Non-dominant foot training enhances technical skills in under-13 Palestinian football players: a randomized controlled trial

El entrenamiento del pie no dominante mejora las habilidades en futbolistas palestinos menores de 13 años: un ensayo controlado aleatorizado

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Abstract

Introduction and Objective. Structured training from the dominant foot continues to be a poorly exploited strategy in youth football, despite its potential to reduce functional asymmetries and improve bilateral competence. The ability to perform technical skills with both feet is fundamental for a more versatile and balanced performance. The objective of this study was to evaluate the effects of a specific non-dominant foot training program on technical skills in Palestinian football players under 13 years old. Methodology. A randomized controlled study was carried out with 30 players (average age = 10.47 ± 0.97 years), randomly assigned to an experimental group (n = 15) or a control group (n = 15). The experimental group completed 16 sessions spread over eight weeks, centered on countries, zigzag races and shots with the dominant foot. The control group continued with conventional bilateral training. Pre and post intervention evaluations included the Loughborough Soccer Passing Test (reliability: r = .89), zigzag regate time and shot accuracy tests. Results. The experimental group showed significant improvements in all variables evaluated: pase accuracy (from 4.20 ± 1.37 to 6.40 ± 1.12; t(14) = −7.06, p < .001), regatta time (from 16.80 ± 1.97 s to 12.13 ± 2.19 s; t(14) = 10.78, p < .001) and precision in the shot. On the contrary, the control group did not present statistically significant improvements (p > .05). Comparisons between post-intervention groups confirmed significant differences in favor of the experimental group (p < .001). Conclusions. This study provides solid empirical evidence that supports the systematic inclusion of dominant foot training in youth football training programs. The benefits observed in specific skills suggest that this intervention can contribute to the balanced technical development of young players. It is recommended to carry out in-depth longitudinal investigations to evaluate the sustainable effects of bilateral training on competitive performance and injury prevention.

Keywords

Bilateral motor training; football skill acquisition; motor asymmetry; randomized controlled trial; youth athletes.

Resumen

Introducción y objetivo. El entrenamiento estructurado con el pie dominante sigue siendo una estrategia poco explotada en el fútbol juvenil, a pesar de su potencial para reducir las asimetrías funcionales y mejorar la competencia bilateral. La capacidad de realizar habilidades técnicas con ambos pies es fundamental para un rendimiento más versátil y equilibrado. El objetivo de este estudio fue evaluar los efectos de un programa específico de entrenamiento con el pie no dominante en las habilidades técnicas de futbolistas palestinos menores de 13 años. Metodología. Se realizó un estudio controlado aleatorizado con 30 jugadores (edad promedio = 10,47 ± 0,97 años), asignados aleatoriamente a un grupo experimental (n = 15) o a un grupo control (n = 15). El grupo experimental completó 16 sesiones repartidas en ocho semanas, centradas en países, carreras en zigzag y remates con el pie dominante. El grupo control continuó con el entrenamiento bilateral convencional. Las evaluaciones pre y post intervención incluyeron el Loughborough Soccer Passing Test (fiabilidad: r = .89), el tiempo de rescate en zigzag y las pruebas de precisión de remate. Resultados. El grupo experimental mostró mejoras significativas en todas las variables evaluadas: precisión de pase (de 4,20 ± 1,37 a 6,40 ± 1,12; t(14) = −7,06, p < ,001), tiempo de regata (de 16,80 ± 1,97 s a 12,13 ± 2,19 s; t(14) = 10,78, p < ,001) y precisión en el disparo. Por el contrario, el grupo control no presentó mejoras estadísticamente significativas (p > ,05). Las comparaciones entre los grupos postintervención confirmaron diferencias significativas a favor del grupo experimental (p < ,001). Conclusiones. Este estudio proporciona evidencia empírica sólida que apoya la inclusión sistemática del entrenamiento dominante en los programas de entrenamiento de fútbol base. Los beneficios observados en habilidades específicas sugieren que esta intervención puede contribuir al desarrollo técnico equilibrado de los jugadores jóvenes. Se recomienda realizar investigaciones longitudinales en profundidad para evaluar los efectos sostenibles del entrenamiento bilateral sobre el rendimiento competitivo y la prevención de lesiones.

Palabras clave

Entrenamiento motor bilateral; adquisición de habilidades en fútbol; asimetría motora; ensayo controlado aleatorizado; deportistas juveniles.

Introduction

Football is a complex, multidimensional sport that demands the integration of technical, tactical, physiological, and psychological competencies for successful performance (Seo & Lee, 2018). Among these, technical skill acquisition is widely recognized as a critical predictor of player development and long-term performance success, particularly in youth athletes (Križaj, 2020). Foundational motor competencies acquired in early developmental windows shape an athlete's future capabilities and adaptability. This is particularly salient during the preadolescent stage, specifically between ages 9 and 13, which corresponds to a neurodevelopmental sensitive period marked by increased cortical plasticity and capacity for motor learning (Lloyd & Oliver, 2012; Ford et al., 2011).

