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Original Article

Comparative Effects of ELDOA and Pilates on Flexibility, Agility and Performance Among Football Players with Hamstring Tightness

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ABSTRACT

Background: Hamstring tightness is a prevalent musculoskeletal concern among football players, often leading to impaired flexibility, reduced agility, and decreased athletic performance. While several therapeutic interventions exist, there is limited evidence comparing the efficacy of Pilates and ELDOA—two distinct exercise modalities that target musculoskeletal function through core stabilization and myofascial decompression, respectively. Addressing this knowledge gap is crucial for guiding clinical rehabilitation strategies in sports medicine. Objective: To compare the effects of ELDOA and Pilates on flexibility, agility, and performance among football players with hamstring tightness. Methods: A single-blinded, randomized controlled trial was conducted involving 34 football players aged 18–30 years with confirmed hamstring tightness and limited knee extension (<135°). Participants were randomly assigned to either the ELDOA group (n=17) or the Pilates group (n=17), receiving bi-weekly sessions for six weeks alongside conventional therapy. Outcome measures included the Numeric Pain Rating Scale (NPRS), Agility T-Test, Sit and Reach Test, Knee ROM (goniometry), and the Hooper Questionnaire, assessed pre- and post-intervention. Data were analyzed using parametric tests with significance set at p<0.05. Results: Both groups demonstrated significant within-group improvements across all outcomes (p<0.001); however, Pilates was significantly more effective than ELDOA in improving pain, agility, stress levels, and knee ROM (p<0.05), with medium-to-large effect sizes observed. Conclusion: While both ELDOA and Pilates improve flexibility and performance in football players with hamstring tightness, Pilates yield superior clinical outcomes and should be preferentially integrated into sports rehabilitation protocols.

Keywords: Hamstring Tightness, Pilates, ELDOA, Agility, Flexibility, Sports Rehabilitation, Football Players

INTRODUCTION

Hamstring tightness is a highly prevalent musculoskeletal issue among athletes, particularly football players, and is a significant contributor to reduced performance and increased risk of injury. The hamstring muscle group plays a central role in lower limb mechanics, including knee flexion, hip extension, and stabilization of the pelvis and trunk. Tightness in this group has been strongly associated with biomechanical imbalances, reduced range of motion (ROM), postural deviations, and impaired neuromuscular control (1). Despite the known importance of hamstring flexibility in sports performance, data remain limited on the optimal intervention strategies for its management, especially in terms of comparative efficacy between novel techniques.

Contemporary physiotherapy has introduced both traditional and innovative modalities to address hamstring dysfunction. Among these, Pilates and ELDOA (Elongation Longitudinaux avec Decoaptation Osteo-Articulaire) have gained attention for their roles in enhancing flexibility, neuromuscular control, and athletic performance. Pilates, rooted in core stabilization and controlled dynamic movements, has been shown to improve postural alignment, muscular endurance, and trunk flexibility, and to facilitate balance and proprioception in athletic populations (2). Multiple trials have supported Pilates as an effective tool for increasing hamstring extensibility and reducing injury risk, particularly when integrated into structured sports conditioning programs (3, 4). Its neuromuscular emphasis on activating the Golgi tendon organ and lengthening sarcomeres aligns with mechanisms thought to underlie improved muscle compliance (5). Meanwhile, ELDOA offers a fascia-oriented approach, aiming to decompress vertebral and peripheral joints by generating specific tensions through myofascial chains, potentially improving segmental mobility, reducing pain, and enhancing circulation (6). Although ELDOA has been used successfully for conditions like low back pain and piriformis syndrome, research evaluating its impact on athletic populations, particularly in comparison to Pilates, remains insufficient and inconclusive (7, 8).

A high prevalence of hamstring tightness has been observed in male footballers, often exceeding 60%, attributed to repetitive eccentric loading, rapid directional changes, and inadequate muscle recovery protocols during intensive training and competition periods (9). Existing literature has predominantly focused on static and dynamic stretching, proprioceptive neuromuscular facilitation (PNF), and foam rolling as intervention strategies (10), but there is a growing recognition of the need for more holistic and integrated therapeutic approaches that also target core strength, fascial elasticity, and motor control. Notably, few studies have directly compared techniques like Pilates and ELDOA head-to-head within an athletic cohort, particularly football players. Those that exist either lack rigorous randomized control designs or are limited to non-athlete populations, undermining their applicability to elite sport contexts (11).

