Comparative analysis of motor abilities between senior and junior male football players: a multidimensional approach

Análisis comparativo de las habilidades motoras entre futbolistas masculinos sénior y juveniles: un enfoque multidimensional

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Abstract

Background: Football is a sport that requires a high level of technical, tactical, and motor skills, with particular emphasis on agility, speed, explosive strength, and flexibility. The development of these abilities depends on biological maturity, training experience, and individual factors, which affect player performance across different age categories.
Purpose: The aim was to examine and compare the level of motor abilities between football players of FC GOŠK Gabela (Premier League of Bosnia and Herzegovina) in the junior (U19) and senior (U25) age categories, focusing on key elements such as agility, speed, explosive and repetitive strength, as well as flexibility.
Method: The sample consisted of 22 players from the same club, divided into two groups by age category: 11 juniors (U19) (body height = 181.56 ± 5.74 cm; body weight = 73.29 ± 6.40 kg; BMI = 22.21 kg/m^2) and 11 seniors (U25) (body height = 184.98 ± 5.97 cm; body weight = 77.35 ± 5.70 kg; BMI = 22.55 ± 0.38 kg/m^2). Descriptive statistics were used to analyze the data, and differences between groups were determined using an independent t-test for small samples. Statistical significance was set at $p < 0.05$. Mean Difference and 95% Confidence Intervals were also calculated to further assess the significance and effect size of the detected differences (Cohen’s d).
Results: Seniors achieved significantly better results in agility tests (Illinois and Zig-Zag tests) and the 60-meter sprint, while differences in other tests were statistically insignificant ($p > 0.05$). Differences in upper body explosive strength (medicine ball throw) and flexibility were not significant, although seniors showed slightly better average values.
Conclusion: The obtained results indicate that biological maturity and longer training experience significantly influence the improvement of motor abilities, especially agility and speed over longer distances.

Keywords

Motor abilities, football, biological maturity, difference.

Resumen

Antecedentes: El fútbol es un deporte que requiere un alto nivel de habilidades técnicas, tácticas y motoras, con especial énfasis en la agilidad, la velocidad, la fuerza explosiva y la flexibilidad. El desarrollo de estas habilidades depende de la madurez biológica, la experiencia de entrenamiento y factores individuales, que afectan el rendimiento del jugador en las diferentes categorías de edad.
Objetivo: El objetivo fue examinar y comparar el nivel de habilidades motoras entre los jugadores del FC GOŠK Gabela (Liga Premier de Bosnia y Herzegovina) en las categorías júnior (sub-19) y sénior (sub-25), centrándose en elementos clave como la agilidad, la velocidad, la fuerza explosiva y repetitiva, así como la flexibilidad.
Método: La muestra estuvo compuesta por 22 jugadores de un mismo club, divididos en dos grupos por categoría de edad: 11 juveniles (U19) (altura = 181,56 ± 5,74 cm; peso = 73,29 ± 6,40 kg; IMC = 22,21 kg/m^2) y 11 séniores (U25) (altura = 184,98 ± 5,97 cm; peso = 77,35 ± 5,70 kg; IMC = 22,55 ± 0,38 kg/m^2). Se utilizaron estadísticas descriptivas para analizar los datos, y las diferencias entre los grupos se determinaron mediante una prueba t independiente para muestras pequeñas. La significación estadística se estableció en $p < 0,05$. También se calcularon la diferencia de medias y los intervalos de confianza del 95% para evaluar la significación y el tamaño del efecto de las diferencias detectadas (d de Cohen).
Resultados: Los adultos mayores obtuvieron resultados significativamente mejores en las pruebas de agilidad (pruebas de Illinois y Zig-Zag) y en la carrera de 60 metros lisos, mientras que las diferencias en otras pruebas fueron estadísticamente insignificantes ($p > 0,05$). Las diferencias en la fuerza explosiva del tren superior (lanzamiento de balón medicinal) y la flexibilidad no fueron significativas, aunque los adultos mayores mostraron valores promedio ligeramente mejores.
Conclusión: Los resultados obtenidos indican que la madurez biológica y una mayor experiencia de entrenamiento influyen significativamente en la mejora de las habilidades motoras, especialmente la agilidad y la velocidad en distancias más largas.

