junior football players, computer-based techniques.*

Received: *19 Iunie 2024 /* **Accepted:** *12 December 2024 /* **Published:** *30 December 2024*

Introduction

As a sports discipline, football has experienced a remarkable development, with competitions being currently organised for all categories, from grassroots to professional football. In parallel with its quantitative development, football has also evolved a lot in terms of quality, and consequently the level of play is particularly high nowadays.

Specific physical training, the basic component of the entire instructive-educational process without which the other elements cannot be designed, is a prerequisite for achieving sports results (Oliver et al., 2023; Silva et al., 2023). Modern football demands the rapid development of game actions. This means that players must have well-developed speed in all

its forms of manifestation (reaction, movement, execution), which allows us to state that speed is a characteristic of the modern football game (Ates, 2018; Abarghoueinejad et al., 2021).

Modern football demands fast-paced play. This means that players must have speed in all its forms (reaction, movement, execution), which is one of the characteristics of the modern game. Childhood and adolescence are favourable conditions for developing speed in all its aspects. Between 10 and 18 years of age is a favourable stage for the development of speed, and later on there is little opportunity to improve speed parameters (Sellami et al., 2024). In training, it is best to place specific speed exercises at an early stage, as they create biochemically favourable conditions for further strength development. The physiological age of children and juniors should be taken into account in the composition of training groups, rather than their chronological age. The premature introduction of special speed training exercises, after an initial phase of great satisfaction, will eventually lead to stagnation and failure to achieve great performances. In sport, speed is often triggered by a moving object (ball, opponent, team-mate), which seriously hampers the related part of the motor reaction and the central analysis of the temporal and spatial parameters of the moving object.

Neurophysiological studies (Thiagarajan & Ciuffreda, 2013; Baillargeon et al., 2012) have shown that in such cases a double visual accommodation is required: a kinetic accommodation, obtained by the convergence movement of the two eyeballs, and a dioptric accommodation, at distance, imposed by the length of the object-athlete path (Mann et al., 2021). This ability can be perfected through well-selected and judiciously timed exercises, with dynamic games being recommended for this purpose. In these, the athlete must react quickly to the appearance of a ball thrown from different positions and with different trajectories and speeds, observing the rule 'from easy to hard'. By changing the trajectory and speed of the ball, increasingly difficult situations can be created, which place increasing demands on the athlete's ability to react quickly in the most varied situations. When the moving object (e.g. the ball) is fixed by the player's gaze before moving, the motor reaction and therefore the speed of execution will be enhanced.

In sports games the player must achieve a good execution speed in cramped conditions or in option conditions from several possible responses. This ability to react quickly to situations arising from unexpected changes in the surrounding environment improves with increasing sporting skill. The beginner does not have ready-made, appropriate responses to various situations and, when asked to choose an effective response, hesitates, which leads to a lengthening of the execution time. The advanced athlete, on the other hand, thanks to the experience acquired during a long process of training and competitive activity, reacts quickly and effectively, because his response is already developed when the opponent's preparatory actions are triggered, without waiting for the actual motor action.

The speed of execution in the case of complex motor acts, or in special conditions of weighting and option, comprises the time period from the moment of the appearance of the signal to the complete completion of the appropriate motor act. If the triggering signal is a moving object (ball), the identification, perception of direction, trajectory and forward speed, and the choice of the optimal time for triggering the response reaction are additional time consuming.

Speed endurance has been a major feature of recent major tournament finals. Although games were played at short intervals, players had plenty of resources for all matches, even for the last few minutes of play at the end of an exhausting game. Today's football involves intermittent movements and changes in intensity, especially when players must cover greater distances; thus, they perform high-intensity sprints (Andrašić et al., 2021) that alternate with light running, walking, hop-step running, running crossings at a steady pace, ball kicks, jumps, turns and so on. The higher the player's level, the higher the energy requirement and overall stress during the game (Bompa, 2003).

Research shows that the intensity of play depends on the skill levels of football players (Díaz-Soto et al., 2023, Zaharia, 2022). Of the total distance run during a game, about 10% is covered at maximum speed, with sprints that usually range from 30 to 40 m; on the other hand, high-intensity running approaches 2.5 km per match (McBurnie et al., 2022). When the data was analyzed based on game positions, there were significant differences in both the best sprint time and average time values. However, no significant differences were found in the fatigue index. Forwards, full-backs, and wingers exhibited higher performance compared to central midfielders, central defenders, and goalkeepers (Çetin & Koçak, 2022). In terms of 10m sprint ability, midfielders and forwards demonstrated significantly higher sprint performance compared to goalkeepers. However, no significant differences in sprint ability were observed between defenders and the other groups (Pivovarniček et al., 2014).

Most studies specify that speed is mainly based on the genetically determined quality of receiving, transmitting and processing information from the external and internal environment, as well as on the rapidity with which peripheral muscle effectors execute the command received, which is why the important role of educating and improving this ability through training cannot be doubted (Jacob et al., 2021; Suraci et al., 2021). In our opinion, it would be a mistake for coaches to take a passive position regarding speed education or to postpone improvement actions until the full biological maturation of children's bodies, believing that innate talent will sooner or later find its way. For complete fulfilment, talent needs careful and constant attention throughout the period of growth. Therefore, assessing and monitoring the individual acceleration-speed profile in football players is crucial for training improvement and injury management (Morin et al., 2021; Formenti et al., 2021).