Within this framework, a pressing issue is the marked asymmetry in skill execution between the dominant and non-dominant lower limbs. Core football actions including dribbling, passing, and shooting are predominantly executed using the dominant foot, resulting in the systematic underdevelopment of the non-dominant side (Silva et al., 2022; Selcuk et al., 2019). This technical imbalance compromises bilateral coordination, reduces tactical versatility, and may elevate injury susceptibility due to biomechanical inefficiencies (Cè et al., 2018). In contrast, athletes with more balanced bilateral skills display greater adaptability, unpredictability, and role flexibility in gameplay.

Recent studies have highlighted the potential of targeted non-dominant foot training to mitigate these asymmetries. Hammami et al. (2024) demonstrated that structured bilateral skill drills significantly enhance limb-specific control, dynamic stability, and proprioceptive acuity. Similarly, Silva et al. (2022) reported notable gains in passing and shooting proficiency following an 8-week non-dominant limb training protocol. However, bilateral interventions remain underemphasized in mainstream coaching practice, particularly in settings where coach education and curriculum design lag behind empirical best practices.

The need for structured bilateral training is especially acute in under-resourced contexts. Palestine, for example, faces unique infrastructural and institutional challenges in sports development. According to a 2022 report by the Palestinian Ministry of Youth and Sports, over 70% of football academies operate without licensed coaching staff, and fewer than 35% of municipal districts possess regulation-size football fields. A UNESCO (2022) assessment of youth sports infrastructure in the West Bank similarly noted significant disparities in access to training equipment and organized programs. These constraints not only limit general athletic development but also render the implementation of evidence-based training programs logistically challenging.

In parallel, much of the literature on non-dominant foot development originates from elite European academies with access to advanced sports science resources. Trecroci et al. (2019), while influential, focus on high-performance populations and do not explore regional disparities in training implementation. Thus, there is an urgent need to empirically evaluate whether short-term, low-resource bilateral training models can be effective in regions such as Palestine, where systematic development opportunities are constrained.

From a theoretical perspective, bilateral skill development is supported by several motor learning frameworks. Schmidt's Schema Theory and the dynamic systems approach posit that increased variability in practice including the use of the non-dominant foot enhances motor generalizability and movement adaptability (Schmidt et al., 2019). Furthermore, neural cross-education literature suggests that training one limb can induce neuroplastic adaptations in the contralateral limb via interhemispheric transfer (Carroll et al., 2006). These findings reinforce the potential of bilateral training to facilitate both intra-limb and inter-limb learning processes.

Nevertheless, contradictory findings in the literature suggest that bilateral skill transfer may be task-dependent and influenced by pre-existing asymmetries. Teixeira et al. (2021) found that in some cases, intensive unilateral training did not elicit performance improvements in the non-trained limb, especially when baseline asymmetry was substantial. This suggests a possible threshold effect, wherein bilateral interventions are most effective when initiated early and applied consistently. The current study aims to test this proposition in a developmentally sensitive cohort.

The present research addresses these gaps by evaluating the efficacy of an eight-week, coach-delivered, non-dominant foot training intervention for under-13 male football players in Palestine. The intervention was designed with practical constraints in mind: sessions were 45 minutes long, conducted twice weekly, and required minimal equipment. Performance was assessed through standardized motor skill tests focusing on passing accuracy, shooting accuracy, ball control (juggling), dribbling speed, and distance passing with the non-dominant foot.

We hypothesize that players in the experimental group will exhibit performance gains of at least 25% across all non-dominant foot skill domains relative to the control group. We also expect large effect sizes, particularly in coordination-intensive tasks such as dribbling and shooting. These predictions are based on previous evidence of rapid motor adaptation in similarly aged athletes when exposed to structured bilateral practice (Silva et al., 2022; Hammami et al., 2024).

In addition to empirical validation, this study provides a model for designing developmentally informed, context-sensitive training programs that are feasible in low-resource environments. The results have direct implications for youth coaching strategies, national sport policy, and global efforts to democratize access to effective athlete development systems.

In conclusion, this study investigates whether a short-duration, ecologically valid training intervention can enhance non-dominant foot performance in youth football players operating in a systemically underdeveloped context. By integrating motor learning theory, regional specificity, and robust methodological design, it seeks to generate actionable insights for improving bilateral skill acquisition in global football development.

Theoretical Foundations of Laterality in Youth Football

Football demands precise and adaptable motor skills performed under constant spatial and temporal pressure. At the core of effective technical execution is limb laterality the consistent preference for one limb, typically the dominant foot, in executing key skills such as passing, dribbling, shooting, and tackling (Lipecki, 2017). Without structured training, this preference becomes entrenched, reinforcing functional asymmetries that limit players' technical versatility and tactical adaptability.