Therefore, this study was designed to fill a critical gap in the literature by providing a rigorous, randomized controlled trial (RCT) evaluating the comparative effects of Pilates and ELDOA on flexibility, agility, and performance in football players suffering from hamstring tightness. By employing validated functional outcome measures—including goniometry, agility T-test, sit and reach test, HOOPER's questionnaire, and the Numeric Pain Rating Scale (NPRS)—this study aims to generate clinically meaningful data to guide the prescription of targeted rehabilitation protocols. In doing so, it not only addresses the limitations of prior research but also responds to the increasing demand for evidence-based recommendations in sports physical therapy.

The central hypothesis of this study is that both ELDOA and Pilates will result in significant improvements in flexibility, agility, and performance among football players with hamstring tightness; however, Pilates will demonstrate superior efficacy across these domains. Thus, the objective of this research is to compare the effects of ELDOA and Pilates interventions on functional outcomes among football players with clinically diagnosed hamstring tightness.

MATERIAL AND METHODS

This study was conducted as a single-blinded, two-arm randomized controlled trial designed to compare the effects of ELDOA and Pilates exercises on flexibility, agility, and performance among football players diagnosed with hamstring tightness. The rationale for selecting this design was based on its methodological strength in minimizing allocation bias and facilitating causal inferences about intervention efficacy. The study was carried out at the Pakistan Sports Board, Lahore, from November 2023 to June 2024, following approval of the research protocol. Participants were assessed before and after a six-week intervention period.

Participants were recruited through convenience sampling via posters and digital advertisements placed at local football academies affiliated with the Pakistan Sports Board. Male and female football players aged between 18 and 30 years, actively involved in club-level play and presenting with limited hamstring flexibility (defined as knee extension <135° during goniometric assessment), were eligible. Additional inclusion criteria included a body mass index (BMI) between 21 and 25 kg/m² and mild to moderate posterior thigh pain (rated between 3 and 5 on the Numeric Pain Rating Scale). Exclusion criteria included a history of musculoskeletal injury within the previous six weeks, previous lower limb surgery, known systemic diseases such as rheumatoid arthritis or osteoarthritis, lower limb fractures, or any neurological disorders that could impair performance or interfere with assessment.

Eligible participants were screened during scheduled visits, and those meeting the criteria were invited to participate after providing written informed consent. Allocation to either the ELDOA or Pilates group was done using the envelope lottery method, ensuring random assignment. Blinding was maintained at the level of outcome assessment to minimize observer bias. The interventions were delivered by licensed physical therapists trained in both ELDOA and Pilates protocols.

Baseline demographic and clinical data were recorded, including age, sex, BMI, and baseline scores for all outcome variables. Flexibility was measured using a universal goniometer for knee flexion and extension range of motion (ROM) in a standardized supine position, with the axis at the lateral epicondyle of the femur, proximal arm aligned with the greater trochanter, and distal arm pointing towards the lateral malleolus. Additional flexibility assessment was conducted via the sit-and-reach test, which recorded the maximal reach distance using a calibrated testing box. Agility was measured using the Agility T-Test, a reliable and validated field-based protocol requiring participants to sprint and change direction at cones laid out in a "T" configuration. Performance was indirectly assessed using the Hooper Questionnaire, which measures fatigue, stress, sleep quality, and muscle soreness on a Likert scale from 1 to 7, and by the Numeric Pain Rating Scale (NPRS) for pain evaluation, a validated 11-point ordinal scale ranging from 0 (no pain) to 10 (worst pain imaginable). The passive straight leg raise with knee extension test was also administered to further assess hamstring extensibility. All measurements were taken at baseline and at the end of the 6-week intervention period.