Palabras clave

Habilidades motoras, fútbol, madurez biológica, diferencia.

Introduction

The research problem of this study concerns the insufficiently defined differences in motor abilities between junior and senior football players, as well as the lack of multidimensional and longitudinal approaches in examining the physical fitness of players in different age categories. Although numerous studies investigate individual components of the physical and psychomotor preparedness of football players, few systematically analyze all key motor abilities in the context of biological maturity and training across different stages of player development. This is problematic because, without a detailed understanding of the interrelationships between biological maturity, physical fitness, and motor abilities, it is not possible to optimally adjust training and selection processes, which may limit the development potential of young players and their success at higher levels of competition.

Football is globally recognized as the most popular sport, characterized by its complexity and the demand for highly developed technical, tactical, cognitive, and physical abilities. In modern game conditions, especially at the professional level, players' motor skills play a crucial role in their success and efficiency on the field. Football exerts a broad and comprehensive influence on all functional systems of the human body without exception. Moreover, the significant demands this sport places on the development of these systems underscore its integral role in enhancing human physiological capacities. Modern football is defined by the necessity for exceptionally fast and precise technique, sophisticated and diverse tactical approaches, and a high level of overall physical preparedness (Pavlovic, & Siryi, 2023). Given the high game intensities, the increasing frequency of matches, and the demands for rapid decision-making within limited timeframes, the level of physical preparedness directly affects player performance during competition (Weinberg & Gould, 2019; Slimani et al., 2019; Delecroix et al., 2018; Lisenchuk et al., 2025). In recent years, research on the physical and physiological capacities of young football players has shown significant progress. More and more authors are studying the relationship between the intellectual and physical capabilities of football players at different stages of training (Neledva, & Yachsie, 2024; Salnikov, 2024). They have found a high correlation between the psychological and physical capabilities of football players. This correlation increases with the growth of athletes' skill. Studies on psychomotor skills show that football players have certain features in the development of balance, aerobic and anaerobic capabilities compared to players in other sports (Qadir et al., 2024). Also, certain features in the development of psychomotor qualities are characteristic of football players of different playing positions (Kozina et al., 2023). Some authors propose effective training programs for the development of physiological capabilities of football players of different ages at different stages of preparation (Fitrian et al., 2023). Other authors conducted studies on the psychological difficulties of young athletes' transition to higher-level groups and more qualified clubs (Abdullah et al., 2022).

Results from previous studies indicate that elite youth players generally achieve better outcomes than their non-elite peers, both in physical characteristics (height, body mass, flexibility) and physiological capacities (strength, agility, speed, aerobic and anaerobic endurance). These parameters have proven to be key in differentiating between elite and non-elite athletes at youth levels. For example, Pinheiro et al., (2022) investigated the differences in discriminative reaction time between elite youth football players in different age categories and found that older players achieved better results in this aspect of motor skills, which can have a significant impact on their performance. One of the important factors that may contribute to this superiority is biological maturity, as more mature athletes often exhibit greater physical and functional advantages compared to their less mature peers. Motor abilities such as speed, agility, explosive strength, and endurance enable footballers to respond effectively to the situational demands of a match, including sprints of 10–30, sometimes even 60 meters, changes of direction, duels, and continuous movement without the ball. Throughout the athletic development process, players' abilities change due to the synergistic effects of biological maturation, training load, and game experience. The transition from junior to senior level implies a shift from developmentally-oriented to competitive professional systems, resulting in numerous physiological, psychomotor, and biomechanical adaptations (Palucci et al., 2021).

Research shows that senior players achieve significantly better results than juniors in tests of explosive strength (e.g., vertical jump, standing long jump), maximum speed (10 m and 30 m sprints), agility (T-test, Illinois test), and sport-specific endurance (Yo-Yo Intermittent Recovery Test), largely due to training experience and biological maturity (Hammami et al., 2017; Duarte et al., 2019; Rebelo et al., 2013;