Individual offensive skills, such as cutting, crossing, or finishing from different angles, often require proficiency with both feet to reduce predictability and exploit spatial advantages. Similarly, defensive actions such as blocking, positioning, and recovering from duels are enhanced by balanced motor control and bilateral foot use. Studies in Retos have shown that training both feet, especially through small-sided and task-specific formats, enhances overall individual technique and motor performance (Sánchez, Molinero, & Yagüe, 2012).

From a motor learning perspective, Schema Theory (Schmidt et al., 2019) and Gentile's Stages of Motor Learning (Gentile, 1972) both support the notion that variable and deliberate practice particularly involving the non-dominant foot facilitates inter-limb transfer and fosters the development of more adaptable and generalized motor programs. This principle is supported by evidence from unbalanced small-sided games, which improve decision-making and cognitive-motor coupling by forcing players to adapt under pressure (Sousa et al., 2021). The ecological dynamics framework further emphasizes the importance of representative learning design, where technical and perceptual cues emerge in realistic, game-like conditions.

Moreover, research has shown that players with greater bilateral proficiency exhibit higher tactical fluency and decision-making accuracy, particularly in dynamic, high-pressure match situations (Sousa et al., 2021). This reinforces the importance of laterality-focused training in developing players who can perform fluidly across multiple positions and tactical roles.

Developmentally, the ages of 9–13 represent a sensitive period of heightened neuroplasticity, especially for motor coordination and inter-limb control (Lloyd & Oliver, 2012; Pietsch & Jansen, 2018). During this window, the central nervous system is particularly receptive to structured skill interventions. When non-dominant foot training is introduced during this stage, it can yield long-lasting improvements in bilateral technical execution.

Taken together, these theoretical and empirical foundations support the design and implementation of structured non-dominant foot interventions in youth football. By embedding such training within representative, context-rich environments, coaches can reduce performance asymmetries, improve individual technique, and promote well-rounded skill development.

Empirical Foundations of Non-Dominant Foot Training

Skill Enhancement through Structured Protocols

Gür (2008) implemented a structured 10-week intervention targeting non-dominant foot utilization and reported statistically significant improvements in shooting accuracy and dribbling performance among youth aged 12–14 and 16–18. These findings highlight the efficacy of targeted bilateral training in fostering technical skill development. Lipecki (2017) further corroborated these outcomes, demonstrating that a six-month regimen of bilateral footwork training resulted in a 4.3% reduction in inter-limb asymmetry, thereby emphasizing the potential of such protocols to counteract entrenched patterns of motor dominance.

In addition, (Cè et al., 2018) reported positive transfer effects from non-dominant to dominant limb performance, lending support to the dynamic systems theory, which posits that enhanced adaptability and coordination arise when motor redundancy is deliberately challenged through varied practice.

Cognitive-Motor Coupling and Coordination Gains

The benefits of non-dominant foot training are not confined to physical performance alone. Pietsch and Jansen (2018) observed significant gains in mental rotation ability among adolescent football players following structured non-dominant limb training, suggesting that bilateral motor engagement may facilitate cognitive-perceptual integration. Similarly, Bigoni et al. (2017) investigated postural control in youth athletes and found no significant differences between dominant and non-dominant limbs. However, they emphasized that gross motor coordination served as a key mediating variable, reinforcing the need for comprehensive training approaches that integrate bilateral limb coordination, balance, and perceptual-motor synchrony.

Complex Skill Systems and Environmental Design

Effective laterality interventions yield greater impact when embedded within comprehensive motor learning systems. Seo and Lee (2018) demonstrated that an eight-week multi-component training program significantly improved both dominant and non-dominant limb performance in agility and sprinting tasks. Complementarily, Ardiansyah et al. (2024) reported similar outcomes using a SABC framework (Speed, Agility, Balance, Coordination), reinforcing the value of integrative approaches. Hintermann et al. (2021) found that manipulating environmental constraints such as adopting a 4v4 game format led to increased technical actions and elevated non-dominant foot usage. These findings highlight that motor skill development is highly sensitive to task design, and that ecologically valid modifications can implicitly promote bilateral engagement, especially when grounded in principles of non-linear pedagogy.

Contextual Gaps and Regional Representation

Despite a growing body of literature, research on non-dominant foot training remains scarce in under-resourced and non-Western contexts. A systematic search of Scopus and Web of Science (2000–2024) yielded no peer-reviewed studies focused specifically on bilateral interventions among Middle Eastern youth footballers. This evidences a critical knowledge gap. Reports by the Palestinian Ministry of Youth and Sports (2022) and UNESCO (2022) confirm systemic limitations in Palestine, including restricted access to structured facilities, certified coaches, and sport-specific pedagogical frameworks. Youth athletes frequently train in suboptimal environments, where individualized instruction is minimal. These challenges underline the necessity for low-cost, adaptable, and context-sensitive interventions, designed to operate effectively within infrastructural and financial constraints.

