The effects of a 6-month proprioception training program on speed in young football players

Los efectos de un programa de entrenamiento de propiocepción de 6 meses sobre la velocidad en jugadores jóvenes de fútbol

Authors

Dritan Adili [1]
Aida Bendo [2]

[1] University of Tetovo (North Macedonia)
[2] Sports University of Tirana (Albania)

Corresponding author:
Aida Bendo
abendo@ust.edu.al

How to cite in APA

Bendo, A., & Adili, D. (2025). The effects of a 6-month proprioception training program on speed in young football players. *Retos, 71*, 580–592. https://doi.org/10.47197/retos.v71.116098

Abstract

Introduction: Speed is a key performance factor in football. While traditional training emphasizes strength and power, proprioception—the body's awareness of position and movement—supports balance and neuromuscular control, which are essential for efficient movement.
Objective: This study aimed to assess the effects of a 6-month proprioception training program on linear and change-of-direction speed in 17-year-old male football players.
Methodology: A randomized controlled trial was conducted with 62 adolescent male footballers. The experimental group received proprioceptive training focusing on ankle, knee, and hip joint stability, integrated into their regular sessions. The control group continued standard football training. Speed and agility were tested before and after the intervention. Data were analyzed using paired and independent t-tests, with significance set at $p < 0.05$.
Results: The experimental group showed significant improvements in both linear and change-of-direction speed after six months. The control group did not demonstrate notable changes. Post-test comparisons revealed statistically significant differences between the groups ($p < 0.05$), favoring the experimental group.
Discussion: Performance gains in the experimental group likely resulted from improved neuromuscular coordination, joint stability, and movement efficiency due to proprioceptive training. These adaptations may contribute to faster, more controlled sprinting and directional changes.
Conclusion: A 6-month proprioception training program effectively enhances speed performance in adolescent football players. Incorporating such training into youth development programs is recommended to support optimal athletic performance.

Keywords

Football; performances variables; proprioceptive training; speed.

Resumen

Introducción: La velocidad es un componente esencial en el rendimiento futbolístico. Aunque el entrenamiento tradicional se enfoca en la fuerza y la potencia, la propiocepción—la capacidad del cuerpo para percibir su posición y movimiento—es clave para el equilibrio y el control neuromuscular, factores determinantes en la eficiencia del movimiento.
Objetivo: El objetivo de este estudio fue analizar los efectos de un programa de entrenamiento propioceptivo de 6 meses sobre la velocidad lineal y la velocidad de cambio de dirección en futbolistas adolescentes de 17 años.
Metodología: Se llevó a cabo un ensayo controlado aleatorizado con 62 futbolistas varones de 17 años. El grupo experimental realizó entrenamiento propioceptivo enfocado en la estabilidad del tobillo, rodilla y cadera, mientras que el grupo control siguió su rutina habitual. Se midió el rendimiento en velocidad y agilidad antes y después, utilizando pruebas t pareadas e independientes ($p < 0,05$).
Resultados: El grupo experimental mostró mejoras significativas en la velocidad lineal y de cambio de dirección tras seis meses, mientras que el grupo control no presentó cambios relevantes. Se observaron diferencias significativas entre grupos en las mediciones postest ($p < 0,05$).
Discusión: Las mejoras se atribuyen a un mayor control neuromuscular, equilibrio y estabilidad articular derivados del entrenamiento propioceptivo, lo que optimiza la ejecución de movimientos rápidos y precisos.
Conclusión: Un programa de propiocepción de 6 meses mejora significativamente el rendimiento de velocidad en jóvenes futbolistas, por lo que se recomienda su inclusión en los planes de desarrollo deportivo juvenil.

Palabras clave

Entrenamiento propioceptivo; fútbol; pruebas de velocidad; variables de rendimiento,