Rebelo-Gonçalves et al., 2015; Nobari et al., 2020; Nobari et al., 2021). However, the junior age group is characterized by high plasticity of the organism, which allows for rapid adaptation to various forms of training loads, provided they are exposed to appropriate training stimuli and guided sports education (Lloyd & Oliver, 2019; Lloyd et al., 2020; Padrón-Cabo et al., 2020). It is particularly important to emphasize that the differences between juniors and seniors cannot be explained solely by chronological age. Factors such as the level of biological maturity, functional preparedness, training age, and individual characteristics must also be considered. Biological maturity, expressed through phenomena such as peak height velocity (PHV) and hormonal changes, directly affects the development of strength and speed. Some young athletes may experience temporary performance declines or "plateau effects" if training demands are not synchronized with their biological development (Philippaerts et al., 2006; Lloyd, et al., 2014; Malina et al., 2015, Malina et al., 2021). More biologically mature players often show better physical and motor characteristics, which can impact their sports success and selection. In this context, it is important to investigate not only the impact of biological maturity on individual characteristics but also the relationship between physical attributes and motor abilities, as many previous studies have examined these dimensions separately (Burhaein et al., 2020; Ithon & Hirose, 2020). Sports performance is not solely a result of training processes but is also shaped by natural developmental trajectories, which depend on the degree of biological maturity. Assuming that maturity affects both physical and motor parameters, it is necessary to further clarify their interrelationships. Additionally, studies show that certain motor abilities—such as speed, agility, and cardiorespiratory endurance—reach their developmental peak during the most intense phase of height growth, which further confirms the importance of considering maturity status in the identification and development of young football players (Meylan et al., 2014; Pereira et al., 2018; Turisco, et al. 2022).

Despite the importance of this topic, literature that directly compares motor abilities of football players of different age categories is still underdeveloped—especially when it comes to longitudinal and multidimensional approaches that include multiple components of physical fitness. Furthermore, most existing studies focus on elite academies, while data from semi-professional and lower-tier leagues remain underrepresented, even though they could offer valuable insights into the developmental potential of athletes in a broader context. In line with the above, to comprehensively analyze differences in motor abilities between junior and senior football players, this study applied a battery of nine standardized tests covering key components of physical fitness relevant to football. To assess agility, the following tests were used: 505 Agility Test, Agility T-Test, Illinois Agility Test, 5-10-5 Agility Drill, and Zig-Zag Test. These tests allow for accurate measurement of direction change ability and body control under high-frequency movement conditions. Agility is especially important in the context of duels, defensive responses, and off-ball movements (Duarte et al., 2019; Young et al., 2021, Young et al., 2022). Explosive and repetitive strength was assessed using the Push-ups 10" test, which measures the ability of the upper body to generate force over a short time interval while maintaining movement continuity. Flexibility, as a vital factor for injury prevention and biomechanical efficiency, was assessed using the Sit and Reach test—one of the most commonly used tools for evaluating hamstring and lower back flexibility (Ayala et al., 2013, Ayala et al. 2015). Speed was evaluated through two tests: a 30-meter sprint and a 60-meter sprint, both measuring maximum velocity. Together, these nine tests provide a comprehensive quantitative assessment of the athletes' physical fitness and serve as a valid basis for identifying developmental differences between the observed age categories. The contribution of this research lies in filling the gap in the literature through a multidimensional analysis of differences in motor abilities between junior (U19) and senior (U25) football players. By using a wide range of standardized tests and considering factors such as biological maturity and training experience, the results of this study may contribute to more accurate assessments of physical fitness, more efficient player selection, and better individualization of training processes.

The aim of this study was to identify and analyze differences in motor abilities between junior (U19) and senior (U25) players of FC GOŠK Gabela. Particular focus was placed on key components of physical fitness relevant to football performance, including agility, speed, explosive and repetitive strength, flexibility, and aerobic endurance. The research was conducted using standardized tests that allow for objective and quantitative assessment of the athletes' motor capacities. The obtained results have the potential to contribute to improved diagnostic procedures, optimization of training content, and individualization of the selection process in accordance with the players' actual potential at various stages of their physical and sporting development. It is assumed that there are significant differences in motor abilities between junior and senior players, with seniors achieving better results in most tests due to greater biological maturity and training experience. It is also expected that these differences are not solely related to chronological age, but also to the level of biological maturity and the individual characteristics of the players.