Methodological Foundations and Advances

Earlier studies frequently failed to account for biological maturation, a factor known to influence coordination, strength, and task responsiveness. The present study improves upon this by employing Peak Height Velocity (PHV) calculations to estimate biological maturity (Moore et al., 2015). Regarding

measurement tools, the Loughborough Soccer Passing Test (LSPT) was selected for its domain specificity and validated psychometric properties. The test exhibits high test–retest reliability (r = .89) and strong construct validity in youth football populations (Ali et al., 2007). The incorporation of ecologically valid, football-specific assessments rather than generic lab-based metrics further enhances the applicability of the current findings. This responds to critiques by Hintermann et al. (2021), who advocated for match-realistic evaluation tools.

Longitudinal Impact and Retention

Much of the existing literature is constrained to short-term intervention windows (typically 6–12 weeks), limiting insight into the durability of bilateral gains. Teixeira et al. (2021) found that multi-sport interventions involving non-dominant foot usage yielded long-term improvements in injury resilience and reduced overuse of the dominant limb. However, the field continues to lack longitudinal studies assessing retention and transfer effects, such as sustained performance in match metrics (e.g., pass completion, assist rates). Addressing this represents a key direction for advancing the evidence base.

Gender, Age, and Equity Considerations

Demographic diversity is underrepresented in the literature. Most studies focus exclusively on male participants within academy systems. Sociocultural factors and economic disparities often limit female participation or access to structured training (UNESCO, 2022). Moreover, low-income regions face barriers such as limited infrastructure, equipment scarcity, and a lack of qualified personnel UNESCO (2022). Future research should prioritize inclusivity by expanding to different genders, regions, and ability levels. Contextual adaptability should also be a guiding design principle.

Synthesis and Implications for Practice

In synthesis, five key insights emerge:

1. Structured non-dominant foot training improves both task-specific and general motor performance.
2. Interventions are most effective during ages 9–13 due to neurodevelopmental receptivity.
3. Integrating bilateral training into broader motor tasks amplifies outcomes.
4. Low-cost, scalable models are critical for equitable global application.
5. Methodological rigor, ecological validity, and demographic inclusivity remain essential for future research.

Justification for the Present Study Practice

This study makes several contributions to the literature and practice:

- Addresses a documented regional research gap by examining laterality training in Palestinian youth football.
- Tests the feasibility of a coach-delivered, low-cost protocol, suitable for implementation in resource-constrained environments.
- Employs validated and age-appropriate measurement tools, alongside maturation controls.
- Demonstrates statistically significant gains across five core football performance domains.

In alignment with international priorities for inclusive, evidence-based sport development, this study offers a practical, scalable model for bilateral training, rooted in both scientific rigor and contextual realism.

Method

This study employed a randomized controlled trial (RCT) with a pretest–posttest control group design to evaluate the efficacy of a structured, non-dominant foot training intervention for under-13 male football players. This design is considered appropriate for assessing the causal impact of specific training regimens on performance metrics while minimizing internal validity threats.

Participants

The final sample consisted of 30 male football players (M age = 10.47 ± 0.51 years) recruited from the Brotherhood Football Academy and Tubas Sports Club in Palestine. All participants had at least two years of organized football experience and no lower-limb injuries in the previous six months.

A priori power analysis using G*Power 3.1 (α = .05, power = 0.80, effect size d = 0.80) indicated that a minimum of 26 participants would be required to detect a large effect in a two-group comparison. Therefore, a sample size of 30 was deemed sufficient to ensure statistical power while accounting for possible attrition.

While the sample size is modest, it reflects common constraints in field-based research with school-aged athletes, including limited population access, parental consent requirements, and logistical coordination with training facilities. These factors are particularly pronounced in under-resourced or conflict-affected regions such as Palestine.

Despite these limitations, the design ensured internal validity through randomization, baseline equivalence checks, and standardized protocols. Moreover, small sample sizes are not uncommon in youth football intervention studies particularly when the goal is to evaluate controlled, skill-specific programs (Sánchez, Molinero, & Yagüe, 2012).

To estimate biological maturation and ensure baseline equivalence, anthropometric measures were collected, and maturity offset was computed using the Peak Height Velocity (PHV) equation (Moore et al., 2015). The offset between PHV and chronological age served as a proxy for maturity status. However, the PHV equation has not been validated in Middle Eastern populations, which may limit generalizability.

The current study provides initial empirical evidence on non-dominant foot training effectiveness and serves as a foundation for larger-scale replication studies with broader samples in future research.

Procedure

Participants were randomly assigned to either the experimental group (n = 15) or control group (n = 15) using a computer-generated sequence with simple randomization. Allocation was managed by an independent researcher not involved in testing or intervention delivery.