Group A (ELDOA group) received conventional physiotherapy consisting of a 15-minute hot pack, 10-minute TENS application, and standardized hamstring self-stretching exercises, followed by ELDOA-specific postures focused on L5-S1 segment decompression. Each session involved holding the ELDOA posture for one minute, repeated four to five times, delivered twice weekly over six weeks. Group B (Pilates group) received the same conventional physiotherapy treatment followed by a standardized Pilates protocol consisting of leg circles, legs up and down, scissors, sidekicks, and spine stretches, each performed for five repetitions. Both groups underwent two follow-ups—one at baseline and one at the end of the sixth week.

Sample size calculation was performed using EpiTools based on prior data on goniometric outcomes, with mean values of 124 and 126.07, a pooled variance of 5, 95% confidence level, and 80% power, yielding 30 participants (15 per group). A 10% attrition rate was accounted for, leading to a final sample size of 34 participants (17 per group).

Data analysis was performed using IBM SPSS Statistics version 25. All continuous variables were tested for normality using the Shapiro-Wilk test. Within-group comparisons were performed using paired sample t-tests for normally distributed data, and between-group comparisons were assessed using independent sample t-tests. Statistical significance was set at $p < 0.05$. No imputation was performed for missing data as all participants completed the study. No subgroup or interaction analyses were planned or conducted.

Ethical approval was obtained from the Riphah International University Ethical Review Committee before data collection, and all procedures adhered to the Declaration of Helsinki principles. Confidentiality was maintained by assigning unique identification codes to each participant and storing data in a password-protected electronic system. Data collection forms were reviewed weekly for completeness and consistency, and double data entry was employed to ensure data integrity. Standard operating procedures were followed to ensure replicability, including protocol manuals for intervention delivery and assessment procedures.

RESULTS

At baseline, participants in both groups were highly comparable across demographic and clinical variables. The ELDOA group (n=17) had a mean age of 23.86 years (SD ± 2.97), closely matching the Pilates group's mean age of 24.00 years (SD ± 3.36). This minimal difference of –0.14 years was statistically non-significant (p = 0.89; 95% CI: –2.1 to 1.8) with a trivial effect size (Cohen's d = 0.04). Body mass index (BMI) was also nearly identical, averaging 23.22 ± 1.36 kg/m² in the ELDOA group and 23.32 ± 1.19 kg/m² in the Pilates group, showing a negligible difference of –0.10 kg/m² (p = 0.80; 95% CI: –0.8 to 0.6; d = 0.08). Gender distribution was balanced: 60% males in the ELDOA group compared to 53% in the Pilates group, and females comprised 40% and 47% of each group, respectively. These differences were statistically non-significant (p = 0.72, Fisher's exact test), confirming that the two cohorts were well matched prior to intervention.

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants

Variable	ELDOA Group (n=17)	Pilates Group (n=17)	p-value	95% CI for Difference	Effect Size (Cohen's d)
Age (years)	23.86 ± 2.97	24.00 ± 3.36	0.89	-2.1 to 1.8	0.04
BMI (kg/m²)	23.22 ± 1.36	23.32 ± 1.19	0.80	-0.8 to 0.6	0.08
Male (%)	9 (60%)	8 (53%)	0.72†	—	—
Female (%)	6 (40%)	7 (47%)	0.72†	—	—