Technological advances in elite football have enabled highly detailed analysis of individual player and team performance. The volume and immediate accessibility of this information allow coaches and researchers in the sports field to make informed decisions about current and future needs, thus increasing the performance potential of football teams. Consequently, we can ask ourselves: "What is the development level of speed indices in U16 National League players after completing a motor programme based on means specific to the football game?"

Methodology

Scope

The *purpose* of the research is to assess the speed indices of U16 football players using computer-based techniques to fully understand their training and then establish the measures to be taken in order to increase their performance.

Objectives

- To identify the agility levels of 16-year-old football players following the implementation of a specialized training program designed specifically for improving agility and performance; this refers to the development of players' ability to move quickly and efficiently across the pitch, changing direction and position with agility.
- To improve the movement speed of 14-16-year-old football players using athletics - specific means.

Hypotheses

H1. Investigation of speed and agility indices for U16 football players shows significant differences between the two testing sessions following the completion of a specialized motor improvement training program focused on enhancing these specific skills.

Participants

The experimental research tested 36 members of two football clubs registered in the National Championship (Romania). The participants were all juniors (born in 2006 and 2007) and were distributed into two groups as follows:

- experimental group (EG): 18 players from the Concordia Chiajna Football Academy;
- control group (CG): 18 players from the Voluntari Football Club (FC Voluntari).

Both groups benefited from comparably equal training conditions.

Measures

The use of Illinois and Micro Gate Witty Speed Tests in assessing the performance of junior football players is justified by several arguments related to their relevance and specificity for the physical and technical requirements of football.

The Micro Gate Witty test

- Evaluating reactions and response times: Micro Gate Witty is an advanced system that measures the reaction times and speed of player execution, critical aspects in football, and, where quick decisions and precise executions can determine the outcome of a match.

- Advanced technology and precision: This system uses state-of-the-art technology to provide accurate and reliable data, essential for monitoring progress and identifying areas for improvement.
- Versatility: Micro Gate Witty can be used for a variety of tests and exercises, providing a comprehensive assessment of the physical and cognitive performance of players.

The Illinois test

- Relevance to agility and speed: The Illinois test is designed to measure the agility and speed of players, essential skills in football, where rapid direction changes and acceleration are crucial to performance.
- Simulation of game movements: This test includes sprints and turns that mimic the frequent movements of a football match, which is, allowing to assess the ability of players to execute rapid direction changes in a controlled manner.
- Recognised Standards: The Illinois test is an internationally recognised standard for measuring agility, allowing comparisons and benchmarking with other players and teams.

In order to analyse speed and agility indices as accurately as possible, two tests were described:

1. Witty System Speed Test. The Witty System is Microgate's portable timing system; the compact size, anatomical shape and innovative design make the Witty Timing System practical and easy to use. Various types of pre-configured tests are available (single tests, group tests, in-line tests, shuttles, counter, etc.), and the user can also create customised test protocols directly on the timer. The Witty System includes: 1 timer, 2 wireless photocells, 2 reflectors, 4 tripods, 1 battery charger - USB cable, 1 padded backpack and software (Figure 1) (Perform Better UK, 2022).

Figure 1. Witty System Speed Test (Source: Perform Better UK, 2022)

2. Illinois Agility Test. Designed by Getchell (1979), the test is commonly used in many sports to measure an athlete's running agility while turning in different directions and quickly changing speeds. This is a timed test that involves straight sprinting and multiple direction changes around obstacles (cones).

Equipment required: flat non-slip surface, marking cones, timer, measuring tape, timing gates (optional).

Pre-test: Participants were explained the testing procedures. A health-risk assessment was performed, and informed consent was obtained. Forms were prepared and basic information (age, height, body weight, gender, test conditions) was recorded. The test area was measured and marked using cones. The timing gate equipment was checked and calibrated if necessary.

Course layout: The length of the course is 10 meters and its width is 5 meters. Four cones are used to mark the start, finish and the two turning points. Another four cones are placed in the centre at an equal distance; thus, each cone in the centre of the course is placed 3.3 meters apart (Figure 2) (Wood, 2008).

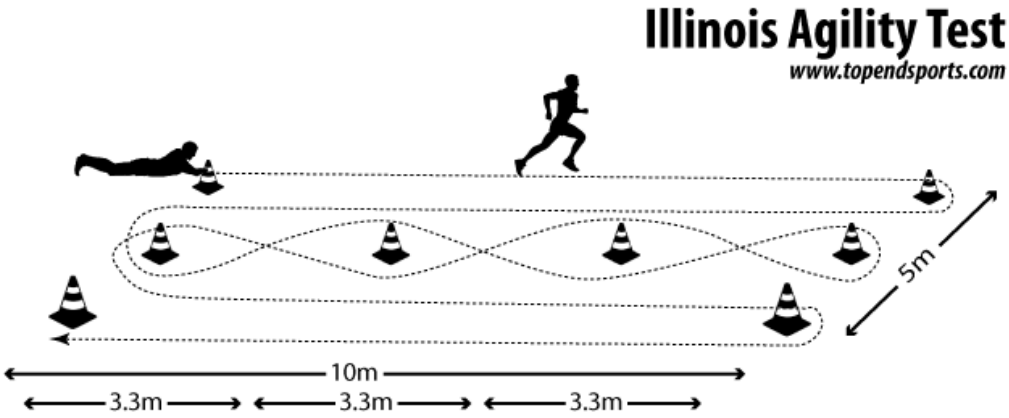

Figure 2. Illinois Agility Test (Wood, 2008)