Introduction

Football, a globally popular sport, demands explosive movements like kicking, tackling, jumping, sprinting, and rapid changes in direction, requiring strong muscular effort and driving force for players (Hasan et al., 2024). The scientific study of football, dating back to the 1970s, has significantly developed, with its influence on daily practices in football organizations, particularly elite teams, often overlooked (Drust & Green, 2013). Football academies are vital institutions in developing athletes for competitive excellence, requiring a unique combination of physical and technical skills (Saputra et al., 2025). Soccer is a team sport with intermittent high intensity, requiring players to repeatedly perform sprints with short recovery periods (Maciel et al., 2024). Football requires players to possess cognitive abilities such as quick decision-making and rapid reaction times, which are traditionally developed through physical training, tactical drills, and match experience (Swamynathan et al., 2025). Soccer, as an acyclic sport, is influenced by technical, tactical, physiological, biomechanical, and psychological factors, emphasizing the need to maintain these variables at reasonable levels (Hermosilla et al., 2024). Football has various factors that affect achievement, including physical condition, technique, tactics and mentality (Nurcahyo et al., 2025). Personality is crucial for long-term success and relationship maintenance, and understanding an athlete's personality type is vital for performance, including football, and predicts long-term success (Kurniawan et al., 2024). Existing literature underscores the transformative impact of integrating quantitative and qualitative player statistics in the identification and development of football talent (Yunus & Aditya, 2024). Evaluating technical skills throughout a soccer match can provide valuable insights to enhance soccer players employability across various match stages and aid in the development of specific training methodologies (de Pablo et al., 2024). Football is particularly important due to its complex physical skill exercises and intensity (Ali et al., 2024). Training load is defined as the total intensity, volume, and type of physical activity that athletes must perform during training and competition (Apriantono et al., 2024). Adolescent football players may enhance flexibility and agility for competitiveness, but early sports specialization and training don't guarantee success or future athletic success, and adolescent years pose unique injury risks (Brown et al., 2017). Athletes require hip and trunk muscle strength for stability in all three planes of motion, with lumbar spine stability influenced by trunk loading direction and magnitude (Leetun et al., 2004). Athletic development involves youth training in health, skill, and performance components to improve performance, reduce injury risk, and enhance confidence (Lloyd et al., 2015). Resistance training in youth aged 6-18 improves muscular strength, power, running speed, endurance, dynamic balance, flexibility, and general motor performance, making them more resistant to injuries (Zwolski et al., 2017). Modern soccer demands high-intensity movements for performance, requiring players to maintain short distances and constant movements, tackles, sprints, direction changes, and pressure in all positions (Lee & Joo, 2024). Soccer players' ability to produce high-speed actions significantly impacts match performance (Little & Williams, 2005), categorized into acceleration, maximal speed, and agility. Professional soccer players cover 10-12 km during matches, with high intensity actions occurring almost 1 km and sprinting intensity over 200m (Castillo et al., 2021). Soccer players travel an average of 10 km at 70% VO2max intensity, with sprints, accelerations, direction changes, jumps, and shoots determining success and discriminating between elite and lower categories (Hermosilla-Palma et al., 2024). For pre-youth soccer players, substituting physical training with technical, tactical, and physical training improves bioadaptive performance and potentially improves final performance (Burgos Angulo et al., 2024). Proprioceptive training is a form of exercise that focuses on improving proprioception (Yılmaz et al., 2024). Proprioception is the brain's control of movement, integrating sensory signals from mechanoreceptors, and aids in understanding our environment by identifying, organizing, and interpreting sensory information (Han et al., 2016), which is crucial for joint stability and injury prevention (Riva et al., 2016). Proprioceptive feedback is a fast and predictable source of information that can be used for optimizing movement patterns, as it is related to metabolic energy expenditure and the mechanical state of the body (Dean, 2013). A study identifies two key principles for proprioception: combined afferent response provides movement information, and signals are interpreted in terms of limb endpoint dynamic displacement (Proske & Gandevia, 2012). Research shows proprioceptive training effectively prevents ankle sprains in team athletes, but not as a sole prevention for knee injuries (Virto et al., 2024). Training the proprioceptive sense is a potential therapy for improving motor function and neural control, but its effectiveness is unclear due to differing definitions and potential for both conscious and unconscious aspects (Aman et al., 2015). Proprioceptive training enhances neuromuscular control, balance, and coordination, enabling athletes to adapt to rapid changes in movement and environment (Eraslan et al., 2025). Balance, postural control or equilibrium are definitions used to describe how we keep our body in an upright position and, when necessary, adjust this position (Bendo et al., 2014). Equilibrium is described as the ability to maintain the body's position within its base of support (Bendo et al., 2023a). Equilibrium tests on force plate are used to assess balance ability and athletic performance, focusing on static balance, which involves maintaining a stable position with minimal movement, and dynamic balance, which involves performing tasks on unstable surfaces (Hrysomalli, 2011). The ability to maintain a stable posture while contacting the ball is rather important for the players' performance in the match (Bendo et al., 2023b). Sports experts recommend Proprioceptive Neuromuscular Facilitation (PNF) techniques for improving muscle elasticity, joint range of motion, peak torque, and muscle strength in static and dynamic stretching methods (Al Hazmy et al., 2025). Physical capacity and technique are crucial for a player's performance, as they cover 10-13 km, requiring aerobic and anaerobic demands, agility, flexibility, strength, and muscular power (de Souza et al., 2025). A meta-analysis comparing strength and power training programs on muscle strength, power, and speed, incorporating progressive power training into a well-rounded program with other strength and conditioning (Behm at el., 2017). It is observed that midfielders cover the most distance in training, and older, experienced players have lower subjective perception of effort compared to younger, less experienced players (Rodríguez et al., 2024). Agility is a crucial skill in sports, involving rapid whole-body movement in response to stimuli, including change of direction ability for predetermined tasks without stimulus reaction (Young et al., 2021). Achieving and maintaining postural balance requires intricate coordination and integration of various sensory motor and biomechanical factors (Bendo & Brovina, 2024). The researchers have concluded that using exercises within the training curriculum positively impacts the development of extraordinary agility and skill performance in football (Mohammed et al., 2025). A major priority for both athletes and coaches is improving athletic performance, especially in physically demanding and dynamic sports like football. Speed is essential for success in football and involves rapid changes of direction, acceleration, and agility. This traditional line of training emphasizes the development of strength and power, but there is increasing information suggesting that proprioception is a fundamental element of athletic skills, such as sprinting. Our body's proprioceptive receptors play a key role in joint stability, coordinating movement, and facilitating economical muscle contractions–speed building components. Thus, the objectives of the present research were to investigate the effects of a 6-month proprioceptive training program on linear sprinting and change-of-direction speed performances in 17-year-old male football players as well as to assess potential differences compared to a control group using traditional training methods. The hypothesis of the study is that the experimental group who received the 6-month proprioception training program will have significant improvements in linear and change-of-direction speed performance behaviors than those subjects in the control group who received regular football training.

Method

Study design

This study used a parallel group, randomized controlled trial (RCT) to evaluate the effects of a proprioceptive training program on speed of performance. The participants were randomly allocated in an experimental group which performed the 6-month proprioceptive-training program and in a control-group practicing a standard football-training program. Participants are male adolescent footballers (approximately 17 years of age) who participate in competitive school-based football in the Republic of North Macedonia. Although the sample (N = 62) came from one institution (Drita' high school in Kichevo), it is considered as representative of such a population. A convenience sample was conducted because of a logistical reason and all eligible players were invited to participate. But there was no probability of sampling formula or power analysis, which was used to determine the minimum sample size in advance. Thus, while the sample may match the demographic profile of the population, statistical representativeness cannot be claimed according to the present criteria such as an anticipated effect size, level of confidence (e.g., 95%), power (e.g., 0.80), and degree of error. Baseline measures were obtained in the pre-test using standardized sprint tests. Data was collected after the 6-month intervention with the same procedures. Allocation was concealed, and the researchers who collected and analyzed the data remained blind.

