

Age-related differences in physical fitness components of youth soccer players

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Abstract

Background and Study Aim

Soccer performance relies heavily on physical fitness components, including linear speed, explosive power, change-of-direction ability, and aerobic endurance. During early adolescence, these attributes develop alongside biological maturation and systematic training exposure, which may differentially influence performance outcomes across age groups. Despite the widespread use of standardized field-based tests to assess physical fitness in youth soccer players, the manifestation of age-related differences between closely spaced categories remains a matter of practical interest. This study aimed to investigate differences in selected physical fitness components between U13 and U15 youth soccer players using standardized field-based tests.

Material and Methods

A cross-sectional comparative design was employed with 36 male youth soccer players (U13: $n = 18$, mean age 12.7 ± 0.4 years; U15: $n = 18$, mean age 14.6 ± 0.5 years) from organized training programs at Nakhchivan State University. All participants had at least two years of systematic soccer training and were free from recent injuries. Physical fitness was assessed using the 30 m sprint test (linear speed), the standing long jump (lower-body explosive power), the Illinois agility test (change-of-direction ability), and the Yo-Yo Intermittent Recovery Test Level 1 (aerobic endurance). Data were analyzed using independent-samples t-tests and Cohen's d effect sizes ($p < 0.05$). The study adhered to the Declaration of Helsinki. Informed consent was obtained from parents or guardians, and participants provided assent.

Results

Statistically significant differences were found between groups in all measured variables ($p < 0.001$). U15 players outperformed U13 players with faster 30 m sprint times (4.41 ± 0.27 s vs. 4.82 ± 0.31 s, $t = 4.12$, $d = 1.38$), greater standing long jump distances (1.95 ± 0.18 m vs. 1.72 ± 0.15 m, $t = -3.89$, $d = 1.40$), quicker Illinois agility test times (16.93 ± 0.69 s vs. 18.21 ± 0.74 s, $t = 5.06$, $d = 1.45$), and higher Yo-Yo IR1 distances (1420 ± 260 m vs. 910 ± 210 m, $t = -6.01$, $d = 2.15$). All effect sizes were large.

Conclusions

The results demonstrate clear age-related differences in physical fitness between U13 and U15 youth soccer players. Older players showed superior sprint speed, explosive power, agility, and aerobic endurance. These findings reflect the combined influence of biological maturation and accumulated training experience during early adolescence. The study highlights the importance of age-specific and developmentally appropriate training programs in youth soccer. Regular assessment of physical fitness using standardized field-based tests may support evidence-based training planning, performance monitoring, and long-term athlete development in youth soccer environments.

Keywords:

youth soccer, age-related differences, sprint performance, agility, aerobic endurance, physical fitness

Introduction

Physical fitness represents one of several key factors influencing performance in youth soccer, contributing to players' capacity to meet the physical and technical demands of training and competition across different stages of development. During adolescence, soccer-specific performance is shaped by a complex interaction of growth-related changes, neuromuscular development, and accumulated training stimuli, which together affect speed, power, agility, and endurance capacities. These components do not develop uniformly, and their expression may vary substantially between age

groups even within relatively narrow chronological ranges. Consideration of how multiple physical fitness attributes manifest across adjacent youth categories is important for interpreting performance differences and aligning training demands with players' developmental characteristics.

Building on this perspective, soccer is characterized by its intermittent high-intensity nature, requiring players to repeatedly perform actions such as sprinting, jumping, accelerating, decelerating, and changing direction throughout a match [1, 2]. As a result, success in soccer depends not only on technical and tactical skills but also on well-developed physical fitness components, including speed, strength, power, agility, and

aerobic endurance [1, 3, 4]. In youth soccer, the development of these physical attributes plays an important role in both short-term performance and long-term athlete development [5].

During childhood and adolescence, players experience rapid physiological, neuromuscular, and morphological changes associated with growth and biological maturation [6, 7]. These changes strongly influence physical performance and may lead to substantial differences among players across age categories [5, 8]. Consequently, consideration of age-related variations in physical fitness is essential for coaches, physical education teachers, and sport scientists who aim to design appropriate training programs and to ensure healthy and sustainable development in young soccer players [9].

Youth soccer development systems are typically organized by chronological age (e.g., U13, U15, U17). While this classification is practical for competition and training organizations, it does not always reflect individual differences in biological maturation [7]. Nevertheless, age-group-based analysis remains a widely used and valuable approach for examining developmental trends in physical fitness and performance [5, 10]. Research focusing on age-related differences can provide reference values that help practitioners evaluate player development and identify appropriate training priorities for each age group [8].