Instrument

- Five football-specific motor skill assessments were used, each validated in prior literature:
- Passing Accuracy Test: Adapted from Ali et al. (2007), this test involved five non-dominant foot passes to a 60 × 60 cm target from 10 meters. Scoring ranged from 0–10 points.
- Distance Passing Test: Players completed three maximal-effort non-dominant passes; the farthest distance was recorded (Ben Kahla et al., 2022).
- Ball Juggling Test: Players juggled within a 3-meter circle using only their non-dominant foot; total consecutive touches were recorded.
- Shooting Accuracy Test: Players aimed for one of five marked zones in a standard goal, earning 1 point per accurate shot (Arslan et al., 2020).
- Zigzag Dribbling Test: Adapted from the Loughborough Soccer Passing Test (LSPT), players dribbled through a four-cone course (1.5 m spacing), with time recorded to the nearest 0.01 s.

A pilot test on 10 age-matched players confirmed test-retest reliability over a 5-day interval. Intraclass correlation coefficients (ICC) were as follows: Passing (ICC = 0.89), Distance Passing (ICC = 0.91), Ball Juggling (ICC = 0.93), Shooting (ICC = 0.82), Dribbling (ICC = 0.87)

Equipment Specifications

- Stopwatch: Casio HS-80TW-1EF (±0.01 s)
- Height scale: SECA 213 portable stadiometer (±0.1 cm)
- Digital scale: Omron HBF-514C (±0.1 kg).

Intervention and Control Protocols

Experimental Group The experimental group received a structured intervention over 8 weeks (2 sessions/week, 45 min/session). Each session included:

Table 1. Structure and Intensity Progression of the 8-Week Non-Dominant Foot Training Protocol for the Experimental Group

Week	Component	Drill Example	Duration	Intensity Cue
1–2	Familiarization	Stationary non-dominant passing	15 min	RPE 5/10
3–4	Skill Consolidation	Zigzag dribbling, target shooting	25 min	RPE 6–7/10
5–6	Variability Training	Random cone passing, under pressure	30 min	RPE 7/10
7–8	Game Simulation	3v3 small-sided non-dominant only	30 min	RPE 8/10

All drills were coach-supervised with immediate feedback. Progression between levels was based on skill mastery, operationalized as achieving ≥8/10 successful passes or hits in three consecutive trials.

Control Group The control group followed regular academy routines over the same 8-week period, with 3 weekly sessions (60 minutes/session). Each session included approximately 20 minutes of dominant-foot technical drills, 15 minutes of possession-based games, and 10 minutes of open scrimmage. Coaching personnel were consistent throughout the intervention.

Data analysis

Statistical analyses were conducted using SPSS version 26. The following procedures were applied:

- Descriptive statistics (M, SD, skewness) for baseline equivalence
- Shapiro-Wilk test for normality and Levene's test for homogeneity of variance
- ICC for test–retest reliability
- Paired-sample t-tests for within-group pre–post comparisons
- Independent-sample t-tests for between-group comparisons
- Cohen's d effect sizes interpreted as small (≥0.2), medium (≥0.5), and large (≥0.8), following Cohen (1988)
- Significance threshold was set at α = .05.

Results

Overview

This section presents the statistical outcomes of an eight-week controlled training intervention aimed at enhancing non-dominant foot performance among under-13 male football players. The findings are organized by descriptive and inferential statistics corresponding to five primary skill variables: passing accuracy, passing distance, ball control (juggling), shooting accuracy, and zigzag dribbling time. All analyses were conducted using SPSS version 26 with a significance threshold of α = .05.

Descriptive Statistics and Assumption Testing

Table 1 summarizes anthropometric data for the total sample (N = 30). Skewness values for all variables were within the ±2 threshold suggested by Kim (2013), supporting normality assumptions. Shapiro-

Wilk tests confirmed normality for all skill metrics ($p > .05$), and Levene's test confirmed homogeneity of variances for between-group comparisons ($p > .05$).

Table 2. Baseline anthropometric characteristics (N = 30)

Variables	Measurement Unit	Minimum value	Maximum value	Arithmetic average	Standard deviation	Twist
Age	Year	9	12	10.47	0.97	0.140-
Height	Meter	1.30	1.55	1.42	0.06	0.392
Body mass	Kg	29	55	40.80	7.52	0.075-
Growth rate	Year	1.23	3.61	2.52	0.63	0.031-

Test-Retest Reliability

All motor skill tests demonstrated acceptable test-retest reliability over a 5-day interval, with ICCs exceeding 0.75 (Table 3).