Sample Size justification

A priori power analysis was conducted with G*Power 3.1 software to verify the sample size. The analysis is conducted on the t- test with independent and assumed: Score for the effect size (relative to group comparison) = 0.80 (large effect from the literature for proprioceptive training and speed); Significance level (α) = 0.05; Statistical power (1 - β) = 0.80; Allocation ratio (N1/N2) = 1. The least number of participants was required for the sample size, which was 52 (26 in each group) to have sufficient power to detect a significant difference of the selected parameters. The total sample (62; 31 per group) exceeds this threshold, attributing to the adequacy of the study power to detect relatively large effect sizes. This increases the robustness and generalizability of the findings and reduces the probability of a Type II error.

Participants

The study's sample consisted of 62 young male football players (17.32 ± 0.13 years, 174 ±3.6 cm and 70.40 ± 2.43 kg), all members of competitive football players of the "Drita" high school within the local community of Kichevo, Republic of Macedonia. The subjects of this study were divided into two subgroups [control (CG) and experimental (EG)] to be involved in a pre- and post- training measurement design. All participants attended a period of six months of football training planned with three 45-minute weekly sessions. The experimental group consisted of 31 players who trained three times a week for 45-minute sessions using regular football program activities (technical, tactical, and physical) throughout a six-month period. The control group consisted of 31 athletes who trained three times a week for 45-minute sessions over a six-month period utilizing certain proprioception exercises. All participants undertook standardized speed testing procedures before and after the 6-month intervention period, including agility tests and sprint timings across S1 = 15 m, S2 = 30 m, S3 = 60 m, and S4 = 100 m distances, to evaluate the program's effectiveness. The methodology was carefully developed to ensure ethical conduct, minimize bias, and produce data that could be considered applicable to the target population.

Participant Recruitment

Inclusion criteria required participants to be female, aged between 18 and 24 years, for those of non-

Recruitment of participants was initiated by contacting the coaching staff. Following approval from the team, all eligible 17-year-old players were invited to participate in informative meetings outlining the research objectives, experimental procedures, potential risks, and guarantees of data confidentiality. Players were informed about the randomization process and the potential for being assigned to either the intervention or control group. Voluntary informed consent was obtained from each subject's parents to consider them as study participants, prior to any data collection. The study was approved and provided by the Ethics Committee of the Sports University of Tirana with protocol no. 252-2, from the Ethical Committee of the University of Sports of Tirana. A detailed consent form outlined their rights as a participant, including the freedom to withdraw from the study at any time without penalty.

Inclusion and Exclusion Criteria

Inclusion criteria

The study focuses on male football players who are 17 years old at the time of enrollment and are actively participating as football players. Participants must regularly engage in team football training at least three times per week to be eligible. Additionally, all individuals are required to provide voluntary informed consent, with parental or guardian consent obtained for those under the age of 18. These inclusion criteria ensure that the study targets a specific group of athletes who are consistently involved in structured football training and meet the necessary ethical and participation requirements.

Exclusion criteria

The study excludes individuals with any recent history of lower limb musculoskeletal injury within the last six months that would hinder full participation in training. Additionally, participants with a current diagnosis of a neuromuscular disorder that could influence the study outcomes are ineligible. Those actively engaged in a structured proprioceptive training program outside of their regular football training during the study period are also excluded. Finally, individuals who fail to provide informed consent will not be included. These exclusion criteria ensure that the study focuses on participants without confounding factors that could affect the results or their ability to fully engage in the research.

Protocols

Baseline speed performance was evaluated using four standardized sprint tests, which provided objective measures of each athlete's speed and established a performance baseline. In addition, commonly used agility tests relevant to football contexts were also considered. All assessments were conducted under the supervision of experienced personnel, employing electronic timing systems and standardized protocols. Prior to each testing session, participants completed a standardized warm-up routine. The six-month intervention program adhered to a prescribed protocol, as outlined below.

Procedures

Both proprioceptive and traditional training comprise six micro cycles of training implemented for 4 weeks each. Participants undertook three training sessions per week. Every training session lasts 45 minutes. Proprioceptive training comprises 12 training sessions implemented for 45 minutes each. During these sessions subjects are trained using proprioceptive exercises. Micro-cycles, sessions, duration and heart-rate intensity range for the sessions are presented in Table 1.

Table 1. Proprioceptive and traditional training micro cycles.

Micro cycle (weeks)	Session	Duration	Intensity
1 – 4	1 – 12	12 × 45	45 – 55 %
5 – 8	13 – 24	24 × 45	55 – 65 %
9 – 12	25 – 36	36 × 45	65 – 75 %
13 – 16	37 – 48	48 × 45	75 – 85 %
17 – 20	49 – 60	60 × 45	85 – 90 %
21 – 24	61 – 72	72 × 45	90 – 95 %

Participant Training Procedures

The experimental group participated in a proprioception training program 3 times per week, for 45 minutes per session, in addition to their regular football training activities. This program included exercises designed to enhance joint stability, balance, and body awareness, with a focus on dynamic movements relevant to football such as single-leg hops, agility drills on unstable surfaces, and plyometric exercises involving balance disks and dynamic weight transfers following a progressive overload principle. The control group, conversely, continued with their standard football training regimen without any specific proprioceptive exercises. Speed was assessed using standardized timed sprint tests: 15, 30, 60 and 100-meter sprints for both groups, at two different time periods: Pre-intervention (baseline measurements taken prior to the commencement of the intervention program) and post-intervention (measurements taken upon completion of the 6-month training period). All testing procedures were conducted by trained personnel using calibrated equipment and under consistent environmental conditions. The data collected from both pre- and post-tests in both groups were then analyzed using appropriate statistical methods to determine the effectiveness of the proprioception program on speed performance. This rigorous approach allowed for a thorough examination of the hypothesized relationship between proprioceptive training and speed improvement in young football players, while controlling for the typical training effects of their regular football sessions.