Procedure

Witty Timing System. Due to the integrated transmission system that has a range of 150 meters, the photocells are highly reliable. Redundant radio transmission ensures that the data obtained are transmitted to the timer with the highest accuracy (±0.4 thousandths of a second), even if the signal is disturbed. The Witty timer remotely recognizes the photocell ID number, so the user can easily set the signal type on the photocell: start, stop and intermediate times. The assessment was made for the distances of 5 m, 20 m and 30 m.

Illinois Agility Test. Participants should lie face down on the floor (heads to the start line and hands by their shoulders). On the "Go" command, the timer is started, and the athlete gets up as quickly as possible and sprints forwards 10 meters to run around a cone, then back 10 meters, and then sprints up and back through a slalom course of four cones. Finally, the athlete runs another 10 meters up and back past the finishing cone, at which point the timer is stopped. Two attempts were made, and the best result was recorded.

Experimental design

The research was conducted in the 2022-2023 competition year. This induced formative-ameliorative experiment aims to verify the formulated research hypothesis. The dependent variables were represented by the participants' results obtained in the tests used to determine the improvement of speed and agility indices, while the independent variable was represented by the motor programme consisting of structured exercises performed in the preparatory and pre-competitive periods.

The training content focused on the development of movement speed to increase the athletes' performance in accordance with the requirements of competitive football at junior level. During the research, the experimental group performed the speed optimisation programme three times a week for 45 minutes per workout, with variations in volume and intensity, while the control group followed the training according to the annual plan, with the same number of weekly workouts.

Adolescent football players can increase their speed through a combination of focused training techniques that emphasize technical proficiency, tactical awareness, and physical development. It's critical to set a solid foundation so that the players don't sustain any injuries. Teenage football players can increase their speed by using these practical strategies:

1. Training for Agility and Speed:
    - Short Sprints: To build explosive speed, incorporate short sprints (10–30 meters) with enough recovery in between sets.
    - Change of Direction Drills: Exercises like cone drills and zig-zag runs improve agility, reaction time, and lateral speed.
    - Acceleration Drills: To improve acceleration and first-step quickness, begin sprints from a variety of postures, such as standing, kneeling, or prone.
2. Plyometric Exercises:
    - Explosive strength and leg power are developed by leaping onto boxes or platforms.
    - Single-leg hops are a form of exercise that enhances balance and unilateral strength, which are crucial for dynamic actions on the field.
1. Strength Training:
    - Lower Body Strength: Exercises like squats, lunges, and deadlifts can increase leg strength, which can lead to greater sprinting power.
    - Core Stability**:** Core stability can be improved by performing planks, Russian twists, and other core exercises, which is essential for maintaining speed when changing directions.
2. Flexibility and Mobility Work:
    - Dynamic stretching should be done prior to training to increase mobility and prepare muscles for high-intensity work by including dynamic movements such as leg swings, lunges with twists, and hip openers.
    - Static stretching after training helps maintain muscle flexibility and reduces the risk of injury.

3. Specific drills:
   - Small-Sided Games: Playing in small spaces (3v3 or 4v4) improves decision-making speed and agility under pressure.
   - Timed Runs: Incorporate drills that require players to reach certain points on the field within specific times, enhancing real-game speed.
4. Proper Nutrition and Recovery:

- Balanced Diet: Ensure adequate intake of proteins, carbohydrates, and healthy fats to support muscle growth and recovery.
- Adequate Sleep and Active Recovery: Emphasize the importance of sleep, foam rolling, and light activity on recovery days to prevent burnout.

As an example, we will present some of the means used to improve the speed indices of junior football players during the preparatory period:

- Acceleration sprint with progressive increase in intensity from one repetition to another: intensity 80-90%, 3-5x 40-60 m (pause: 50-60 s);
- Flying-start sprint: intensity 95-100%, 3-5x 40 m, (pause: 40-50 s);
- Relay sprint: intensity 95-100%, 4-7x 50 m each switch (pause: 50-60 s);
- Jump squat: 1x 10 (75%), 2x 7 (85%, pause: 20 s), 3x 5 (90%, pause: 20 s), 2x 7 (85%, pause: 25 s);
- Prone-start sprint, one leg bent: intensity 100%, 5x 20-30 m (pause: 60 s);
- Handicap sprint with a crouch start: intensity 100%, 4-7x 30-50 m (pause: 60-90 s);
- Crouch-start sprint: intensity 100%, 2.30 m, 2x 50 m (pause: 1 min), 1x 80 m;
- Downhill sprint: intensity 100%, 4-7x 25-40 m (pause: 1 min).

