



Effect of integrated training with assistive equipment on eye-foot coordination, agility and Euro Step in U-18 basketball players

Efecto del entrenamiento integrado con equipamiento auxiliar sobre la coordinación óculo-podal, la agilidad y el Euro Step en baloncesto sub-18

Authors

Akram Mustafa Nají¹
Ahmed Aboodee Hussein¹

¹ University of Kufa, Najaf, Iraq

Corresponding author:
Akram Mustafa Nají
Akramm.alkemiawi@student.uokufa.edu.iq
ahmeda.hussein@uokufa.edu.iq

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Abstract

Introduction. Integrated training that couples physical and skill stimuli within the same session is advocated for adolescent team-sport athletes, but transfer to deceptive finishing skills such as the Euro Step has not been examined in a controlled trial.

Objective. To test whether an 8-week integrated programme using assistive equipment (agility ladders, mini-hurdles, cones, hoops) was superior to traditional coach-led practice for developing eye-foot coordination, agility and the Euro Step in male U-18 basketball players.

Methodology. Fourteen sub-elite players (age 15.6 ± 0.8 yr) were randomised 1:1 to an experimental group ($n = 7$; integrated training, 3 sessions/week, 8 weeks) or a volume-matched control ($n = 7$). Eye-foot coordination (Numbered Circles, s), agility (s) and Euro Step skill (0-12 points) were assessed pre- and post-intervention. Independent and paired t-tests with Cohen's d (95% CI) were used.

Results. Pre-test outcomes did not differ between groups (all $p > 0.20$). At post-test, the experimental group significantly outperformed the control on all outcomes: eye-foot coordination ($d = 3.39$, 95% CI [1.76, 5.03]), agility ($d = 8.63$, 95% CI [5.27, 12.00]) and Euro Step ($d = 1.76$, 95% CI [0.53, 3.00]); all $p \leq 0.006$. Relative improvements were 3-4 times larger than control.

Discussion. Findings extend evidence that combined ladder, hurdle and skill-coupled training drives larger adaptation than isolated modalities in youth athletes, and provide the first peer-reviewed evidence of transfer to the Euro Step.

Conclusions. An 8-week integrated programme with assistive equipment produced substantially larger gains than volume-matched traditional practice. Replication in larger multi-club samples is the priority next step.

Keywords

Agility ladder; assistive equipment; eye-foot coordination; integrated training; youth basketball.

Resumen

Introducción. El entrenamiento integrado que combina estímulos físicos y técnicos en la misma sesión se recomienda en deportistas adolescentes, pero su transferencia al Euro Step no se ha examinado en un ensayo controlado.

Objetivo. Comprobar si un programa integrado de 8 semanas con equipamiento auxiliar (escaleras de agilidad, mini-vallas, conos y aros) era superior a la práctica tradicional para desarrollar la coordinación óculo-podal, la agilidad y el Euro Step en baloncesto masculino sub-18.

Metodología. Catorce jugadores sub-élite (edad $15,6 \pm 0,8$ años) fueron aleatorizados 1:1 a un grupo experimental ($n = 7$; entrenamiento integrado, 3 sesiones/semana, 8 semanas) o a un grupo control con volumen equiparado ($n = 7$). Se evaluaron la coordinación óculo-podal (Círculos Numerados, s), la agilidad (s) y el Euro Step (0-12 puntos) pre y post intervención. Se utilizaron pruebas t independientes y emparejadas con la d de Cohen (IC 95%).

Resultados. No hubo diferencias pre-test entre grupos ($p > 0,20$). En el post-test, el grupo experimental superó al control: coordinación óculo-podal ($d = 3,39$; IC 95% [1,76; 5,03]), agilidad ($d = 8,63$; IC 95% [5,27; 12,00]) y Euro Step ($d = 1,76$; IC 95% [0,53; 3,00]); todos $p \leq 0,006$. Las mejoras fueron 3-4 veces mayores que las del control.

Discusión. Los resultados amplían la evidencia de que el trabajo combinado de escalera, vallas y técnica acoplada produce mayor adaptación que las modalidades aisladas, y aportan la primera evidencia revisada de transferencia al Euro Step.

Conclusiones. Un programa de 8 semanas con equipamiento auxiliar produjo mejoras sustancialmente mayores que la práctica tradicional. La prioridad es replicar en muestras multicéntricas mayores.

Palabras clave

Agilidad; baloncesto juvenil; coordinación óculo-podal; entrenamiento integrado; equipamiento auxiliar.

Introduction

Modern basketball is a high-intensity, intermittent court sport in which adolescent players perform a change of activity every 1–3 seconds, alternating short sprints, jumps, lateral shuffles, and rapid decelerations under continuous perceptual demand (Ben Abdelkrim et al., 2007; Stojanović et al., 2019). Because the technical actions of basketball — driving, cutting, finishing, and defending — are executed within this perceptually noisy environment, players must possess not only a high level of change-of-direction (COD) speed, but also the underlying eye–foot coordination that allows them to couple their gaze, body, and feet to evolving game cues (Sheppard & Young, 2006; Paul et al., 2016). For the U-18 age group these qualities are particularly responsive to training: the Youth Physical Development model identifies the 12–16-year window in males as a period of accelerated neural and hormonal adaptation, during which agility, coordination, speed, and skill show heightened sensitivity to systematic training stimuli (Lloyd & Oliver, 2012; Lloyd, Read, et al., 2013; Lloyd, Oliver, Faigenbaum, et al., 2015).