Data collection

Data collection primarily occurred on the football pitch during scheduled training sessions and in the gymnasium for proprioceptive training and specific speed assessments. All necessary equipment, including cones, agility ladders, timing gates, measuring tapes, and specialized proprioception training tools (e.g., balance boards, wobble cushions), were provided by the research team. Prior to testing, participants completed a standardized warm-up including light aerobic activity, dynamic stretching, and practice sprints. Data collection was conducted by trained research assistants to ensure accuracy and consistency across all participants and testing sessions. The order of all speed tests was kept constant for each athlete. All timing information collected in the speed tests was recorded in a digital format using the electronic timer, which reduced the margin of human error. Test administrators were trained to ensure proper placement of timing gates to facilitate accurate measurements. The accelerometer and activity logs were collected and verified upon completion. Data from both groups were then compiled and analyzed using appropriate statistical measures to determine if any significant differences existed between the groups post-intervention, specifically in sprint speed over the four distances, and were compared to the baseline performance of each group.

Speed Assessment

The primary measure for this study was sprint speed, assessed using a series of time-trials across various distances. Four sprint tests were conducted using an electronic timing system. Participants were instructed to perform maximal effort sprints from a standing start. Specifically, the following sprint tests were administered:

- 15-meter Sprint: This test measured acceleration and initial speed capabilities. Timing gates were positioned at the start and 15-meter mark. Each participant performed two trials, and the best time was recorded in seconds.
- 30-meter Sprint: This added an element of maintaining speed and continued acceleration. Timing gates were placed at the start and 30-meter point. Two trials per participant were completed, with the faster time logged.
- 60-Meter Sprint: This test assessed the athletes' sustained speed capacity. Timing gates were positioned at the start line and at the 60-meter mark. Each participant performed two trials, with the fastest sprint time recorded.
- 100-Meter Sprint: This test evaluated maximal sustained speed over a longer distance. Timing gates were placed at both the starting point and the 100-meter finish line. Two attempts were conducted, and the best performance time was documented.

All sprint tests were conducted on a flat, non-slip surface, with adequate space for acceleration and deceleration. Consistent verbal encouragement and standardized instructions were provided before each trial to ensure reliable results. Testing occurred at a similar time of day to minimize diurnal variations affecting performance. A familiarization session with the sprint tests was conducted prior to data collection to minimize learning effects.

Data analysis

All sprint tests were described in terms of means and SD, using descriptive statistics. Because the sample size was greater than 50 patients, normality was tested using the Kolmogorov–Smirnov test. Normal distribution was verified by the Shapiro-Wilks test, and the results of normal distribution were met ($p > 0.05$). Equality of variances was examined using Levene’s test ($p > 0.05$). Paired-samples t-tests assessed differences in sprint performance within each group between the pre- and post- intervention 6-month intervention at each sprint distance (15m, 30m, 60m and 100m respectively). Paired-samples t-tests and independent-samples t-tests were employed to compare the post-intervention results between experimental and control groups. Finally, the extent of differences was estimated by effect sizes with Cohen’s d. All statistical analyses were performed using IBM SPSS Statistics version 26, and the statistical significance was at $p < 0.05$.

Results

Table 2 presents the descriptive statistics and results of t-tests analysis for the 15-meter sprint times for both groups at pre-test and post-test.

Table 2. The results for 15-Meter Sprint Times (Seconds)

Group	Time Point	Mean ± SD	t-value within group t (30)	p-value within group	t-value between groups t (60)	p-value between group	Cohen’s d-value
Experimental	Pre-test Post-test	2.95 ± 0.12 2.65 ± 0.10	11.58	< 0.001	2.73	0.003	0.58
Control	Pre-test Post-test	2.90 ± 0.11 2.69 ± 0.13	8.35	< 0.001			

*Significant differences, p< .05.
Note: Adili & Bendo (2025).

As seen at pre-test baseline, the mean speed test time was 2.95 seconds (s) for the experimental group and 2.90 s for the control group. At the post-test, the experimental group exhibited a mean speed time of 2.65 s compared to a mean 2.69 s for the control group. These descriptive data suggest a reduction in sprint time (improvement in speed) for both groups, with the experimental group showing a greater reduction. Table 3 presents the descriptive statistics and results of t-tests analysis for the 30-meter sprint times for both groups at pre-test and post-test.

Table 3. The results for 30-Meter Sprint Times (Seconds).

Group	Time Point	Mean ± SD	t-value within group t (30)	p-value within group	t-value between groups t (60)	p-value between group	Cohen's d-value
Experimental	Pre-test Post-test	4.92 ± 0.15 4.51 ± 0.18	12.97	< 0.001	4.39	< 0.01	0.86
Control	Pre-test Post-test	4.85 ± 0.17 4.64 ± 0.16	8.87	< 0.01			

*Significant differences, p< .05.
Note: Adili & Bendo (2025).

Speed was measured using a 30-meter sprint test before (pre-test) and after (post-test) the intervention period. The mean pre-test time for this group was 4.92 seconds, decreasing to a mean post-test time of 4.51 seconds. Table 4 presents the descriptive statistics and results of t-tests analysis for the 60-meter sprint times for both groups at pre-test and post-test. The descriptive statistics for both the experimental and control groups are shown in Table 4. At baseline, the experimental group demonstrated an average 60m sprint time of 9.0 seconds, while the control group averaged 8.85 seconds.

Table 4. The results for 60-Meter Sprint Times (Seconds).

Group	Time Point	Mean ± SD	t-value within group t (30)	p-value within group	t-value between groups t (60)	p-value between group	Cohen's d-value
Experimental	Pre-test Post-test	9.00 ± 0.35 8.40 ± 0.28	14.92	< 0.001	3.19	0.002	0.9
Control	Pre-test Post-test	8.85 ± 0.32 8.48 ± 0.30	7.50	< 0.001			

*Significant differences, p< .05.
Note: Adili & Bendo (2025).