Statistical Analysis

Statistical data processing was made using the Data Analysis program (Microsoft Excel) by calculating descriptive data: mean, standard mean error, standard deviation and sum. To highlight that the chosen training program produces significant effects in terms of results obtained, the dependent and independent t tests were applied, with the significance threshold set at the p value <0.05 for $N = 18$.

Results

Tables 1 and 2 presents the initial and final data obtained at the Microgate Witty Speed Test by control group F.C. Voluntari football team and the experimental group Concordia Chiajna Football Academy.

Table 1. *Results obtained by the control group F.C. Voluntari to Witty Speed Test*

Initial Test			Final Test		
5m	20m	30m	5m	20m	30m
1.18	3.23	4.45	1.05	3.16	4.41
1.18	3.23	4.48	1.11	3.12	4.31
1.08	3.09	4.37	1.04	3.05	4.31
1.08	3.13	4.32	1.07	3.08	4.29
1.06	3.13	4.41	1.06	3.12	4.39
1.11	3.13	4.31	1.1	3.07	4.28
1.16	3.34	4.69	1.15	3.22	4.69
1.09	3.21	4.49	1.08	3.2	4.37
1.1	3.16	4.46	1.09	3.15	4.3
1.09	3.28	4.32	1.09	3.1	4.34
1.11	3.19	4.53	1.1	3.19	4.5
1.12	3.19	4.66	1.1	3.22	4.48
1.03	3.14	4.4	1	3.12	4.39
1.08	3.15	4.45	1.07	3.13	4.43
1.08	3.06	4.41	1.05	2.99	4.14
1.14	3.25	4.51	1.12	3.21	4.51
1.13	3.17	4.41	1.06	3.11	4.37
1.09	3.19	4.46	1.02	3.06	4.34

Table 2 *Results obtained by the experimental group* C*oncordia Chiajna Football Academy to Witty Speed Test*

Initial Test			Final Test		
5m	20m	30m	5m	20m	30m
1.18	3.23	4.45	1.05	3.16	4.41
1.18	3.23	4.48	1.11	3.12	4.31
1.08	3.09	4.37	1.04	3.05	4.31
1.08	3.13	4.32	1.07	3.08	4.29
1.06	3.13	4.41	1.06	3.12	4.39
1.11	3.13	4.31	1.1	3.07	4.28
1.16	3.34	4.69	1.15	3.22	4.69
1.09	3.21	4.49	1.08	3.2	4.37
1.1	3.16	4.46	1.09	3.15	4.3
1.09	3.28	4.32	1.09	3.1	4.34
1.11	3.19	4.53	1.1	3.19	4.5
1.12	3.19	4.66	1.1	3.22	4.48
1.03	3.14	4.4	1	3.12	4.39
1.08	3.15	4.45	1.07	3.13	4.43
1.08	3.06	4.41	1.05	2.99	4.14
1.14	3.25	4.51	1.12	3.21	4.51
1.13	3.17	4.41	1.06	3.11	4.37
1.09	3.19	4.46	1.02	3.06	4.34

Table 3 presents the initial and final data obtained at the Illinois Test by control group F.C. Voluntari football team, and experimental group Concordia Chiajna Football Academy.

Table 3. *Results obtained by the control group F.C. Voluntari and the experimental group Concordia Chiajna Footbal Academy – Illinois Test*

F.C. Voluntari		Concordia Chiajna Football Academy	
Initial Test	Final Test	Initial Test	Final Test
16.2	16.5	16.8	16.2
16.4	16.2	16.7	16.4
16.6	17.1	16.6	16.1
16.8	16.5	16.8	16.8
17.1	16.9	17.1	16.9
17.2	17.5	17.4	16.8
17.4	17.3	17.4	17.1
17.6	17.9	17.6	17.2
16.2	16.4	17.3	16.8
16.4	16.2	16.5	16.4
16.6	16.5	16.6	16.1
16.8	17.1	16.8	16.5
17.1	17.3	17.2	17.1
17.2	17.2	17.2	16.9
17.4	17.9	17.4	17.1
17.6	16.9	17.6	17.2
17.2	17.3	16.4	16.2
16.1	16.3	16.6	16.1

In order to determine the effects of the process of improving speed and agility indices, we compared the mean scores obtained by the control and experimental groups at the initial and final testing (dependent t test). The results are shown in Table 4 and Table 5.

Table 4. *Statistical indicators for the control group – Witty System Speed Test, Initial test vs.Final testing*

Initial vs Final Witty System Speed Test – Voluntari			
	5 m	20 m	30 m
Mean	1.007	6.490	8.534
Variance	0.002	225.931	435.794
Observations	18.000	14.000	14.000
Hypothesized Mean Difference	0.000	0.000	0.000
df	17.000	26.000	26.000
t Stat	-0.851	0.014	-0.025
P(T<=t) one-tail	0.203	0.494	0.490
t Critical one-tail	1.740	1.706	1.706
P(T<=t) two-tail	**0.407**	**0.989**	**0.981**
t Critical two-tail	2.110	2.056	2.056

- Variance indicates the spread or variability of the data points around the mean. Higher variance suggests more variability in times recorded. At 5 m, the variance is very low (0.002), indicating consistent performance. At 20 m and 30 m, the variance is higher (225.931 and 435.794), suggesting more variation in speeds.
- The t-Stat values for each distance (5 m: -0.851, 20 m: 0.014, and 30 m: -0.025) suggest that the differences between initial and final means are minor.
- One-tail p-values are 0.203 (5 m), 0.494 (20 m), and 0.490 (30 m). Since these p-values are greater than 0.05, there is no statistically significant evidence to suggest that the initial and final means are different for any of the distances in a directional hypothesis.
- Two-tail p-values are 0.407 (5 m), 0.989 (20 m), and 0.981 (30 m). These values are also above the 0.05 threshold, confirming there is no statistically significant difference between the means in a non-directional hypothesis.