Previous research has consistently shown that older youth soccer players tend to perform better physically than their younger counterparts [5, 11]. Improvements in sprint speed, muscular power, agility, and aerobic endurance have been reported with increasing age. These changes are largely attributed to maturation-related increases in muscle mass, neuromuscular coordination, and cardiovascular capacity [12, 13]. In addition, older players generally have greater exposure to structured training programs, which further enhances their physical fitness [9, 14].

Speed and agility are particularly important physical attributes in soccer, as decisive game actions such as winning duels, creating space, and reacting to opponents often occur within very short time frames [1, 15]. Studies have indicated that sprint performance over short distances and change-of-direction ability improve markedly during early and mid-adolescence [12, 13]. Similarly, lower-body explosive power, commonly assessed through jumping tests, shows significant age-related progression. It is closely associated with sprinting and agility performance in youth soccer players [16].

Aerobic endurance is another key component of soccer performance, as players must sustain repeated high-intensity efforts throughout a match [3, 17]. Field-based endurance tests, such as the Yo-Yo Intermittent Recovery Test Level 1, have been widely used to assess soccer-specific aerobic capacity

in youth players [11, 17]. The Yo-Yo IR1 test is particularly relevant for soccer because it mimics the intermittent nature of match play. It has also been shown to discriminate between players of different competitive levels and age categories [15, 18].

Despite the growing body of literature on youth soccer performance, several gaps remain. Many studies have focused on elite academy players from well-established soccer nations, whereas evidence from other soccer systems and diverse regional contexts is less extensive [4, 18]. In addition, some studies have examined broad age ranges without providing detailed comparisons between closely related age groups, such as U13 and U15. These categories represent critical stages of physical and biological development [5, 17].

From a practical perspective, a lack of age-specific reference data may lead coaches to apply similar training loads and physical demands across different age groups. This approach may increase the risk of overtraining or injury in younger players [9]. Conversely, insufficient physical stimulus may limit performance development in older players. Therefore, research that identifies age-related differences in physical fitness can support more individualized and developmentally appropriate training approaches [14, 19].

In physical education and youth sport contexts, empirical evidence on physical fitness development can inform curriculum design and assessment practices. Information on how physical performance evolves across age categories allows educators to set realistic expectations and to promote positive and developmentally appropriate experiences in sport participation [9]. Such evidence also aligns with the broader framework of long-term athlete development, which emphasizes gradual progression, age-appropriate training, and the avoidance of early specialization [10].

Within this framework, comparative research examining age-related differences in physical fitness among youth soccer players provides a practical basis for structuring training models, assessment strategies, and performance monitoring systems across age groups [20]. Evidence derived from standardized field-based testing protocols supports informed decision-making in both coaching practice and educational settings, including higher sports education institutions involved in youth sport development.

Analysis of research findings has shown that physical fitness components in youth soccer develop progressively with age, reflecting the combined influence of biological maturation and systematic training exposure. Researchers emphasize that attributes such as speed, power, agility, and aerobic endurance play a critical role in shaping performance during key developmental stages of adolescence. At the same time, the multifactorial nature of physical

development and the close proximity of certain age categories highlight unresolved aspects related to the interpretation of age-related differences and their practical implications for training and assessment. This context points to the need for the search for more effective approaches to evaluating physical fitness and informing training organization in youth soccer. This context points to the need for the search for more effective approaches to evaluating physical fitness and informing training organization in youth soccer. Within this framework, the present study examined differences in selected physical fitness components between U13 and U15 youth soccer players using standardized field-based tests.

Materials and Methods

Participants

A total of 36 male youth soccer players volunteered for the study. Participants were divided into two age groups based on chronological age: U13 ($n = 18$; mean age 12.7 ± 0.4 years) and U15 ($n = 18$; mean age 14.6 ± 0.5 years). All participants were actively involved in organized soccer training and competition at the time of the study and had at least two years of systematic training experience. Players trained three to four times per week and regularly participated in weekend matches.

The inclusion criteria for participation were as follows: (a) registration as an active soccer player in a youth training program, (b) absence of musculoskeletal injury or illness during the three months preceding the study, and (c) regular attendance at training sessions. Players who reported recent injuries or medical conditions that could affect physical performance were excluded from the study.

Ethical Considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki for research involving human participants. Prior to data collection, players and their parents or legal guardians were informed about the study purpose, procedures, potential risks, and benefits. Written informed consent was obtained from parents or guardians, and verbal assent was obtained from all participants. Participation was voluntary, and players were free to withdraw from the study at any time without penalty.