Post-intervention, the experimental group showed an improvement in speed, achieving an average time of 8.4 seconds. The control group also demonstrated a slight speed increase, with an average time of 8.48 seconds at the post-test. Table 5 presents the descriptive statistics and results of t-tests analysis for the 100-meter sprint times for both groups at pre-test and post-test.

Table 5. The results for 100-Meter Sprint Times (Seconds).

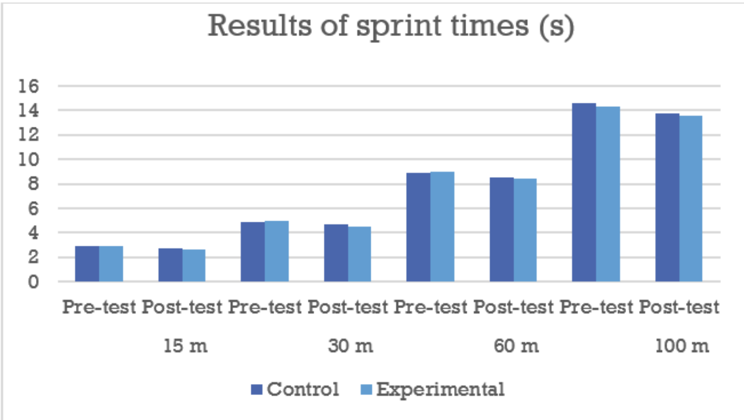
Group	Time Point	Mean ± SD	t-value within group t (30)	p-value within group	t-value between groups t (60)	p-value between group	Cohen's d-value
Experimental	Pre-test Post-test	14.62 ± 0.58 13.75 ± 0.49	4.67	< 0.001	2.73	0.08	0.84
Control	Pre-test Post-test	14.33 ± 0.61 13.59 ± 0.52	3.25	< 0.01			

*Significant differences, p< .05.
Note: Adili & Bendo (2025).

Initial pre-test results using a 100-meter sprint test revealed an average time of 14.62 seconds for the experimental group and 14.33 seconds for the control group. Post-test assessments showed a mean time of 13.75 seconds for the experimental group and 13.59 seconds for the control group, as presented in table 5, which demonstrated a reduction in mean sprint time from pre-test to post-test.

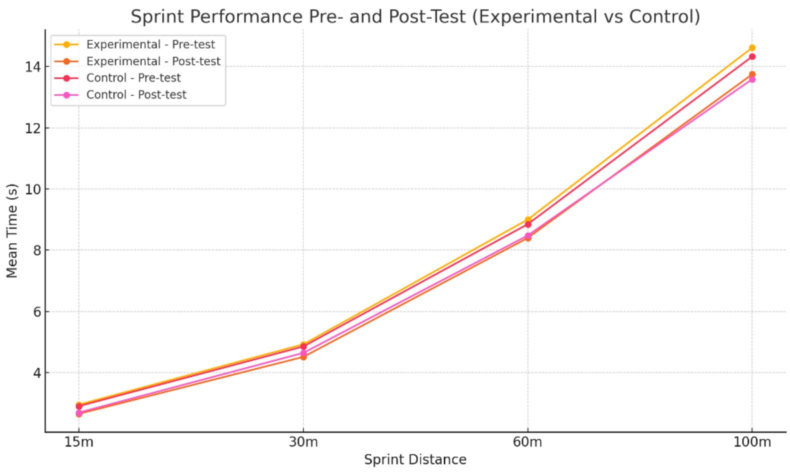
Figure 1 below represents the results of mean speed time in 15, 30, 60 and 100 m sprint at pre-test and post-test, for the experimental and control group. This graph visually highlights the improvement across time and the differences between the experimental and control group. Figure 2 shows the graphs of sprint performance pre and post-test for both groups.

Figure 1. Visually represents the changes in mean sprint times, as well as the difference between pre- and post-test for the two groups.



Nota: Adili & Bendo (2025).

Figure 2. The graphs of sprint performance pre- and post-test in Experimental and Control groups.



Nota: Adili & Bendo (2025).

Discussion

This study aimed to determine whether a specific 6-month proprioceptive intervention, integrated into existing football training, would lead to a statistically significant improvement in linear speed compared to a control group engaged in their standard football training regime. Paired t-tests were conducted to examine the changes in sprint times within each group.

Results of 15 m indicate a significant decrease in sprint time from pre-test to post-test for the experimental group ($t(30) = 11.58$, $p < 0.001$). Similarly, the control group also showed a significant improvement in sprint time over the 6-month period ($t(30) = 8.35$, $p < 0.001$). These within-group changes demonstrate that players may improve their speed during a season. An independent t-test was performed to compare changes in sprint times (post-test minus pre-test) between the experimental and control groups. Results showed a statistically significant difference between groups ($t(60) = 2.73$, $p = 0.003$). This indicates that the experimental group had a significantly greater improvement in sprint time compared to the control group.

The paired-samples t-test for 30 m revealed a statistically significant difference between pre-test and post-test times ($t(30) = 12.97$, $p < 0.001$) in experimental group. This indicates that the proprioception training program was effective in improving sprint speed within the experimental group. The control group also demonstrated a change in time, from a pre-test meantime of 4.85 seconds to a post-test meantime of 4.64 seconds. Similarly, a paired-samples t-test showed a statistically significant difference within this group ($t(30) = 8.87$, $p <0.01$). The change in speed, calculated by the difference in pre-test and post-test times, showed a statistically significant difference between group differences ($t(60) =4.39$, $p < 0.01$). This indicates that the proprioception training program induced a significantly greater improvement in 30-meter sprint time compared to routine training. While the control group did show an improvement, it must be noted the result was not as large as the experimental group.

Ther result of 60 m in the experimental group exhibited a statistically significant improvement in sprint speed after the 6-month intervention ($t(30) = 14.92$, $p < 0.001$). The control group also demonstrated a statistically significant improvement in speed from pre-to-test ($t(30) = 7.50$, $p < 0.001$) but to a smaller extent. The results of the independent samples t-test for 60 meters were used to compare the differences in speed change between the experimental and control groups from the pre-test to the post-test. A significant difference was found between the groups ($t(60) = 3.19$, $p = 0.002 < 0.05$) indicating that the experimental group showed significantly greater improvement in sprint speed over the course of the study compared to the control group.