The results indicate that there is no significant difference between the initial and final speed tests for the 5 m, 20 m, and 30 m distances. The mean times are very similar, and the p-values confirm that any observed differences are likely due to random variation rather than a meaningful change in performance.

Table 5. *Statistical indicators for the experimental group – Witty System Speed Test, Initial test vs.Final testing*

Initial vs Final Witty System Speed Test – Chiajna			
	5 m	20 m	30 m
Mean	1.106	3.182	4.452
Variance	0.002	0.005	0.011
Observations	18.000	18.000	18.000
Hypothesized Mean Difference	0.000	0.000	0.000
df	17.000	17.000	17.000
t Stat	3.809	4.293	3.779
P(T<=t) one-tail	0.001	0.000	0.001
t Critical one-tail	1.740	1.740	1.740
P(T<=t) two-tail	**0.001**	**0.000**	**0.001**
t Critical two-tail	2.110	2.110	2.110

- The variances are 0.002 (5 m), 0.005 (20 m), and 0.011 (30 m), indicating low variability in the performance times for each distance. The low variance suggests that the times were consistent across the trials.
- t Stat: The t-Stat values are 3.809 (5 m), 4.293 (20 m), and 3.779 (30 m). These values indicate that the observed mean differences are significantly different from zero.
- Between the tests, one-tail p-values are 0.001 (5 m), 0.000 (20 m), and 0.001 (30 m). These values are all below the significance threshold of 0.05, indicating statistically significant differences between initial and final performance times.
- Two-tail p-values are 0.001 (5 m), 0.000 (20 m), and 0.001 (30 m), also below 0.05, confirming the significant differences in directional hypotheses.

The results indicate significant improvements in performance between the initial and final tests at all distances (5 m, 20 m, and 30 m). The statistically significant p-values and

high t-Stat values suggest that the changes observed are unlikely due to chance and likely reflect genuine performance improvements.

- Comparative analysis of the results obtained by the control group (CG) and the experimental group (EG) – Witty System Speed Test, Final testing (Table 6, Figure 3)

Table 6. *Comparative statistical indicators for the control and experimental groups – Witty System Speed Test, Final testing*

	Final testing					
	5 m		20 m		30 m	
	CG	EG	CG	EG	CG	EG
Mean	1.0178	1.0756	3.105	3.1278	4.3917	4.3806
Standard error	0.0108	0.0430	0.0237	0.0260	0.0366	0.2130
Median	1.02	1.075	3.12	3.12	4.38	4.37
Mode	1.02	1.1	3.12	3.12	4.38	4.31
Coefficient of variation	4.515	4.515	3.2437	3.243	3.353	3.534
Standard deviation	0.046	0.1871	0.1007	-0.3895	0.1552	2.1896
Kurtosis	-0.5808	-0.1314	-0.424	-0.2311	1.1547	0.7105
Skewness	-0.1216	1	0.154	2.99	0.9505	4.14
Minimum	0.94	1.15	2.93	3.22	0.61	4.69
Maximum	1.1	1.0756	3.29	3.1278	4.18	4.3806
t Stat	-4.1696		-0.80769		0.2472	
P(T<=t) two-tail	0.000217		0.4258		0.8065	
t Critical two-tail	2.0369		2.0452		2.0452	

- For the 5 m distance, there are significant differences between the control and experimental groups, with a significantly lower mean for the control group. The very small p-value (0.000217) indicates this significant difference.
- For the distances of 20 m and 30 m, there are no significant differences between the two groups, as p-values are higher than the conventional significance level of 0.05.
- Overall, the coefficient of variation is relatively constant for both groups and distances, indicating similar variation in the data.
- The Skewness and Kurtosis indices vary by group and distance, suggesting differences in data distribution.