Table 3. Test–retest reliability of football skill tests (n = 10)

Variables	Measurement Unit	First test		Second test		Stability
		Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation	
Passing	Number of points earned	3.9	1.59	4.0	1.24	0.894*
Passing the Ball for the Furthest Distance with the Weak Foot	Meter	11.0	2.05	11.1	2.07	0.936*
Ball Dribbling	Number	7.4	2.36	7.6	2.36	0.944*
Shooting at the Goal	Degree	1.6	1.17	1.8	1.13	0.767*
Zigzag Running with the Ball	Second	11.1	1.66	11.2	1.75	0.755*

Within-Group Comparisons

Control Group (n = 15)

Table 3 and Figure 1 show minimal changes in the control group. Only zigzag dribbling improved significantly:

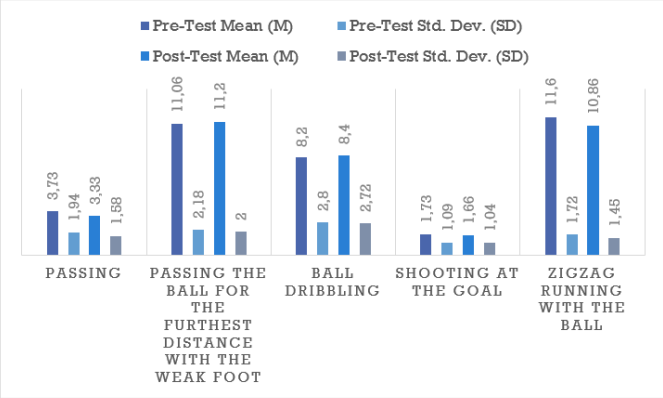
- Zigzag dribble: M = 11.60 s (SD = 1.72) → M = 10.86 s (SD = 1.45), $t(14) = 2.58$, $p = .022$, $d = 0.67$, 95% CI [0.18, 1.15] Other skills did not show statistically significant pre-post differences..

Table 4. Paired t-test for control group pre-post differences (n = 15)

Variables	Measurement Unit	Pre-Test Mean M	Pre-Test Std. Dev. SD	Post-Test Mean M	Post-Test Std. Dev. SD	t-Value	Significance Level
Passing	Number of points earned	3.73	1.94	3.33	1.58	1.146	0.271
Passing the Ball for the Furthest Distance with the Weak Foot	Meter	11.06	2.18	11.2	2	-0.397	0.698
Ball Dribbling	Number	8.2	2.8	8.4	2.72	-0.676	0.51
Shooting at the Goal	Mark	1.73	1.09	1.66	1.04	0.235	0.818
Zigzag Running with the Ball	Second	11.6	1.72	10.86	1.45	2.582	0.022*

*Significance Level $p \leq 0.05$, M Mean, SD Standard Deviation.

Figure 1. Means and Standard Deviations of Some Basic Skills Between Pre-Test and Post-Test Measurements for Control Group Members n=15.



Fuente: Authors

Experimental Group (n = 15)

Table 4 and Figure 2 show statistically significant improvements in all measured skills for the experimental group.

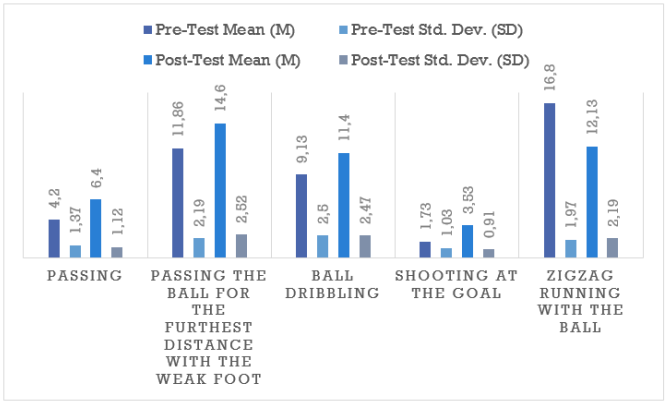
- Passing accuracy: t (14) = −7.06, p < .001, d = 1.82, 95% CI [1.26, 2.38]
- Passing distance: t (14) = −7.36, p < .001, d = 1.90, 95% CI [1.32, 2.48]
- Ball control: t (14) = −7.55, p < .001, d = 1.95, 95% CI [1.36, 2.54]
- Shooting accuracy: t (14) = −6.87, p < .001, d = 1.77, 95% CI [1.20, 2.33]
- Zigzag dribble: t (14) = 10.78, p < .001, d = 2.78, 95% CI [1.96, 3.60]

Table 5. Paired t-test for experimental group pre-post differences (n = 15)

Variables	Measurement Unit	Pre-Test Mean M	Pre-Test Std. Dev. SD	Post-Test Mean M	Post-Test Std. Dev. SD	t-Value	Significance Level
Passing	Number of points earned	4.2	1.37	6.4	1.12	-7.059	.000*
Passing the Ball for the Furthest Distance with the Weak Foot	Meter	11.86	2.19	14.6	2.52	-7.364	.000*
Ball Dribbling	Number	9.13	2.5	11.4	2.47	-7.549	.000*
Shooting at the Goal	Degree	1.73	1.03	3.53	0.91	-6.874	.000*
Zigzag Running with the Ball	Second	16.8	1.97	12.13	2.19	10.783	.000*

*Significance Level 0.05≥p, M Mean, SD Standard Deviation.

Figure 2. Means and Standard Deviations of Basic Skills Between Pre-Test and Post-Test Measurements for Experimental Group Members n=15.