To analyze the significance of these changes within each group, paired t-tests were employed. The experimental group exhibited a statistically significant improvement in sprint time ($t(30) = 4.67$, $p < 0.05$), with an average reduction of 0.87 seconds, or approximately 6% improvement in speed. Similarly, the control group also demonstrated a statistically significant decrease in sprint time ($t(30) = 3.25$, $p < 0.05$), with an average reduction of 0.74 seconds, or approximately 5% improvement in speed. To determine whether the proprioception training had a different effect in the groups, an independent sample t-test was conducted. This showed no significant difference in performance between the groups ($t(60) = 2.73$, $p > 0.05$) which implies there was no significant difference in the magnitude of improvement of each group.

To assess the practical significance of the observed between-group difference, Cohen's d was calculated. In the 15 m test, the effect size for the between group difference at post-test was $d = 0.58$, indicating a moderate effect size. This suggests that the proprioception training program had a practically meaningful impact on the speed of the experimental group compared to the control group, however, the change appears more substantial in the experimental group. This indicates that proprioceptive training produced a moderate but meaningful improvement in acceleration speed.

Cohen's coefficient calculated for 30 m, yield a value $d = 0.86$, showing a large effect size indicating that the training program yielded a substantial effect. This suggests that the intervention had a substantial impact on the players' ability to maintain and build up sprint speed. The experimental group, which participated in the 6-month proprioception training, showed a statistically significant improvement in speed performance. The comparisons between groups resulted in a Cohen's value of $d=0.9$ which indicates a large size effect in favor of the experimental group and also indicating a strong effect of proprioceptive training on sustained sprinting ability. For the 100-meter sprint, although the effect size remained large (Cohen's $d = 0.84$), the p-value (0.08) did not reach statistical significance. This suggests that while improvements were notable, the variance or sample size may have limited the statistical power to detect significance at this distance.

The results suggest that the proprioception training program had a positive effect on the 15-meter sprint speed of young football players. While both groups demonstrated improved speed after 6 months, the experimental group experienced a significantly greater reduction in sprint time compared to the control group, highlighting the added benefit of the proprioception training. The improvements seen in the control group may be attributed to normal maturation, or to regular football training.

The 6-month proprioception training program led to a statistically significant improvement in 30-meter sprint speed in young football players. Furthermore, the experimental group demonstrated a significantly greater decrease in sprint time compared to the control group, suggesting the proprioception training yielded a specific benefit. The speed of the players measured using a 60-meter distance sprint test suggests that proprioception training may be an effective method for enhancing speed performance in this population of athletes. The data from 100 m analysis suggests that both groups improved but the experimental group did not achieve a significantly bigger improvement compared with the control group.

The significant difference observed between the experimental and control groups provides evidence to support the use of a 6-month proprioception training program to enhance sprint speed in young footballers. Further analysis might involve exploring correlations between specific proprioceptive measures and sprint performance to further refine training protocols.

The results indicate that a 6-month proprioception training program led to a statistically significant improvement in sprint speed within the experimental group. The control group also showed a significant improvement, likely from the normal effects of training over time, suggesting that improvements in speed are not solely due to proprioception training. Critically, the improvement in the experimental group was significantly greater as shown by the comparison at post-test. This suggests the addition of proprioception training provides an added benefit over traditional football training alone. The moderate effect size further supports the practical value of incorporating proprioception training into young football players' regimens for enhancing speed.

A study has confirmed the advantages of yoga exercises for the equilibrium system and emphasizes their importance in improving quality of life, including psychological and emotional dimensions (Bendo & Haxholli, 2017). The results of another study have shown that equilibrium variables increased after proprioception training, which was very effective in reducing sway indexes at athletes, to improve and to increase the balance condition and sport performances (Bendo et al., 2023a). Integrating proprioceptive training with sport-specific agility drills can improve agility performance by requiring rapid changes in direction, acceleration, and deceleration, resulting in faster, more effective responses in dynamic game situations (Eraslan et al., 2025). Enhancing awareness of body position and movement in space is the goal of proprioception training, which may increase speed through several processes. First, better neuromuscular control makes it possible for muscles to be activated and coordinated more effectively, which results in quicker and more accurate motions. As a result, muscles contract with the proper force and timing to maximize speed without wasting energy. Second, better agility allows for faster reflexes and direction changes. This is a direct consequence of improved proprioceptive. Proprioceptive athletes can anticipate and adjust to unforeseen circumstances more skillfully, which leads to faster and more fluid movements. Therefore, proprioception training can help athletes improve their stability and balance, which lowers their risk of falling and keeps them moving quickly. Despite not receiving specialized proprioception instruction, the control group showed improvement for several reasons. Participating in a study that involves speed-related tasks can serve as training in and of itself, promoting neuromuscular adaptations and honing movement patterns. It's possible that the individuals unconsciously concentrated on their posture and motion throughout the tests, which resulted in unintentional gains in proprioception and, as a result, speed. Additionally, by strengthening muscles and enhancing joint stability, general strength and conditioning programs—which are frequently a part of athletic training can indirectly enhance proprioception. Finally, the control group's success might have also been influenced by the learning effect, which occurs when people naturally get better at a task just by practicing. The study found that a 6-month proprioception training program significantly improved the speed of young football players, with the experimental group showing larger improvements in sprint times, suggesting its incorporation into training regimens can enhance athletic performance. The findings could be relevant to all sports. The program is tailored to specific contexts, analyzing local training environments, equipment availability, and injury patterns. The approach includes individualized load adjustments based on biomechanical assessments from motion capture, ensuring training sessions are tailored to each player's needs, potentially maximizing effectiveness and mitigating injury risk. The research could contribute to evidence-based training protocols to maximize speed capabilities, to scientific knowledge and benefit the future athletic potential of these young players, potentially leading to improved player performance.