Method

Participants

The research sample consisted of 22 male football players from FC GOŠK Gabela (Premier League of Bosnia and Herzegovina). Participants were stratified into two groups based on age category: a junior group (U19**)** comprising 11 players (mean body height = 181.56 ± 5.74 cm; mean body weight = 73.29 ± 6.40 kg; BMI = 22.21 kg/m^2) and a senior group (U25) also with 11 players (mean body height = 184.98 ± 5.97 cm; mean body weight = 77.35 ± 5.70 kg; BMI **=** 22.55 ± 0.38 kg/m^2)**.** All participants were healthy, free of musculoskeletal injuries for at least six months prior to testing, and demonstrated regular training attendance. No subject reported recent viral infections or acute illness (e.g., influenza) at the time of testing. Prior to data collection, players and coaching staff were thoroughly briefed on the purpose, methods, and procedures of the study. All participants provided written informed consent, and in the case of minors, parental consent was also obtained. The testing was conducted during the preparatory phase of the competitive season in 2024, on the official training grounds of FC GOŠK Gabela. The Ethics Committee of H.S. Skovoroda Kharkiv National Pedagogical University was given permission to conduct this research, as it complies with the Declaration of Helsinki of the World Medical Association - ethical principles of medical research involving human subjects (No. KhNPU/PhES/EC/4/6/2024).

Measurements and Testing Protocol

Anthropometric measurements were conducted in accordance with the International Society for the Advancement of Kinanthropometry (ISAK) standards and procedures (Marfell-Jones et al., 2012). All assessments were performed by a certified anthropometrist to ensure measurement accuracy and reliability. Body height was measured to the nearest 0.1 cm using a portable stadiometer (SECA 213, Hamburg, Germany), with participants standing barefoot in an upright position, with their head positioned in the Frankfurt horizontal plane. Body mass was recorded using a digital scale (Tefal, France; capacity 0–160 kg), with accuracy to 0.1 kg. Players were measured in light sports clothing and without shoes. Body mass index (BMI) was subsequently calculated using the standard formula:

$$BMI = \text{body mass (kg)} / \text{height}^2\ (m^2)$$

These basic anthropometric variables provided essential information for group comparison and potential interpretation of differences in motor performance. The same instruments and protocols were used for all subjects to minimize measurement error and ensure internal consistency. To assess key components of motor abilities, a battery of nine standardized motor tests was administered, aimed at evaluating agility, speed, explosive and repetitive strength, and flexibility (https://www.brianmac.co.uk/conditon.htm). All measurements were conducted in a controlled outdoor setting, on the club's training pitch, under similar weather conditions for all participants. Testing was carried out over two consecutive days, in the morning hours (between 9:00 and 11:30 a.m.), and under the supervision of certified sports science professionals. Prior to testing, each player completed a standardized 15-minute warm-up, which included light aerobic activity (5 minutes of jogging), dynamic stretching (5 minutes), and sport-specific drills (5 minutes). Players were instructed to maintain regular hydration and avoid strenuous training 24 hours prior to testing. Each test was demonstrated beforehand, and players were given a familiarization trial before the official measurement to reduce the impact of learning effects. Three trials were allowed for each test (where applicable), with the best result retained for analysis. Rest intervals between attempts were 1–2 minutes, and 3–5 minutes between different test categories to prevent fatigue accumulation.

Agility Tests

1. 505 Agility Test – measures the ability to accelerate, decelerate and change direction over a short distance.

2. Agility T-Test – evaluates multidirectional movement including forward sprinting, lateral shuffling, and backpedaling.
3. Illinois Agility Test – measures agility through a course requiring fast changes of direction and speed.
4. 5-10-5 Agility Drill – assesses lateral agility and quickness in a short shuttle format.
5. Zig-Zag Test – performed between cones set at an angle to measure reactive and cutting ability.

Strength and Flexibility Tests

6. Push-ups in 10 seconds – measures explosive and repetitive strength of the upper body. Players performed the maximum number of correct push-ups in 10 seconds, following a strict form.
7. Sit and Reach Test – a standard test of hamstring and lower back flexibility, using a sit-and-reach box with centimeter precision. The best of three attempts was recorded.

Speed Tests

8. 30 meter Sprint Test – players performed maximal sprints from a standing start; time was recorded in seconds using a stopwatch.
9. 60 meter Sprint Test – players performed maximal sprints from a standing start; time was recorded in seconds using a stopwatch.