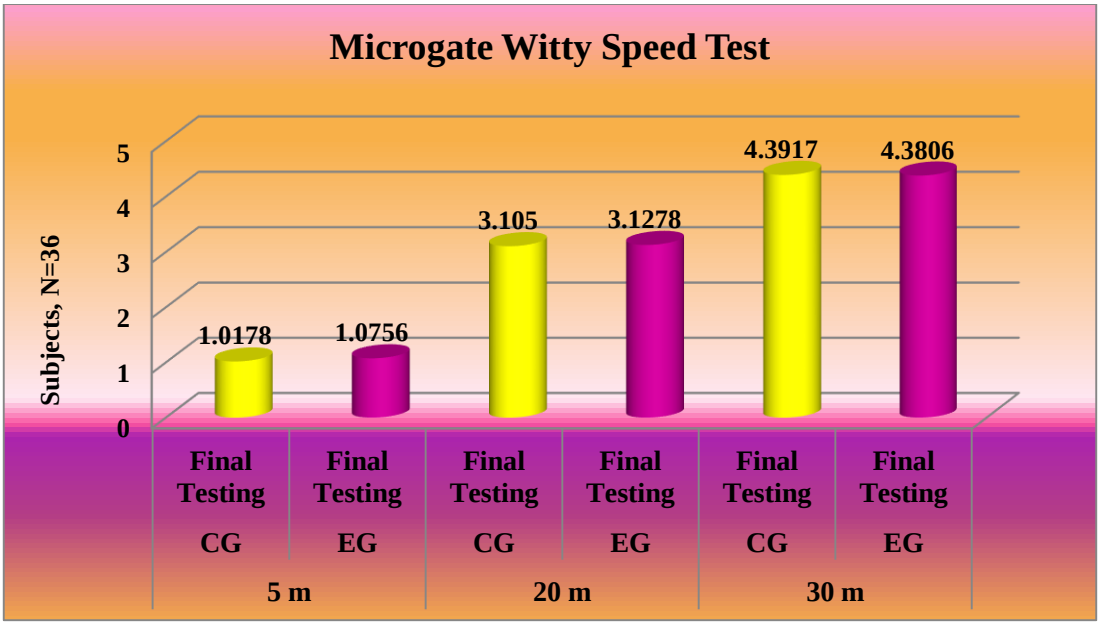

Figure 3. Mean scores for speed indices – Witty System Speed Test, experimental group (EG) vs. control group (CG)

- Comparative analysis of the results obtained by the control group (CG) and the experimental group (EG) – Illinois Agility Test, Final testing (Table 6, Figure 4)

Table 6. *Comparative statistical indicators for the control and experimental groups – Illinois Agility Test, Final testing*

	Final testing	
	CG	EG
Mean	16.944	16.661
Standard error	0.128	0.097
Median	17	16.8
Mode	16.5	16.1
Coefficient of variation	3.214	2.463
Standard deviation	0.545	0.410
Kurtosis	-0.9395	-1.5866
Skewness	0.228379	-0.157
Minimum	16.2	16.1
Maximum	17.9	17.2
t Stat	1.7626	
P(T<=t) two-tail	**0.0435**	
t Critical two-tail	1.6909	

- The mean scores obtained by the two groups in the Illinois Agility Test are 16.66 (EG) and 16.94 (CG), with a mean difference of 0.32 units between them, which is statistically significant according to the dependent t-test, where t Stat is 1.7626 and p = 0.0435 ≤ 0.05.
- The coefficient of variation is higher for the control group, which indicates a relatively greater variation when comparing the mean scores of the two groups (GE: 2.46%, GC: 3.214%).

- The Skewness and Kurtosis indices vary in the case of both groups at the final testing, showing a slight positive asymmetry for the control group and a slight negative asymmetry for the experimental group as regards the Skewness index. Both groups have negative values for the Kurtosis index, showing that their distributions are more flattened than the normal distribution.

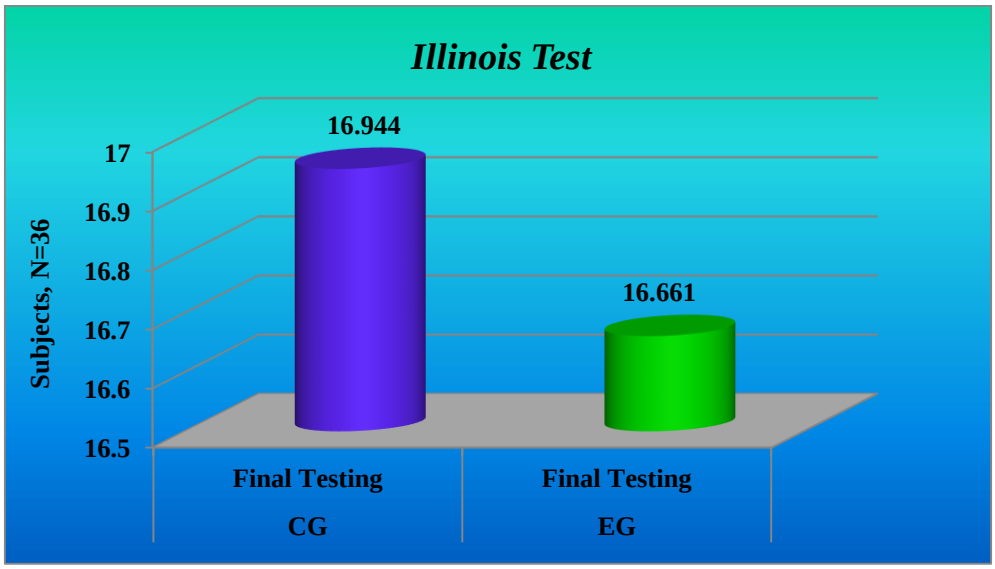

Figure 4. Mean scores for agility indices – Illinois Agility Test, experimental group (EG) vs. control group (CG)

Discussion and Conclusion

The present study aimed to analyse speed and agility indices in U16 football players following the application of an intervention programme based on athletic means. In order to assess as accurately as possible the results obtained by the research participants, the computer-based technique was used, namely Microgate's Witty Speed Test.