Conclusions

The study explores the impact of a six-month proprioception training program on sprint speed in 17-year-old football players in North Macedonia. Sprint speed is crucial for success in football, and proprioception plays a vital role in coordinating movement and maintaining balance. Results show that the training significantly improves sprint times, with the experimental group showing more improvement. primarily in 15m, 30m, and 60m. Thus, the present findings indicate a positive influence of proprioceptive exercises in routine football training on performance and suggest including proprioceptive training in the long-term youth football education.

Impact of the study

The study examined the impact of a 6-month proprioception training program on young football players' speed. Although it showed significant improvements, the practical significance of the difference is debatable. The study suggests that factors like natural maturation and regular training may contribute to these improvements. Future research should explore long-term effects and specific speed components.

Limitations

The study has limitations: the sample size was relatively small and that would affect the generalization of the results to the population. The increase in sprint speed was only small and even in the control group significant, so that superiority of intervention was not quite clear. The study examined only young footballers which limits the generalizability of the results to other sports and age groups. Moreover, it should be emphasized that not only was long-term persistence of the effects of training not analyzed, but also there were no attempts to disassemble performances into its suitable elements, such as acceleration or agility, which could provide a more detailed insight into the operation of the mechanisms through which proprioception training may enhance athletic activity.

Acknowledgements

We would like to appreciate the students who participated in this study, the trainers which applied these specific exercises training programs and their assistance in data collection and the Sports University of Tirana Biomechanics laboratory staff support for the statistical analysis and the data interpretation.

Funding Statement

This research was unfunded. No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors declare no conflict of interest.

References

Al Hazmy, A., Subadi, I., Andriati, A., Indriani, D., Setianing, R., Saputra Perdana, S., & Ferdianto, R. (2025). The effect of adding Proprioceptive Neuromuscular Facilitation (PNF) training on quadriceps and hamstrings muscle strength in cerebral palsy athletes. *Retos*, *63*, 317–325. https://doi.org/10.47197/retos.v63.110094

Aman, J. E., Elangovan, N., Yeh, I. L., & Konczak, J. (2015). The effectiveness of proprioceptive training for improving motor function: a systematic review. Frontiers in human neuroscience, 8, 1075. https://doi.org/10.3389/fnhum.2014.01075

Apriantono, T.., Hasan, M. F., Ramania, N. S., Syafriani, R.., Kusnaedi, K., Sunadi , D., Bahri, S., Juniarsyah, A. D., Latief, G. R. G.., Elhaque, Q. M., Festiawan, RR. & Pambudi, Y. T. (2024). Soccer training load research mapping and trends: a bibliometric analysis. *Retos*, *60*, 990–1001. https://doi.org/10.47197/retos.v60.108324

Behm, D. G., Young, J. D., Whitten, J. H. D., Reid, J. C., Quigley, P. J., Low, J., Li, Y., Lima, C. D., Hodgson, D. D., Chaouachi, A., Prieske, O., & Granacher, U. (2017). Effectiveness of Traditional Strength vs. Power Training on Muscle Strength, Power and Speed with Youth: A Systematic Review and Meta-Analysis. Frontiers in physiology, 8, 423. https://doi.org/10.3389/fphys.2017.00423

Bendo A., & Haxholli K. (2017). The Improvement of Equilibrium Through Yoga Exercises. *Sport Mont*, *15* (1), 7–11. http://www.sportmont.ucg.ac.me/?sekcija=article&artid=1358

Bendo Aida & Brovina Fisnik. (2024). A statisical model using multiple regression analysis to predict equilibrium and sway index. Journal of Physical Education and Sport, 24(6), Art 164, 1446- 1456. DOI:10.7752/jpes.2024.06164

Bendo Aida, Skënderi Dhimitraq, Veveçka Afërdita. (2014). Effect of vision and orientation in human balance. Journal of Multidisciplinary Engineering Science and Technology, 1(5), 336-341.

Brown, K. A., Patel, D. R., & Darmawan, D. (2017). Participation in sports in relation to adolescent growth and development. Translational pediatrics, *6*(3), 150–159. https://doi.org/10.21037/tp.2017.04.03

Castillo, D., Raya-González, J., Sarmento, H., Clemente, F. M., & Yanci, J. (2021). Effects of including endurance and speed sessions within small-sided soccer games periodization on physical fitness. Biology of sport, 38(2), 291–299. https://doi.org/10.5114/biolsport.2021.99325

de Pablo, M., Torres, C., Ulloa Díaz, D., & Fabrica, G. (2024). Analysis of the impact of different intensities and time periods on the physical and technical performance of professional soccer players. *Retos*, *60*, 1016–1024. https://doi.org/10.47197/retos.v60.106937

Dean J. C. (2013). Proprioceptive feedback and preferred patterns of human movement. *Exercise and sport sciences reviews, 41*(1), 36–43. https://doi.org/10.1097/JES.0b013e3182724bb0

Drust, B., & Green, M. (2013). Science and football: evaluating the influence of science on performance. Journal of sports sciences, 31(13), 1377–1382. https://doi.org/10.1080/02640414.2013.828544

Eraslan, M., Gürkan, A. C., Aydın, S., Şahin, M., Çelik, S., Söyler, M., Altuğ, T., & Mülhim, M. A. (2025). The Effect of Proprioceptive Training on Technical Soccer Skills in Youth Professional Soccer. Medicina, 61(2), 252. https://doi.org/10.3390/medicina61020252

Han, J., Waddington, G., Adams, R., Anson, J., & Liu, Y. (2016). Assessing proprioception: A critical review of methods. Journal of sport and health science, 5(1), 80–90. https://doi.org/10.1016/j.jshs.2014.10.004

Hasan, B., Hazeem, Q. M. ., & Al-Sarray, F. A. A. (2024). The effect of basic strength training on developing some physical variables in football for beginners. *Retos*, *61*, 1596–1600. https://doi.org/10.47197/retos.v61.109666