All tests have been previously validated and widely used in football populations to evaluate physical performance and inter-individual differences. The testing order was designed to minimize interference between tests targeting different energy systems and muscle groups.

Data analysis

All collected data were analyzed using Statistics 10.0. Descriptive statistics, including the arithmetic mean (Mean) and standard deviation (SD), were calculated for all variables. The normality of data distribution was assessed using the Shapiro–Wilk test. To determine differences between the junior (U19) and senior (U25) groups, an independent t-test was used for parametric data. In cases where data did not meet the assumptions of normal distribution, the nonparametric Mann–Whitney U test was applied (results not shown, as all tests met normality criteria). The level of statistical significance was set at $p < 0.05$, with statistically significant differences marked by an asterisk (*). In addition to significance testing, Cohen's d effect sizes were calculated to quantify the magnitude of differences between groups (**). The interpretation of effect sizes was based on the following thresholds (Cohen 1988): small effect: $d = 0.2$; medium effect: $d = 0.5$; large effect: $d \geq 0.8$. Also presented are the differences between means (Mean1 - Mean2) and 95% confidence intervals (CI) for each assessed difference.

Results

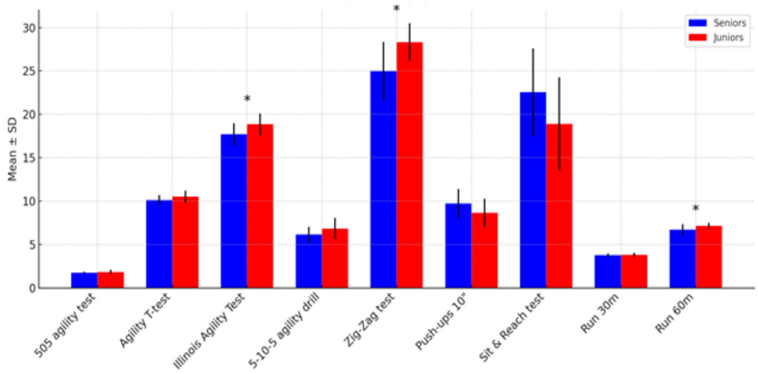
The obtained results are presented in tabular form, with interpretation conducted in the context of motor abilities and performance diagnostics in football. Descriptive statistics and independent samples t-test results for assessing differences in motor abilities between juniors (U19) and seniors (U25) are shown in Table 1 and Figure 1.

Table 1. Results of t-tests for motor abilities between senior and junior football players

Test	Seniors Mean ± SD	Juniors Mean ± SD	t-value	p (2-sided)	Difference (Mean1 - Mean2)	95% CI	Cohen's d
505 agility test	1.74 ± 0.13	1.83 ± 0.25	-1.031	0.315	-0.09	-0.27 to 0.09	-0.45
Agility T – test	10.14 ± 0.54	10.51 ± 0.68	-1.429	0.168	-0.37	-0.92 to 0.17	-0.60
Illinois Agility Test	17.69 ± 1.28	18.85 ± 1.26	-2.148	0.044*	-1.16	-2.29 to -0.03	-0.91**
5-10-5 agility drill	6.13 ± 0.90	6.84 ± 1.20	-1.574	0.131	-0.71	-1.66 to 0.23	-0.67
Zig-Zag test	24.97 ± 3.37	28.33 ± 2.17	-2.776	0.012*	-3.35	-5.88 to -0.83	-1.19**
Push-ups 10"	9.73 ± 1.68	8.64 ± 1.63	1.547	0.138	1.09	-0.38 to 2.56	0.66
Sit & Reach test	22.55 ± 5.05	18.91 ± 5.34	1.642	0.116	3.64	-0.98 to 8.26	0.70
Run 30m	3.75 ± 0.21	3.80 ± 0.25	-0.559	0.582	-0.05	-0.26 to 0.15	-0.22
Run 60m	6.70 ± 0.63	7.15 ± 0.34	-2.101	0.048*	-0.45	-0.91 to -0.00	-0.89**

*Statistically significant (p < 0.05); **Cohen's d (small effect: d = 0.2; medium effect: d = 0.5; large effect: d ≥ 0.8)