Research Design

This study employed a cross-sectional comparative research design to examine age-related differences in selected physical fitness components of youth soccer players. A cross-sectional approach was considered appropriate because it allows comparison of physical performance characteristics across age groups at a single point in time. This design is commonly used in youth sport and

physical education research. It is suitable for identifying developmental differences associated with chronological age.

Testing Procedures

Physical fitness testing was conducted on an outdoor soccer field under standardized conditions. All tests were completed during the competitive season to ensure that players were in regular training condition. Testing sessions were scheduled in the afternoon to coincide with the players' usual training time. Environmental conditions, including temperature and surface type, were consistent for all participants.

Prior to testing, all players completed a standardized warm-up lasting approximately 15 minutes. The warm-up included light jogging, dynamic stretching exercises, mobility drills, and progressive acceleration runs. Adequate recovery time was provided between tests to minimize the effects of fatigue on performance outcomes.

Physical Fitness Tests

30 m Sprint Test. Linear sprint speed was assessed using the 30 m sprint test. Players performed two maximal sprints over a 30 m distance from a standing start. Electronic timing gates were installed at the start and finish lines to ensure accurate timing. The best time recorded from the two trials was used for statistical analysis. A rest period of at least three minutes was provided between trials.

Standing Long Jump. Lower-body explosive power was evaluated using the standing long jump test. Participants stood behind a take-off line with their feet shoulder-width apart and performed a maximal forward jump using a two-foot take-off. Arm swing was permitted. Two trials were performed, and the longest distance achieved was recorded to the nearest centimeter.

Illinois Agility Test. Change-of-direction speed and agility were assessed using the Illinois agility test. The test setup consisted of a rectangular course with cones placed according to standardized guidelines. Players were instructed to complete the course as quickly as possible while following the designated running pattern. Time was recorded using electronic timing gates. Two trials were conducted with adequate recovery, and the fastest time was selected for analysis.

Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IRI) [17]. Aerobic endurance capacity was assessed using the Yo-Yo Intermittent Recovery Test Level 1. The test consists of repeated 20 m shuttle runs performed at progressively increasing speeds and interspersed with 10 s active recovery periods. An audio signal controlled the running pace. The test was terminated when a player failed to reach the finish line in time with the audio signal on two occasions. The total distance covered was recorded and used as the performance indicator.

Test Order. To minimize fatigue effects, tests were administered in the following order: 30 m sprint, standing long jump, Illinois agility test, and Yo-Yo IR1. This order was selected to ensure that maximal anaerobic performance tests were completed before the endurance assessment. All tests were administered by the same research team using standardized protocols to enhance reliability. Prior to data collection, players were familiarized with all test procedures.

Statistical Analysis

Data were analyzed using SPSS statistical software. Descriptive statistics, including the mean and standard deviation (mean ± SD), were calculated for all variables. The normality of data distribution was assessed using the Shapiro–Wilk test. Independent-samples t-tests were conducted to examine differences between U13 and U15 players for each physical fitness variable. The level of statistical significance was set at $p < 0.05$. Effect sizes (Cohen’s d) were calculated to determine the magnitude of the observed differences between age groups.

Results

Descriptive statistics and results of between-group comparisons for all measured physical fitness variables in U13 and U15 soccer players are presented in Table 1.

Table 1 summarizes the descriptive statistics for all measured physical fitness variables in U13 and U15 players. Differences in central tendency and variability were observed between the two age groups across all tested variables.

For sprint performance, the mean 30 m sprint time for U13 players was 4.82 ± 0.31 s, whereas U15 players recorded a mean time of 4.41 ± 0.27 s. Standing long jump performance showed a mean distance of 1.72 ± 0.15 m in the U13 group and 1.95 ± 0.18 m in the U15 group. In the Illinois agility test, U13 players completed the test in 18.21 ± 0.74 s, while U15 players completed it in 16.93 ± 0.69 s.

Aerobic endurance performance, assessed using the Yo-Yo Intermittent Recovery Test Level 1, indicated that U13 players covered a mean distance of 910 ± 210 m. In contrast, U15 players covered 1420 ± 260 m.

Independent-sample t-test results demonstrated statistically significant differences between U13 and U15 players for all measured physical fitness

variables ($p < 0.05$). Significant between-group differences were observed for the 30 m sprint ($t = 4.12, p < 0.001$), standing long jump ($t = -3.89, p < 0.001$), and Illinois agility test ($t = 5.06, p < 0.001$). Analysis of Yo-Yo IR1 performance also revealed a statistically significant difference between age groups ($t = -6.01, p < 0.001$).