The significant improvements achieved by the experimental group in the speed test (5 m) after completion of the intervention programme are consistent with other studies that have also shown significantly improved speed indices in young athletes (González-Fernández et al., 2021; França et al., 2022; Teodorescu et al., 2023). For the distances of 20 m and 30 m, the mean scores achieved by the tested athletes highlight insignificant differences in speed indices between the two testing sessions. In agreement with this statement, Sermaxhaj (2017) concluded that the training programme applied in his study was not enough to improve the speed and agility of football players aged 13-15 years.

As regards the Illinois Agility Test, the experimental group recorded a better time than the control group. The results indicate that the motor programme applied had a predominant role in validating the hypothesis of the study. Other researchers (Trajković et al., 2020; Doğanay et al., 2020; Pavillon et al., 2021) concluded that basic football training resulted in improved quality of speed for young football players.

Future research should explore the improvement of speed indices on several levels, including biomechanical and physiological aspects, in full compliance with football-specific training (Marinho et al., 2020).

According to our results, we have confirmed the previous observations, showing that programmes designed to improve speed and agility in football should be adapted to football-specific stimuli in order to get closer to the game model and succeed in distinguishing the training levels of young athletes by playing position.

In conclusion, the age of adolescence presents favourable conditions for the development of speed. The optimal stage for speed development is between 10 and 18 years of age, after which there is little chance of improving speed parameters.

Acknowledgement: This study is part of the doctoral thesis entitled "Contributions to the optimisation of physical training (strength-speed) in junior football players aged 14-16".

Funding: This research did not receive any external funding.

Institutional Review Board Statement: The research was conducted according to the principles stated in the Declaration of Helsinki and approved by the Research Ethics Committee of UNEFS Bucharest (number assigned 765/0322).

Informed Consent Statement: Written informed consent was obtained for all participants involved in this study.

Data Availability Statement: Data can be made available upon request to the contact author.

Conflicts of Interest: The authors declare no conflict of interest.

References

Abarghoueinejad, M., Baxter-Jones, A. D. G., Gomes, T. N., Barreira, D., & Maia, J. (2021). Motor performance in male youth soccer players: A systematic review of longitudinal studies. *Sports*, *9*(4): 53. https://doi.org/10.3390/sports9040053

Andrašić, S., Gušić, M., Stanković, M., Mačak, D., Bradić, A., Sporiš, G., & Trajković, N. (2021). Speed, change of direction speed and reactive agility in adolescent soccer players: Age related differences. *International Journal of Environmental Research and Public Health, 18*(11): 5883. https://doi.org/10.3390/ijerph18115883

Ates, B. (2018). Age-related effects of speed and power on agility performance of young soccer players. *Journal of Education and Learning, 7*(6), 93-99. https://doi.org/10.5539/jel.v7n6p93

Baillargeon, A., Lassonde, M., Leclerc, S., & Ellemberg, D. (2012). Neuropsychological and neurophysiological assessment of sport concussion in children, adolescents and adults. Brain Injury, 26(3), 211–220. https://doi.org/10.3109/02699052.2012.654590

Bompa, T. O. (2003). *Performanţa în jocurile sportive: Teoria şi metodica antrenamentului* [Performance in sports games: Theory and methodology of training]. Ex Ponto.

Çetin, O., & Koçak, M. (2022). Repeated sprint ability of youth football players in the same age category according to playing position and competition level. *Montenegrin Journal of Sports Science and Medicine, 11*(1), 59-63

Díaz-Soto, F. J., Rico-González, M., Palucci Vieira, L. H., Clemente, F. M., Nobari, H., & Pino-Ortega, J. (2023). A systematic review of velocity and accelerometer thresholds in soccer. *International Journal of Sports Science & Coaching, 18*(5), 1768-1781. https://doi.org/10.1177/17479541221143346

Doğanay, M., Bingül, B. M., & Álvarez-García, C. (2020). Effect of core training on speed, quickness and agility in young male football players. *The Journal of Sports Medicine and Physical Fitness, 60*(9), 1240-1246. https://doi.org/10.23736/s0022-4707.20.10999-x

Formenti, D., Rossi, A., Bongiovanni, T., Campa, F., Cavaggioni, L., Alberti, G., Longo, S., & Trecroci, A. (2021). Effects of non-sport-specific versus sport-specific training on physical performance and perceptual response in young football players. *International Journal of Environmental Research and Public Health, 18*(4): 1962. https://doi.org/10.3390/ijerph18041962

França, C., Gouveia, É., Caldeira, R., Marques, A., Martins, J., Lopes, H., Henriques, R., & Ihle, A. (2022). Speed and agility predictors among adolescent male football players. *International Journal of Environmental Research and Public Health,* 19(5): 2856. https://doi.org/10.3390/ijerph19052856

Getchell, B. (1979). *Physical fitness: A way of life* (2nd ed.). John Wiley & Sons.