Fuente: Authors

Between-Group Post-Test Comparisons

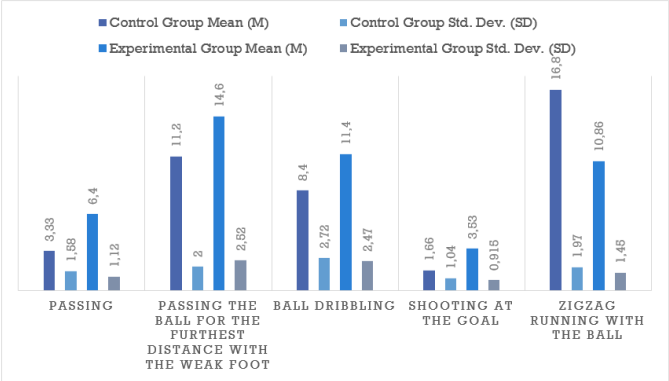
Independent samples t-tests (Table 5, Figure 3) revealed statistically significant post-test differences between the experimental and control groups across all measured football skills, consistently favoring the experimental group. These findings provide strong evidence for the efficacy of the targeted training intervention. In the case of zigzag dribbling, where lower completion times reflect superior agility and control, the experimental group demonstrated significantly faster performance, further reinforcing the program's impact on functional motor coordination and non-dominant foot proficiency.

Table 6. Independent t-test for post-test group differences (N = 30)

Variables	Measurement Unit	Post-Test Mean M Control Group	Post-Test Std. Dev. SD Control Group	Post-Test Mean M Experimental Group	Post-Test Std. Dev. SD Experimental Group	t-Value	Significance Level
Passing	Number of points earned	3.33	1.58	6.4	1.12	-6.108	.000*
Passing the Ball for the Furthest Distance with the Weak Foot	Meter	11.2	2	14.6	2.52	-4.078	.000*
Ball Dribbling	Number	8.4	2.72	11.4	2.47	-3.161	.004*
Shooting at the Goal	Degree	1.66	1.04	3.53	0.915	-5.199	.000*
Zigzag Running with the Ball	Second	10.86	1.45	12.13	2.19	9.374	.000*

*Significance Level 0.05≥p, M Mean, SD Standard Deviation.

Figure 3. Means and Standard Deviations of Some Basic Football Skills in the Post-Test Measurement Between Control and Experimental Groups N=30.



Summary of Findings

Overall, the experimental group demonstrated statistically significant post-test improvements across all five performance metrics compared to the control group. These findings were supported by large effect sizes (d > 1.7), confirming that the intervention induced measurable and meaningful improvements in non-dominant foot performance.

Discussion

This study demonstrated that an eight-week structured training program targeting non-dominant foot use led to statistically significant improvements in all assessed motor skills among under-13 male football players. The experimental group exhibited greater gains in passing accuracy, distance passing, ball

control (juggling), shooting accuracy, and zigzag dribbling time when compared to the control group. These findings support the study's hypothesis that systematically structured bilateral training can improve underutilized motor functions in youth athletes.

The observed improvements align with principles from deliberate practice theory, which emphasizes goal-directed, structured repetition as a key to motor learning (Ericsson, 2019). The intervention's frequency, progression, and task specificity likely enhanced neuromuscular coordination and bilateral motor engrams through targeted sensorimotor engagement. Moreover, the results may reflect the underlying neurodevelopmental plasticity characteristic of the 9–13 age group, a period during which bilateral integration and inter-limb transfer are especially responsive to training (Teixeira et al., 2021).

The large effect sizes, particularly in shooting and dribbling skills, suggest that the motor learning mechanisms activated through bilateral repetition extended beyond mechanical execution to include proprioceptive tuning and cognitive-motor integration. These gains underscore the importance of structured, age-appropriate non-dominant limb activation during sensitive periods of neuromuscular development.

The findings corroborate earlier research by Başkaya (2023), Alficandra (2022), and Ben Kahla et al. (2022), all of whom reported performance improvements following bilateral lower-limb training. This study extends their conclusions by demonstrating similar gains in a constrained-resource context. In contrast to Dwyer (2024), who observed modest outcomes over a shorter intervention span, our findings imply that higher-frequency and longer-duration protocols yield more pronounced improvements. Trecroci et al. (2019) also noted duration as a key moderator in bilateral training outcomes, providing further empirical resonance.

The ecological validity of this study is heightened by its implementation in a setting with limited access to elite coaching and infrastructure. As highlighted by UNESCO (2022), such contexts often lack targeted developmental models, and this study provides initial empirical support for adapting structured motor training to underserved environments.

These findings suggest that bilateral training should be considered a core component of youth football development, particularly during preadolescence. While traditional coaching often emphasizes dominant-limb skills, our results support a shift toward integrated limb usage in skill acquisition frameworks. Embedding bilateral drills into early-stage curricula may enhance coordination symmetry and overall technical versatility.