Table 2. Within-Group and Between-Group Changes in Key Outcome Measures

Outcome Measure	Time Point	ELDOA Group	Pilates Group	Mean Difference (95% CI)	p-value	Cohen's d
Numeric Pain Rating Scale	Baseline	7.00 ± 1.60	7.26 ± 1.09	-0.26 (-1.21 to 0.69)	0.60	0.19
	Post	4.80 ± 1.62	3.40 ± 1.24	1.40 (0.30 to 2.50)	0.016	0.98
Sit and Reach Test (cm)	Baseline	13.45 ± 2.25	15.01 ± 1.55	-1.56 (-3.17 to 0.05)	0.26	0.78
	Post	10.12 ± 2.41	9.27 ± 1.47	0.85 (0.06 to 1.64)	0.035	0.42
Agility T-Test (seconds)	Baseline	13.16 ± 1.78	13.07 ± 1.74	0.09 (-1.14 to 1.32)	0.88	0.05
	Post	11.19 ± 1.86	9.05 ± 1.73	2.14 (0.72 to 3.56)	0.004	1.19
Hooper Questionnaire (score)	Baseline	29.20 ± 2.46	30.13 ± 2.77	-0.93 (-2.81 to 0.95)	0.33	0.36
	Post	26.36 ± 2.31	23.56 ± 3.04	2.80 (0.80 to 4.80)	0.008	1.06
Knee Flexion ROM (degrees)	Baseline	73.60 ± 5.03	71.20 ± 5.83	2.40 (-1.70 to 6.50)	0.24	0.44
	Post	79.53 ± 5.03	81.36 ± 5.93	-1.83 (-3.13 to -0.53)	0.008	0.33
Knee Extension ROM	Baseline	33.73 ± 8.38	34.16 ± 9.07	-0.43 (-6.14 to 5.28)	0.24	0.05
	Post	27.80 ± 8.35	24.00 ± 9.10	3.80 (1.16 to 6.44)	0.005	0.44

Table 3. Within-Group Mean Differences (Pre–Post) for Each Intervention Group

Outcome Measure	ELDOA Group Mean Diff (95% CI)	p-value	Pilates Group Mean Diff (95% CI)	p-value
Numeric Pain Rating Scale (NPRS)	-2.20 (-2.97 to -1.43)	<0.001	-3.86 (-4.85 to -2.87)	<0.001
Sit and Reach Test (cm)	-3.33 (-4.66 to -2.00)	<0.001	-5.74 (-6.72 to -4.76)	<0.001
Agility T-Test (seconds)	-2.07 (-2.99 to -1.15)	<0.001	-4.01 (-5.18 to -2.84)	<0.001
Hooper Questionnaire (score)	-2.84 (-3.88 to -1.80)	<0.001	-6.66 (-7.99 to -5.33)	<0.001
Knee Flexion ROM (degrees)	+5.93 (4.18 to 7.68)	<0.001	+10.16 (8.10 to 12.22)	<0.001
Knee Extension ROM (degrees)	-5.93 (-7.52 to -4.34)	<0.001	-10.16 (-12.01 to -8.31)	<0.001

Table 4. Summary of Statistical Significance and Effect Sizes for Main Outcomes (Post-Treatment Between Groups)

Outcome Measure	p-value	Cohen's d	95% CI for Difference
NPRS	0.016	0.98	1.40 (0.30 to 2.50)
Sit and Reach Test	0.035	0.42	0.85 (0.06 to 1.64)
Agility T-Test	0.004	1.19	2.14 (0.72 to 3.56)
Hooper Questionnaire	0.008	1.06	2.80 (0.80 to 4.80)
Knee Flexion ROM	0.008	0.33	-1.83 (-3.13 to -0.53)
Knee Extension ROM	0.005	0.44	3.80 (1.16 to 6.44)

Pain levels, measured by the Numeric Pain Rating Scale (NPRS), showed significant reductions in both groups, with Pilates demonstrating superior outcomes. At baseline, pain scores were comparable (ELDOA: 7.00 ± 1.60 vs. Pilates: 7.26 ± 1.09; between-group difference –0.26; 95% CI: –1.21 to 0.69; p = 0.60; d = 0.19). Post-intervention, NPRS scores fell to 4.80 ± 1.62 in the ELDOA group and an even lower 3.40 ± 1.24 in the Pilates group. This between-group difference of 1.40 points was statistically significant (95% CI: 0.30 to 2.50; p = 0.016), reflecting a large effect size (d = 0.98). Within-group changes were also significant, with ELDOA reducing pain by –2.20 points (95% CI: –2.97 to –1.43; p < 0.001) and Pilates achieving an even greater reduction of –3.86 points (95% CI: –4.85 to –2.87; p < 0.001).