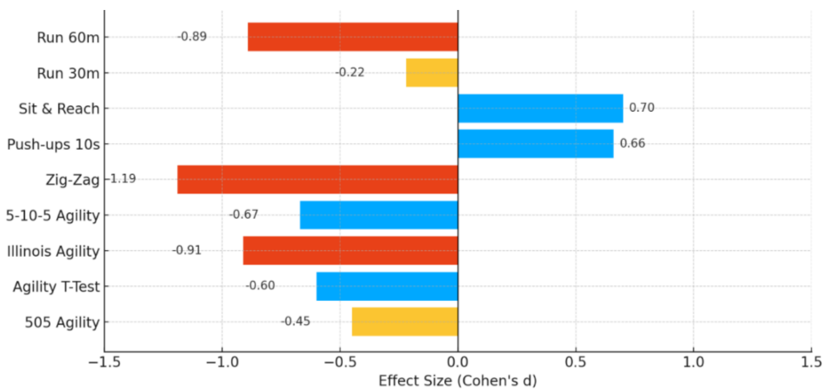
Figure 1. Performance Comparison Between Seniors and Juniors (Sig. P < 0.05)



Seniors generally performed better in most motor tests compared to juniors; however, statistically significant differences ($p < 0.05$) were observed only in select tests. The largest effect sizes were found in the Zig-Zag Test, Illinois Agility Test, and the 60-meter sprint, indicating notable performance differences between the U19 and U25 groups. In the domain of agility, seniors achieved significantly better results in the Illinois Agility Test (seniors: 17.69 ± 1.28 s vs. juniors: 18.85 ± 1.26 s; t = -2.148; p = 0.044) and the Zig-Zag Test (seniors: 24.97 ± 3.37 s vs. juniors: 28.33 ± 2.17 s; t = -2.776; p = 0.012). The difference in the 60-meter sprint was also significant, with seniors being faster (6.70 ± 0.63 s vs. 7.15 ± 0.34 s; t = -2.101; p = 0.048). Other agility tests, including the 505 Agility Test, Agility T-Test, and 5-10-5 Agility Drill, showed a trend favoring seniors, but these differences did not reach statistical significance ($p > 0.05$).

Regarding strength and flexibility, differences between groups were not statistically significant. Seniors exhibited slightly better results in the explosive repetitive strength test (Push-ups in 10 seconds: 9.73 ± 1.68 vs. 8.64 ± 1.63; p = 0.138) and the Sit & Reach flexibility test (22.55 ± 5.05 cm vs. 18.91 ± 5.34 cm; p = 0.116), although these differences were not significant. In the 30-meter sprint test, the difference between seniors and juniors was minimal and statistically insignificant (3.75 ± 0.21 s vs. 3.80 ± 0.25 s; p = 0.582). These results suggest that seniors, compared to juniors, demonstrate significantly better performance in specific components of agility and speed over longer sprints, which may be attributed to greater training experience and biological maturity, as well as superior physical performance.

Figure 2. Cohen's d Effect Sizes: Seniors vs Juniors



Cohen's d effect sizes further support these findings (Figure2). Large effects were observed in the Zig-Zag test (d = -1.19), Illinois Agility (d = -0.91), and the 60-meter sprint (d = -0.89), all favoring senior players. Moderate effects were present in upper body strength (push-ups, d = 0.66), flexibility (sit and reach, d = 0.70), and agility tests like the T-Test and 5-10-5. Small or negligible effects appeared in the 30-meter sprint and 505 agility test, indicating closer performance between groups in those tasks.

Discussion

Football is a sport that demands complete readiness from each individual, both physically and mentally. During the pre-competition period, players must reach peak condition within a limited timeframe, all while facing high expectations—from within the team and the surrounding environment. Physical preparation, including the development of strength, endurance, and speed, is often the focal point of training, as it forms the foundation of athletic performance. However, the mental aspect is equally crucial—emotional regulation, sustained focus, and self-confidence significantly influence how a player responds under pressure and makes decisions on the field (Weinberg & Gould, 2019). The aim of this cross-sectional study was to examine differences in motor abilities between junior (U19) and senior (U25) players of FC GOŠK Gabela, with a focus on key elements such as agility, speed, explosive and repetitive strength, and flexibility. The results clearly indicate significant differences between these age categories. The most pronounced differences were observed in agility and longer-distance sprints, reflected in statistically significantly better performances by the senior players in the Illinois Agility Test, Zig-Zag Test, and 60-meter sprint (Table 1 and Figure 1). These components of motor readiness are crucial for the successful execution of the technical and tactical demands of modern football, where quick changes of direction, explosive movements, and the ability to maintain maximal speed are essential for top-level performance (Young et al., 2021, Young et al., 2022; Lesinksi, et al. 2020; Pereira et al., 2018).