For practice, the intervention provides a potential template for grassroots programs. Although formal economic evaluation was not conducted, the use of minimal equipment and standard coaching supervision suggests the protocol may be cost-effective in principle. Such an approach could inform low-resource youth coaching frameworks, especially in contexts with constrained facilities or staffing.

However, scalability of the model requires further feasibility analysis. Factors such as coach training consistency, program fidelity.

Several limitations must be acknowledged. First, the sample size (N = 30) was relatively small, limiting statistical power and generalizability. Second, all participants were male and drawn from two clubs in one region, constraining the demographic and geographic scope. Third, although PHV estimation was used for maturity offset, direct physiological measures (e.g., Tanner staging) were not employed, which may limit developmental precision. Fourth, the study only assessed short-term outcomes; no follow-up evaluation was conducted to determine retention or decay of skill improvements. Lastly, potential confounding factors such as baseline skill variability, coaching styles, and training intensity were not fully controlled.

Future research should aim to:

1. Conduct longitudinal studies assessing retention of motor gains and their transfer to competitive match scenarios.
2. Compare cost-effectiveness and logistical feasibility of bilateral versus unilateral training models in resource-limited environments.

3. Investigate outcomes in female players and across diverse regional training contexts to improve demographic inclusivity.
4. Incorporate biomechanical and neuromuscular metrics (e.g., EMG, motion capture) to delineate underlying physiological mechanisms.
5. Explore the impact of coach training and intervention fidelity on program effectiveness.

Conclusions

This study found that an eight-week structured training intervention significantly improved non-dominant foot performance in under-13 male football players across five technical domains: passing accuracy, distance passing, ball control, shooting accuracy, and zigzag dribbling time (pre- to post-test *p* < .001, Cohen's *d* = 1.77–2.78). These results support the hypothesis that targeted bilateral training can lead to measurable improvements in motor proficiency during early adolescence, a period of heightened neuroplasticity.

Methodologically, the randomized controlled design within a community-based setting advances ecological validity for motor skill interventions outside elite academies. However, generalizability is constrained by the study's small, male-only sample (N = 30) from two clubs in a single geographic region, as well as the absence of longitudinal or match-performance data. While the intervention required minimal equipment and standard coaching oversight suggesting feasibility in similar resource-limited contexts broader implementation would require validation across diverse populations and environments.

The findings may inform youth coaching practices by highlighting the value of progressive, task-specific non-dominant foot drills to reduce skill asymmetry. For instance, the experimental group's post-test passing accuracy (M = 6.40 vs. control M = 3.33, *d* = 1.97) and dribbling time (Δ = 4.67s, *d* = 2.78) underscore the potential for structured bilateral training to augment technical versatility.

Future research should prioritize:

1. Longitudinal tracking to assess skill retention and translation to competitive match performance.
2. Sex-comparative trials to evaluate applicability beyond male athletes.
3. Cost-benefit analyses of implementing such programs in varied socioeconomic contexts.
4. Biomechanical investigations into neuromuscular adaptations underlying observed improvements.

In summary, this study provides evidence that time-efficient, equipment-minimal bilateral training can reduce technical asymmetries in youth footballers. While promising, scalability and long-term efficacy remain unconfirmed, necessitating replication across larger, demographically diverse cohorts.

Recommendations

1. Practical Application for Coaches

Coaches working with male under-13 athletes in resource-limited environments (e.g., non-Western rural academies, low-budget Palestinian clubs) may consider integrating 20–30 minute non-dominant foot drills into thrice-weekly training sessions. The intervention demonstrated significant bilateral skill improvements (Cohen's *d* = 1.77–2.78) using only cones, standard balls, and timed circuits, suggesting feasibility in comparable settings.

2. Replication in Understudied Populations

Trials replicating this protocol in female cohorts and non-Western contexts (e.g., Sub-Saharan Africa, Southeast Asia) should employ culturally adapted drills that account for local training norms and equipment access. For example, substituting formal agility poles with repurposed materials (e.g., water bottles) may maintain efficacy while addressing infrastructural constraints.

3. Scalability and Fidelity Monitoring

Scalability trials in grassroots systems should incorporate fidelity checklists (e.g., coach adherence to prescribed drill duration/ratios) and cost-tracking for personnel, equipment, and facility usage. Such data would clarify economic feasibility for clubs with budgets under $2,000 annually before broader deployment.

4. Long-Term Skill Retention and Performance Translation

Future studies should prioritize longitudinal tracking (≥6 months post-intervention) to assess retention of motor gains and evaluate skill transfer to competitive match metrics (e.g., weak-foot pass completion rates, dribble success in 1v1 scenarios) using positional tracking systems where feasible.

5. Cultural and Institutional Adaptation Research

Investigate how sociocultural factors (e.g., training frequency, coach-athlete ratios) influence program efficacy. For instance, compare outcomes in academies with 2 vs. 5 weekly training sessions or adapt drills for regions where football is primarily played on uneven terrain.

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