Effect size analysis using Cohen’s d revealed large effects for all variables. Effect sizes were 1.38 for the 30 m sprint, 1.40 for the standing long jump, 1.45 for the Illinois agility test, and 2.15 for the Yo-Yo IR1. These values indicate substantial differences between the age groups.

Discussion

The purpose of this study was to examine age-related differences in selected physical fitness components between U13 and U15 youth soccer players. The results demonstrated statistically significant differences between the two age groups across all measured variables, including sprint speed, lower-body explosive power, agility, and aerobic endurance. These findings are consistent with research by Deprez et al. [5] and Mirkov et al. [20], who reported age-related improvements in physical performance indicators among youth soccer players. Similar age-related trends in sprinting ability, agility, and intermittent endurance have also been reported in recent studies of youth soccer players [21, 22]. From a developmental perspective, age-specific reference values can support more accurate interpretation of physical performance during key stages of youth soccer progression, as also indicated by Aliyev et al. [10].

In the present study, sprint performance differed between U13 and U15 players, with faster sprint times observed in the older age group. Similar age-related improvements in linear sprint speed have been reported in previous research involving youth soccer players [12, 13]. Earlier studies have indicated that sprint ability tends to improve during adolescence in association with neuromuscular maturation, increases in muscle mass, and improvements in motor coordination [6, 7]. In addition, findings from youth soccer research suggest that short-distance sprint performance is influenced by both biological maturation and accumulated training exposure, which may contribute to performance differences across age groups [1, 15]. Comparable age-related patterns in sprint performance have also been

Table 1. Comparison of physical fitness variables between U13 and U15 soccer players

Variable	U13 (Mean ± SD)	U15 (Mean ± SD)	t	p
30 m sprint (s)	4.82 ± 0.31	4.41 ± 0.27	4.12	< 0.001
Standing long jump (m)	1.72 ± 0.15	1.95 ± 0.18	-3.89	< 0.001
Illinois agility test (s)	18.21 ± 0.74	16.93 ± 0.69	5.06	< 0.001
Yo-Yo IR1 (m)	910 ± 210	1420 ± 260	-6.01	< 0.001

described in recent cross-sectional studies of youth soccer players with similar training ages [22, 23].

Similarly, standing long jump performance differed between U13 and U15 players, with higher values observed in the older age group. Previous studies of youth soccer players have reported similar age-related patterns in jump performance and lower-body explosive power during adolescence [12, 16, 23]. These studies have associated age-related changes in muscular power with maturation-related factors, including increases in muscle cross-sectional area, neuromuscular adaptations, and more effective utilization of the stretch-shortening cycle [12]. In addition, research examining the influence of biological maturation on physical performance adaptations has indicated that strength- and power-related outcomes may develop differently across maturation stages during adolescence [24].

Agility performance, assessed using the Illinois agility test, differed between U13 and U15 players, with shorter completion times observed in the older age group in the present study. Similar age-related differences in change-of-direction performance have been reported in youth soccer players, with improvements commonly observed alongside increasing age and training experience [20]. Research examining agility and change-of-direction tasks in adolescent soccer players has indicated that these performance changes are associated with maturation-related developments and accumulated sport-specific training exposure, as reflected in the relationships between sprinting, jumping, and change-of-direction performance [1, 25]. In addition, recent studies analyzing sprinting and change-of-direction performance across youth age categories have reported progressive improvements in agility-related outcomes during adolescence [23].

In the present study, aerobic endurance, assessed using the Yo-Yo Intermittent Recovery Test Level 1, differed between U13 and U15 players, with greater distances covered by the older age group. Similar age-related increases in intermittent endurance capacity have been reported in youth soccer players, with older adolescents typically demonstrating higher Yo-Yo IR1 performance than younger age groups [3, 18]. Normative data derived from adolescent male athletes show that Yo-Yo IR1 distances increase progressively with age, supporting the interpretation of developmental changes in aerobic endurance during adolescence [26]. In addition, research conducted in youth football players has demonstrated a close relationship between aerobic capacity and Yo-Yo IR1 performance, indicating that higher aerobic fitness is associated with greater intermittent endurance distances [27]. The Yo-Yo IR1 test has been widely recognized as a valid and reliable measure of soccer-specific aerobic fitness, and its sensitivity to age-related differences has been consistently reported in youth soccer research [11, 17].