The superiority of seniors in these dimensions can be explained by a higher level of biological maturity, which includes greater muscle volume, more efficient neuromuscular coordination, and more developed motor patterns (Malina et al., 2015; Albaladejo-Saura et al., 2021; Malina et al., 2021a). Biological development, particularly during puberty, provides the foundation for improving motor abilities, as it enables better utilization of strength and speed potential. Puberty is a critical period in athletic development due to a surge in hormones such as testosterone and growth hormone, which directly impact strength and explosiveness (Lloyd et al., 2015). Additionally, the longer training experience of senior players contributes to more advanced technical and motor skills through sport-specific training and a higher number of competitive matches, facilitating physiological adaptation to high-intensity game demands, including efficient energy expenditure and rapid tactical responses (Hammami et al., 2017). Beyond biological factors, the senior players' extended training exposure significantly contributes to better technical and tactical readiness, as continuous training and competition stimulate adaptations in the central nervous and cardiovascular systems (Buchheit et al., 2010; Slimani et al., 2019; Lesinski et al., 2020). Similar findings are reported by Buchheit & Laursen (2013), who emphasize the role of training in enhancing performance in high-intensity sports. This further underscores the importance of continuous and progressive training, which not only develops motor capacities but also improves psychological readiness and tactical intelligence, all of which are vital for sporting success.

Interestingly, senior players achieved significantly better results in the 60-meter sprint, while the difference in the 30-meter sprint was not statistically significant. This suggests that younger players already possess good initial speed and acceleration but lack the endurance and ability to maintain maximal speed over longer sprints (Bangsbo et al., 2018; Nobari et al., 2021). This aligns with sports training principles emphasizing speed development at early stages, while endurance is built over a longer period (Rumpf et al., 2016). The sprint differences highlight the importance of focusing not only on developing explosive speed in youth but also on anaerobic endurance, which is crucial for maintaining performance during prolonged and demanding phases of play. The superior long-sprint results among senior players likely reflect their more efficient anaerobic endurance and capacity to perform repeated maximal efforts—key factors for success at higher levels of competition.

Results from agility tests such as the 505 Agility Test, Agility T-Test, and 5-10-5 Agility Drill, although not statistically significant, indicate a trend in favor of senior players. This may reflect the gradual development of more complex agility components, such as reaction speed and coordinated multidirectional movement, which require specific and continuous training, particularly in younger athletes (Palucci Vieira et al., 2019; Duarte et al., 2019). Agility, as a multidimensional ability, depends on neuromuscular coordination, motor control, and technical skills, which are refined through long-term training and competitive experience (Jimenez-Iglesias, et al., 2024; Rebelo-Gonçalves et al., 2017). These findings suggest the need for integrated training that also includes cognitive aspects such as anticipation and decision-making speed, as agility is not only a physical but also a complex neuromotor process that begins developing as early as primary school age.