González-Fernández, F. T., Sarmento, H., Castillo-Rodríguez, A., Silva, R., & Clemente, F. M. (2021). Effects of a 10-week combined coordination and agility training program on young male soccer players. *International Journal of Environmental Research and Public Health, 18*(19): 10125. https://doi.org/10.3390/ijerph181910125

Jacob, Y., Anderton, R. S., Cochrane Wilkie J. L., Rogalski, B., Laws, S. M., Jones, A., Spiteri, T., & Hart, N. H. (2021). Association of genetic variances in ADRB1 and PPARGC1a with two-kilometre running time-trial performance in Australian Football League players: A preliminary study. *Sports*, 9(2): 22. https://doi.org/10.3390/sports9020022

Mann, D. L., Fortin-Guichard, D., & Nakamoto, H. (2021). Sport performance and the two-visual-system hypothesis of vision: two pathways but still many questions. *Optometry and Vision Science, 98*(7), 696-703. DOI: 10.1097/OPX.0000000000001739

Marinho, J. L. C., Martins, A. O., Rey, E., & González-Víllora, S. (2020). Influence of biological maturation on speed, jump, and endurance in high-level youth soccer players. *Revista Brasileira de Ciências do Esporte, 42*. https://doi.org/10.1590/rbce.42.2019.311

McBurnie, A. J., Parr, J., Kelly, D., & Dos'Santos, T. (2022). Multidirectional speed in youth soccer players: Theoretical underpinnings. *Strength and Conditioning Journal, 44*(1), 15-33. https://doi.org/10.1519/SSC.0000000000000657

Morin, J.-B., Le Mat, Y., Osgnach, C., Barnabò, A., Pilati, A., Samozino, P., & di Prampero, P. E. (2021). Individual acceleration-speed profile in-situ: A proof of concept in professional football players. *Journal of Biomechanics, 123*: 110524. https://doi.org/10.1016/j.jbiomech.2021.110524

Oliver, J. L., Ramachandran, A. K., Singh, U., Ramirez-Campillo, R., & Lloyd, R. S. (2023). The effects of strength, plyometric and combined training on strength, power and speed characteristics in high-level, highly trained male youth soccer players: A systematic review and meta-analysis. *Sports Medicine, 54*, 623-643. https://doi.org/10.1007/s40279-023-01944-8

Pavillon, T., Tourny, C., Aabderrahman, A. B., Salhi, I., Zouita, S., Rouissi, M., Hackney, A. C., Granacher, U., & Zouhal, H. (2021). Sprint and jump performances in highly trained young soccer players of different chronological age: Effects of linear vs. change-of-direction sprint training. *Journal of Exercise Science & Fitness, 19*(2), 81-90. https://doi.org/10.1016/j.jesf.2020.10.003

Perform Better UK. (2022). *Witty Timing System*. https://performbetter.co.uk/products/witty-timing-system

Pivovarniček, P., Pupiš, M., Švantner, R., & Kitka, B. (2014). A Level of Sprint Ability of Elite Young Football Players at Different Positions. *International Journal of Sports Science, 4*(6A), 65-70, DOI: 10.5923/s.sports.201401.09

Sellami, M., Makni, E., Moalla, W., Tarwneh, R., & Elloumi, M. (2024). Effect of maturation level on normative specific-agility performance metrics and their fitness predictors in soccer players aged 11–18 years. *BMC Sports Science, Medicine and Rehabilitation, 16*(1), 61, https://doi.org/10.1186/s13102-024-00855-z

Sermaxhaj, S. (2017). The impact of regular training programme on the speed and agility performance of the young football players. *Sport Science, 10*(1), 117-121.

Silva, H., Nakamura, F. Y., Beato, M., & Marcelino, R. (2023). Acceleration and deceleration demands during training sessions in football: A systematic review. *Science and Medicine in Football, 7*(3), 198-213. https://doi.org/10.1080/24733938.2022.2090600

Suraci, B. R., Quigley, C., Thelwell, R. C., & Milligan, G. S. (2021). A comparison of training modality and total genotype scores to enhance sport-specific biomotor abilities in under 19 male soccer players. *Journal of Strength and Conditioning Research,* 35(1), 154-161. https://doi.org/10.1519/jsc.0000000000003299

Teodorescu, S., Soroceanu, P., & Vasilescu, T. (2023). Aspects relating to the development of motor skills, strength, and balance in U16 football. *Discobolul – Physical Education, Sport and Kinetotherapy Journal*, *62*(3), 254-264. https://doi.org/10.35189/dpeskj.2023.62.3.4

Thiagarajan, P., & Ciuffreda, K. J. (2013). Visual fatigue and accommodative dynamics in asymptomatic individuals. *Optometry and Vision Science*, *9*0(1), 57-65. DOI: 10.1097/OPX.0b013e31827a233e

Trajković, N., Sporiš, G., Krističević, T., Madić, D. M., & Bogataj, Š. (2020). The importance of reactive agility tests in differentiating adolescent soccer players. *International Journal of Environmental Research and Public Health, 17*(11): 3839. https://doi.org/10.3390/ijerph17113839

Zaharia, G. (2022). Effects Of Two Explosive Strength Circuits On Power, Speed And Agility In U16 Football Players. *Discobolul-Physical Education, Sport & Kinetotherapy Journal*, 61(3), Doi: 10.35189/dpeskj.2022.61.3.7

Wood, R. (2008). *Illinois Agility Test.* https://www.topendsports.com/testing/tests/illinois.htm