In the present study, the observed between-group differences may reflect not only age-related maturation but also differences in accumulated training exposure. Previous studies have described biological maturation as an important factor associated with physical performance development during adolescence [12, 13]. In addition, research in youth soccer has indicated that older age groups generally have longer training histories, higher weekly training volumes, and greater exposure to competitive demands than younger players, which may contribute to differences in physical fitness outcomes [9, 10, 14]. Such accumulated soccer-specific training has been linked to progressive improvements in performance components requiring repeated high-intensity actions and intermittent efforts, including sprinting and intermittent endurance measures [1, 3, 9, 14].

From an institutional perspective, the organization of youth training programmes and the selection of physical assessment tools are shaped by strategic planning and management practices within sports education institutions, which influence how training content, load progression, and performance monitoring are implemented across age groups [19]. Such organizational frameworks determine the consistency and specificity of training exposure during different stages of youth development.

At the individual level, maturation-related neuromuscular adaptations occurring during adolescence, including changes in motor unit recruitment, firing frequency, and intermuscular coordination, have been associated with improvements in the execution of rapid and explosive movements [12, 13, 28]. Recent research in youth soccer has shown that training interventions targeting neuromuscular function are associated with improvements in sprinting, jumping, and change-of-direction performance, supporting the role of neuromuscular control and muscle-tendon adaptations during adolescence [29]. In addition, evidence examining the influence of maturation stage on physical fitness attributes indicates that age- and maturation-related differences contribute to variability in speed, power, and agility outcomes in youth athletes [30]. These adaptations are particularly relevant for performance tasks such as sprinting, jumping, and agility, which require rapid force production and efficient motor control [7, 20, 31].

Taken together, the interaction between structured training exposure within organized youth development systems and maturation-related physiological adaptations provides a coherent framework for interpreting the age-related improvements in speed, power, agility, and intermittent endurance observed in older youth soccer players.

Study Limitations and Future Directions

This study has several limitations that should be considered when interpreting the findings. The cross-sectional design does not allow causal inferences regarding the effects of age, maturation, or training on physical fitness development. In addition, biological maturation was not directly assessed, which may have influenced the observed differences between age groups. The sample size was relatively small and limited to male youth soccer players, which may restrict the generalizability of the results.

Future research may benefit from longitudinal designs that track physical fitness development across multiple age categories while accounting for maturation status and training load. Examination of players from different training environments and developmental settings could further extend the applicability of the findings. Such approaches may contribute to more refined age- and development-specific training and assessment frameworks in youth soccer.

Practical Implications

The findings of this study have several practical implications for youth soccer coaching and training organization. Clear differences in physical fitness between U13 and U15 players indicate that training programs should be adapted to players' developmental characteristics rather than applying uniform physical demands across age groups. Age-specific planning may support safer and more effective progression of physical abilities during adolescence.

For younger players (U13), training should prioritize the development of fundamental movement skills, coordination, balance, and basic speed mechanics. Emphasis on technical quality, correct movement execution, and positive training experiences is appropriate at this stage. Strength and power activities may be introduced using bodyweight or low external loads, with a focus on technique rather than maximal output, while excessive high-intensity conditioning should be avoided.

For older players (U15), training programs may gradually incorporate more structured physical conditioning elements. Greater emphasis can be placed on sprint performance, explosive power,

agility, and intermittent endurance, reflecting increased tolerance to training load associated with maturation and accumulated training experience. Progression should remain gradual, and individual responses to training should be monitored.

Regular use of standardized field-based physical fitness tests can support systematic monitoring of player development. Periodic assessment allows practitioners to track changes over time, identify individual strengths and limitations, and adjust training content accordingly. Such an approach may also assist talent development systems in establishing age-appropriate benchmarks and supporting long-term player development through balanced integration of physical, technical, and tactical training.

Conclusions

The findings of this study indicate that physical fitness characteristics in youth soccer players differ systematically between U13 and U15 age groups during early adolescence. Statistically significant differences were observed across all assessed variables, including sprint speed, lower-body explosive power, agility, and aerobic endurance, with higher values consistently recorded in the older age group.

These results reflect age-related changes associated with biological maturation and accumulated training exposure, highlighting the non-uniform development of physical fitness components during adolescence. The observed differences emphasize that even relatively small age gaps may be accompanied by substantial variation in physical performance capacities among youth soccer players.

Overall, the study contributes to a clearer characterization of age-related physical fitness profiles in youth soccer and supports the use of standardized field-based testing to document developmental trends across age categories. Such evidence may assist in improving the interpretation of physical performance outcomes within youth soccer development systems.

Conflict of interests

The authors declare that there is no conflict of interests.

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