In the domain of strength and flexibility, relatively small and statistically insignificant differences were recorded between juniors and seniors, although seniors achieved slightly better average scores in upper-body explosive and repetitive strength (Push-ups 10") and flexibility (Sit & Reach). This could indicate that these capacities mature at different rates or that training at younger ages does not adequately address their development (Abdullah et al., 2022). Flexibility plays a critical role in injury prevention and biomechanical efficiency of movement so its neglect may become a limiting factor in long-term athletic development. Therefore, it is advisable to integrate specific strength and flexibility programs into the systematic training of younger players to enhance preparedness for high-intensity competitive conditions and reduce injury risk. Insufficient focus on these dimensions can hinder athletic careers, making the integration of targeted strength and flexibility programs essential for optimal development (Lauersen et al., 2014; Pavlovic & Siryi, 2023). Moreover, strength development depends on a combination of neural and muscular adaptations, which require appropriate training stimuli. Given that all participants came from the same club and trained under similar conditions, the observed differences most likely reflect individual differences in biological maturity, i.e., the stage of pubertal development. Biologically more mature juniors may show motor performances similar to seniors, while less mature players lag behind, highlighting the importance of monitoring biological rather than only chronological age when planning training and player selection (Meyers et al., 2016; Malina et al., 2021; Albaladejo-Saura et al., 2021). Accurate tracking of pubertal status enables coaches and staff to tailor training and loads to individual needs, thereby reducing the risk of overtraining and injury while maximizing each player's potential (Lloyd et al., 2015). Similar insights are provided by Cumming et al., (2017), who demonstrated that an individualized approach based on biological maturity improves athletic development. The minimal difference in the 30-meter sprint may indicate earlier maturation of initial speed and acceleration or less dependence of these abilities on specific training at this age (Buchheit et al., 2010a). On the other hand, significant differences in the 60-meter sprint confirm that the ability to maintain maximal speed and endurance are key components differentiating age categories. This likely reflects the superior aerobic and anaerobic conditioning of senior players, as well as better biomechanical efficiency during longer sprints. The importance of anaerobic endurance in football is also confirmed by Neldeva et al. (2024), who highlight that the development of repeated sprint ability contributes to overall player success.

Finally, a multidimensional approach in the assessment and development of young footballers—encompassing physical, technical, tactical, and psychological aspects, along with training individualization based on biological maturity—is essential for timely recognition of developmental needs and the creation of effective training programs (Palucci Vieira et al., 2021; Salnikov, 2024). Ongoing systematic monitoring of motor abilities enables coaches to guide player development, maximize their potential, and ensure a successful transition from junior to senior football while minimizing injury risk. A similar recommendation is offered by Till et al., (2014), who emphasize the importance of a multidisciplinary approach in youth athletic development. The results of the present study emphasize the need for an individualized, multidimensional, and age-appropriate approach in the training of young footballers. Monitoring biological maturity, as well as systematically evaluating key motor abilities, is necessary for timely recognition of developmental needs and for creating optimal training programs. This facilitates an efficient transition from junior to senior levels while maximizing athletic potential and reducing injury risk. Future research may further explore the impact of psychological and tactical factors on motor performance, as well as the application of modern technologies in training monitoring and analysis.

Based on the presented findings and their analysis, several practical implications can be highlighted that may contribute to the improvement of the training process, diagnostics, and player selection in modern football:

1. Improvement of diagnostics (the standardized tests used in this study can serve as an efficient tool for monitoring the physical status of football players across different age categories),.

2. Individualization of the training process (the observed differences in motor abilities enable more precise planning of training sessions in accordance with the players' age, maturity level, and current physical capabilities),.

3. Selection and transition between categories (the results provide a basis for making better selection decisions, especially during the transition from junior to senior levels),

4. Injury prevention (the analysis of flexibility and strength can contribute to the design of injury prevention programs for young football players),

5. Support for clubs outside the elite system (the findings are particularly valuable for clubs without access to top-level facilities, as they offer validated methods for player assessment and development).

Limitations and Future Research

This study included a relatively small sample from a single club, limiting its external validity. The cross-sectional design also restricts causal inference. Future research should adopt longitudinal and multi-club approaches to better understand the dynamics of motor ability development over time. Additionally, incorporating psychological and tactical performance indicators may provide a more holistic understanding of player readiness.

Conclusions

The results of this study clearly indicate that biological maturity and training experience play a crucial role in the development of key motor abilities in football players, particularly agility and the 60-meter sprint. The superiority of seniors in these components highlights the importance of targeted and individualized preparation of young athletes, with a special focus on developing agility and high-intensity endurance from the early stages of training. On the other hand, relatively small differences in upper-body explosive strength and flexibility suggest that these dimensions are often neglected in younger age groups, which may limit their further development and increase the risk of injury. Therefore, it is essential to incorporate specific strength and flexibility programs into the systematic development of young football players. In conclusion, an individualized training approach based on monitoring biological maturity and multidimensional assessment of motor abilities is key to maximizing potential and ensuring a successful transition from junior to senior categories.

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