Hermosilla Palma, F. A., Loro-Ferrer, J. F., Merino-Muñoz, P., Gómez-Álvarez, N., Cerda-Kohler, H., Portes-Junior, M., & Aedo-Muñoz, E. (2024). Prediction of physical performance in young soccer players through anthropometric characteristics, body composition, and somatic maturation states. *Retos*, *61*, 1199–1206. https://doi.org/10.47197/retos.v61.110400

Hrysomallis C. (2011). Balance ability and athletic performance. Sports medicine (Auckland, N.Z.), 41(3), 221–232. https://doi.org/10.2165/11538560-000000000-00000

Kurniawan, R., Akbar, A., Elvika, R. R., Taslim, F., Yasmin, M., Aviani, Y. I., Armaita, A., & Nurmina, N. (2024). Personality and athletic performance: A study of Indonesian U-17 football players. *Retos*, *60*, 370–376. https://doi.org/10.47197/retos.v60.108827

Lee U-Yeong., & Joo Chang-Hwa. (2024). The effects of proprioceptive exercise training on physical fitness and performance of soccer skills in young soccer players. Journal of Exercise Rehabilitation, 20(1), 34-41. DOI: https://doi.org/10.12965/jer.2346628.314

Leetun, D. T., Ireland, M. L., Willson, J. D., Ballantyne, B. T., & Davis, I. M. (2004). Core stability measures as risk factors for lower extremity injury in athletes. Medicine and science in sports and exercise, 36(6), 926–934. https://doi.org/10.1249/01.mss.0000128145.75199.c3

Little, T., & Williams, A. G. (2005). Specificity of acceleration, maximum speed, and agility in professional soccer players. Journal of strength and conditioning research, 19(1), 76–78. https://doi.org/10.1519/14253.1

Lloyd, R. S., Oliver, J. L., Faigenbaum, A. D., Howard, R., De Ste Croix, M. B., Williams, C. A., Best, T. M., Alvar, B. A., Micheli, L. J., Thomas, D. P., Hatfield, D. L., Cronin, J. B., & Myer, G. D. (2015). Long-term athletic development, part 2: barriers to success and potential solutions. Journal of Strength and Conditioning Research, 29(5), 1451–1464. https://doi.org/10.1519/01.JSC.0000465424.75389.56

Maciel, O., Martins, R., Nakamura, F. Y., Figueiredo, P., Afonso, J., & Baptista, I. (2024). The Effect of Speed Endurance Versus Core Training on The Repeated Sprint Ability of Youth Male Soccer Players - A Randomized Controlled Trial. Journal of s Sports Science & Medicine, 23(4), 907–915. https://doi.org/10.52082/jssm.2024.907

Mohammed Hammood, Y., Hussein Rashid, A., Adham Ali, O., & Ali, O. (2025). The effect of a proposed training method using play exercises to develop specific agility and skill performance in football. *Retos*, *63*, 719–728. https://doi.org/10.47197/retos.v63.111095

Proske, U., & Gandevia, S. C. (2012). The Proprioceptive Senses: Their Roles in Signaling Body Shape, Body Position and Movement, and Muscle Force. Physiological Reviews, 92 (4), 1651–1697. https://doi.org/10.1152/physrev.00048.2011

Riva, D., Bianchi, R., Rocca, F., & Mamo, C. (2016). Proprioceptive Training and Injury Prevention in a Professional Men's Basketball Team: A Six-Year Prospective Study. Journal of Strength and Conditioning research, 30(2), 461–475. https://doi.org/10.1519/JSC.0000000000001097

Rodríguez Cayetano, A., Neila Simón, D., & Pérez Muñoz, S. (2024). Effect of conditional training on female soccer players: an analysis through three training modalities. *Retos*, *60*, 383–392. https://doi.org/10.47197/retos.v60.107775

Saputra, M., Naza Putra, A., & Sepriadi, S. (2025). Optimizing long passing: a study on the relationship between waist flexibility in soccer players. *Retos*, *64*, 629–636. https://doi.org/10.47197/retos.v64.110914

Swamynathan, S.., Salini, B.., Udaichi, K.., Yoga Lakshmi, P.., Kalmykova, Y., Lobo, JJ... & Setiawan, E. (2025). The role of football video games in boosting cognitive abilities is critical to football performance. *Retos*, *62*, 802–806. https://doi.org/10.47197/retos.v62.109761

Virto, N., Río, X.., Muñoz-Pérez, I., Méndez-Zorrilla, A.., & García-Zapirain, B. (2024). Gait speed in older adults: exploring the impact of functional, physical and social factors. *Retos*, *61*, 552–566. https://doi.org/10.47197/retos.v61.109902

Yılmaz, O., Soylu, Y., Erkmen, N., Kaplan, T., & Batalik, L. (2024). Effects of proprioceptive training on sports performance: a systematic review. BMC sports science, medicine & rehabilitation, 16(1), 149. https://doi.org/10.1186/s13102-024-00936-z

Young, w., Rayner, R., Talpey, S. (2021). It's Time to Change Direction on Agility Research: A Call to Action. Sports Medicine – Open, 7(12), 1-5. https://doi.org/10.1186/s40798-021-00304-y

Yunus, M., & Aditya, R. S. (2024). Talent search and standardization of fitness data in football clubs: a systematic review. *Retos*, *60*, 1382–1389. https://doi.org/10.47197/retos.v60.107767

Zwolski, C., Quatman-Yates, C., & Paterno, M. V. (2017). Resistance Training in Youth: Laying the Foundation for Injury Prevention and Physical Literacy. Sports health, 9(5), 436–443. https://doi.org/10.1177/1941738117704153

Authors' and translators' details:

Dritan Adili	dritana2712@hotmail.com	Author
Aida Bendo	abendo@ust.edu.al	Author
Aurela Kodra	aurelakodra31@gmail.com	Translator