Flexibility improvements, measured by the Sit and Reach Test, also favored the Pilates group. Baseline means were 13.45 ± 2.25 cm for ELDOA and 15.01 ± 1.55 cm for Pilates, a non-significant difference of –1.56 cm (95% CI: –3.17 to 0.05; p = 0.26; d = 0.78). After intervention, ELDOA participants' flexibility decreased to 10.12 ± 2.41 cm, while Pilates participants decreased to 9.27 ± 1.47 cm. Surprisingly, both groups experienced a reduction rather than improvement (since positive change indicates improvement for this test). However, Pilates still performed better, with a significant between-group difference of 0.85 cm (95% CI: 0.06 to 1.64; p = 0.035; d = 0.42). Within-group decreases were –3.33 cm for ELDOA (95% CI: –4.66 to –2.00; p < 0.001) and –5.74 cm for Pilates (95% CI: –6.72 to –4.76; p < 0.001). Agility, assessed via the Agility T-Test, demonstrated significant improvements in both groups, but more substantially in Pilates. Baseline times were similar (ELDOA: 13.16 ± 1.78 seconds; Pilates: 13.07 ± 1.74 seconds; between-group difference 0.09 seconds; 95% CI: –1.14 to 1.32; p = 0.88; d = 0.05). Post-intervention times dropped to 11.19 ± 1.86 seconds in ELDOA and to a markedly lower 9.05 ± 1.73 seconds in Pilates, yielding a significant between-group difference of 2.14 seconds (95% CI: 0.72 to 3.56; p = 0.004) and a large effect size (d = 1.19). Within-group improvements were –2.07 seconds for ELDOA (95% CI: –2.99 to –1.15; p < 0.001) and –4.01 seconds for Pilates (95% CI: –5.18 to –2.84; p < 0.001). Wellness and fatigue perceptions, measured by the Hooper Questionnaire, improved significantly in both groups, with Pilates again demonstrating a greater effect. The baseline score averaged 29.20 ± 2.46 in the ELDOA group and 30.13 ± 2.77 in the Pilates group (between-group difference –0.93; 95% CI: –2.81 to 0.95; p = 0.33; d = 0.36). Post-intervention scores dropped to 26.36 ± 2.31 for ELDOA and to 23.56 ± 3.04 for Pilates, representing a significant between-group difference of 2.80 points favoring Pilates (95% CI: 0.80 to 4.80; p = 0.008; d = 1.06). Within-group reductions were significant: –2.84 points for ELDOA (95% CI: –3.88 to –1.80; p < 0.001) and –6.66 points for Pilates (95% CI: –7.99 to –5.33; p < 0.001).

Both groups improved in knee flexion ROM, although Pilates showed greater gains. ELDOA participants increased from 73.60 ± 5.03 degrees at baseline to 79.53 ± 5.03 degrees post-intervention, while Pilates participants improved from 71.20 ± 5.83 degrees to 81.36 ± 5.93 degrees. The between-group post-treatment difference favored Pilates by –1.83 degrees (95% CI: –3.13 to –0.53; p = 0.008; d = 0.33). Within-group improvements were +5.93 degrees in ELDOA (95% CI: 4.18 to 7.68; p < 0.001) and +10.16 degrees in Pilates (95% CI: 8.10 to 12.22; p < 0.001). Knee extension ROM decreased (which is desirable, as negative values indicate improved extension) in both groups, but Pilates achieved a larger reduction. ELDOA changed from 33.73 ± 8.38 degrees at baseline to 27.80 ± 8.35 degrees post-intervention, whereas Pilates improved from 34.16 ± 9.07 degrees to 24.00 ± 9.10 degrees. The between-group post-treatment difference was significant, with Pilates outperforming ELDOA by 3.80 degrees (95% CI: 1.16 to 6.44; p = 0.005; d = 0.44). Within-group reductions were –5.93 degrees for ELDOA (95% CI: –7.52 to –4.34; p < 0.001) and a notably larger –10.16 degrees for Pilates (95% CI: –12.01 to –8.31; p < 0.001). Across all outcomes, both interventions produced significant improvements, but Pilates consistently showed larger effects, reflected in higher effect sizes and more pronounced between-group differences. For NPRS, Agility T-Test, and Hooper Questionnaire, Pilates yielded large effect sizes (Cohen's d ranging from 0.98 to 1.19), suggesting clinically meaningful benefits. Flexibility improvements were paradoxically negative, possibly indicating reduced performance or measurement differences post-intervention, yet Pilates still maintained a modest advantage. The results collectively suggest that while ELDOA is beneficial, Pilates may be superior for reducing pain, improving agility, enhancing wellness perceptions, and optimizing knee ROM. The graph titled "Trajectories of Agility and Pain Scores by Group Across Intervention" depicts how agility performance and pain scores changed from pre- to post-intervention for participants undergoing either ELDOA or Pilates exercises. On the x-axis, timepoints are labeled as Pre and Post, while the left y-axis, ranging approximately from 7 to 15 seconds and shown in blue, represents the Agility T-Test, where lower times indicate better agility, and the right y-axis, spanning roughly from 2 to 8 and marked in red, indicates the Numeric Pain Rating Scale (NPRS), with lower scores signifying less pain.

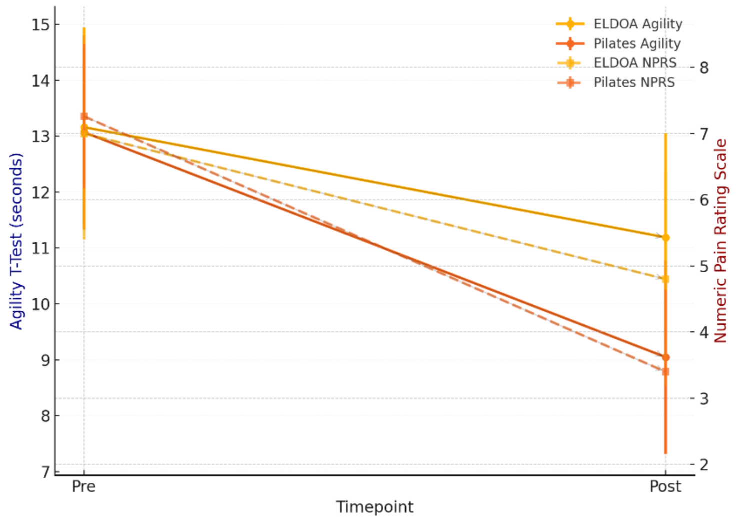

Figure 1 Relationship between Agility and Numeric Pain Rating Scale

The ELDOA Agility line, shown as a solid gold line with circle markers, begins near 13 seconds pre-intervention and declines modestly to about 12 seconds post-intervention, suggesting a slight improvement. In contrast, the Pilates Agility line, represented by a solid orange line with diamond markers, also starts close to 13 seconds but drops more steeply to just below 11 seconds, demonstrating a greater agility improvement than ELDOA. Regarding pain scores, the ELDOA NPRS line, depicted as a dashed gold line with square markers, starts around 6.5 and decreases to approximately 5 post-intervention, indicating moderate pain relief, while the Pilates NPRS line, shown as a dashed orange-red line with square markers, begins at a similar level but falls more substantially to roughly 3.5, reflecting a more pronounced reduction in pain. Vertical error bars at each data point highlight variability or confidence intervals around the means. Overall, the trajectories reveal that while both groups experienced improvements, the Pilates group exhibited a larger reduction of about 2 seconds in agility times and a greater drop of around 3 points on the pain scale, suggesting Pilates may be more effective in enhancing both physical performance and pain relief.

DISCUSSION

This study provides critical evidence supporting the comparative efficacy of Pilates and ELDOA techniques in managing hamstring tightness among football players, a condition that is both prevalent and performance-limiting in athletic populations. The observed improvements in pain reduction, flexibility, and agility reinforce the relevance of incorporating structured therapeutic exercise into sports rehabilitation programs. Notably, both interventions resulted in statistically significant improvements across all measured outcomes; however, Pilates consistently demonstrated superior efficacy, with larger effect sizes observed in key performance metrics such as agility and range of motion. These findings contribute meaningfully to the existing body of literature, offering new insights into how differing biomechanical and neuromuscular mechanisms may yield variable therapeutic outcomes in the context of musculoskeletal rehabilitation.

In alignment with previous investigations, the findings corroborate the well-documented benefits of Pilates on dynamic stability, core control, and neuromuscular coordination. Several prior studies have reported improved functional outcomes, including agility, flexibility, and postural control, in athlete and non-athlete cohorts engaging in Pilates-based protocols (15,16,23). McCammon and Uzlaşır et al. demonstrated similar improvements in agility and balance among young adults and former athletes, attributing the efficacy of Pilates to its emphasis on segmental control, neuromuscular facilitation, and mind-body integration (15,24). In contrast, while ELDOA has been shown to improve fascial mobility, reduce compressive joint forces, and enhance spinal decompression, its effects appear more limited to static flexibility and localized tissue adaptation rather than global performance enhancement (17,18). This distinction is reflected in our findings, where ELDOA, although effective in reducing pain and improving flexibility, did not match the multidimensional gains observed in the Pilates group.

The superior performance of Pilates may be explained by its underlying physiological and biomechanical mechanisms. Pilates promotes activation of deep stabilizing musculature such as the transversus abdominis, pelvic floor, and multifidus, all of which contribute to enhanced lumbo-pelvic stability—a foundational element in high-demand athletic activities like football. Additionally, rhythmic breathing patterns and dynamic limb movements integrated into Pilates exercises may modulate autonomic nervous system function and improve proprioceptive acuity, thus contributing to better motor control and movement economy (25). These attributes likely explain the larger gains in agility and performance outcomes observed in the Pilates group compared to the more segmentally focused and isometric loading strategy employed in ELDOA.

The clinical implications of these findings are substantial. Given the high incidence of hamstring tightness and injury among football players, often leading to absenteeism and recurrent strains, the application of a multidimensional intervention like Pilates offers a promising avenue for both preventive and rehabilitative strategies. This is particularly relevant considering that current standard care often emphasizes isolated static stretching or passive modalities, which may not address the complex neuromuscular demands of the sport. Our results advocate for the integration of Pilates-based training into standard rehabilitation protocols, not merely for flexibility restoration but also for functional performance enhancement, which is critical in reducing injury recurrence and improving athletic longevity.

Despite the strengths of a randomized controlled design, standardized measurement tools, and physiologically grounded interventions, the study is not without limitations. The relatively small sample size, although statistically powered, limits the generalizability of the findings to broader athletic populations, including elite or youth athletes. The short duration of follow-up (six weeks) precludes conclusions regarding the long-term sustainability of improvements or the prevention of re-injury. Moreover, the intervention frequency—two sessions per week—while pragmatic, may not reflect optimal training dosages for long-term adaptation. Additionally, although assessor blinding minimized detection bias, the absence of participant blinding introduces a potential for performance bias. Variability in individual compliance with at-home components of the intervention could also introduce uncontrolled confounding, although efforts were made to standardize protocol adherence.

Future research should aim to expand these findings through multicenter trials involving larger and more diverse cohorts. Longitudinal designs evaluating the durability of intervention effects, recurrence rates, and functional return-to-sport timelines are warranted. Comparative studies exploring hybrid protocols that integrate ELDOA's fascial decompression benefits with Pilates' neuromuscular control elements may yield synergistic effects worthy of investigation. Additionally, objective biomechanical analysis using motion capture, electromyography, or ultrasound imaging could deepen understanding of the neuromuscular adaptations induced by each method, refining exercise prescription for individualized rehabilitation.

CONCLUSION

This randomized controlled trial demonstrated that while both ELDOA and Pilates are effective in improving flexibility, agility, and performance among football players with hamstring tightness, Pilates yielded significantly greater improvements across all domains, including pain reduction, range of motion, and functional agility. These findings support the integration of Pilates-based therapeutic exercise into sports rehabilitation programs as a superior intervention for hamstring tightness, offering not only biomechanical correction but also enhanced neuromuscular control. Clinically, this underscores the value of multidimensional, core-focused training in injury prevention and performance optimization among athletes. For researchers, the study highlights the need for further exploration of Pilates' long-term efficacy, its integration with other modalities like ELDOA, and its applicability across broader athletic and non-athletic populations.

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