Among the offensive tools of the modern game, the Euro Step — a deceptive lateral two-step finishing action that allows the offensive player to pick up the dribble and rapidly relocate the lower body around a help-side defender — has become a defining feature of contemporary basketball, weaponised by both perimeter and front-court players to evade contact and convert at the rim. Biomechanically the action couples a single-leg deceleration with a same-leg unloading and a contralateral lateral cutting step, and therefore depends critically on lateral ground-reaction-force absorption, eccentric strength of the support limb, and visually guided foot placement, mechanics that have been characterised in lateral cutting and false-step studies in basketball (Golden et al., 2009; Kameda et al., 2019). No peer-reviewed training study, however, has yet examined whether structured integrated training transfers to Euro Step proficiency in adolescent players. This is a notable gap, given that the prerequisites of the move — eye–foot coordination, reactive lateral COD, balance during deceleration, and the technical sweep of the ball — are exactly those qualities that integrated training is designed to develop (Bouteraa et al., 2020; Arede et al., 2019).

Several lines of evidence converge on the value of integrated, multi-modal training for youth basketball. First, isolated agility-ladder training in youth athletes has not consistently transferred to sport-specific agility, dribbling, or skill outcomes; Padrón-Cabo et al. (2020) reported no significant pre-to-post or between-group differences in agility, dribbling speed, or slalom-dribbling performance after six weeks of ladder-only training in youth soccer, whereas combining the ladder with plyometric, hurdle, and cone work has yielded reliable improvements in sprint, COD, and skill outcomes (Padrón-Cabo et al., 2021; Koci & Kotorri, 2025; León-Muñoz et al., 2024). Second, eight-week combined balance-plus-plyometric or strength-plus-plyometric programmes in adolescent basketball players have improved drop-jump height, dynamic balance, and Illinois agility time by 4–7% (Bouteraa et al., 2020; Arede et al., 2019). Third, recent meta-analyses indicate that closed-skill agility in basketball improves with effect sizes in the moderate-to-large range when the training stimulus combines reactive, plyometric, and equipment-based drills (Asadi et al., 2016; Guo et al., 2024; Quintero et al., 2025). Across this literature, an 8-week duration with three weekly sessions — yielding approximately 24 sessions in total — is the dose most consistently associated with positive adaptation in 11- to 17-year-old players (Behm et al., 2017; Ramírez-Campillo et al., 2023). Within the Iberoamerican literature specifically, the journal *Retos* has published convergent evidence on the value of combined coordination, plyometric, and change-of-direction stimuli in youth athletes: Corredor-Serrano et al. (2023) documented the structural association between explosive strength, body composition, and agility in basketball players; Alim et al. (2024) reported the development of validated reactive-agility tools for net-group sports; and Sabillah and Saryono (2023) showed that combined hurdle-and-ladder training, but not either modality alone, transferred to football playing skills in adolescent players.

Despite this body of work, three issues remain unresolved for U-18 male basketball. First, most basketball-specific intervention studies have focused on isolated qualities (e.g., plyometrics-only or strength-only) rather than on a single, integrated programme that simultaneously trains coordination, agility, and a basketball-specific skill within each session. Second, the evidence for the assistive-equipment package most accessible to coaches in low- and middle-resource settings — agility ladders, mini-hurdles, cones, and hoops — has been generated almost entirely in soccer, with limited replication in basketball juniors



(Padrón-Cabo et al., 2020, 2021; Singh, 2021). Third, no published trial has examined whether such a programme transfers to a deceptive finishing skill such as the Euro Step.

The present study therefore aimed to determine, in a pilot randomised controlled trial, the effect of an 8-week integrated training programme using assistive equipment on eye-foot coordination, agility, and Euro Step skill in male U-18 basketball players. It was hypothesised that the experimental group would demonstrate significantly greater improvements than a coach-led traditional control group on all three outcomes, with effect sizes in the large-to-very-large range, consistent with previous combined-stimulus interventions in adolescent basketball.

Method

Trial design, ethics and registration

This study was a single-centre, parallel-group, two-arm pilot randomised controlled trial with pre- and post-intervention assessments. Reporting follows the CONSORT 2025 guideline for randomised trials, with the additional CONSORT extension for pilot and feasibility trials (Hopewell et al., 2025). The trial was conducted between 1 December 2025 and 20 February 2026 at a regional sports hall. The protocol adhered to the Declaration of Helsinki. Written informed assent was obtained from each player and written consent from the parent or legal guardian; the club director also provided institutional consent. Approval was obtained from the institutional Research Ethics Committee of the Faculty of Physical Education and Sports Sciences, University of Kufa. The trial was retrospectively registered in a national clinical-research registry prior to the first submission of this manuscript. The authors acknowledge that prospective registration would have been preferable and have recorded the absence of prospective registration as a methodological limitation (see Section 4.5).

Participants

Seventeen male basketball players from the U-18 squad of a single club were screened. Three players were excluded (two had played fewer than three full training seasons, one had a current lower-limb injury). The remaining 14 players (82.4% of the screened cohort) met the inclusion criteria — male, aged 14–18 years, training age ≥ 3 years, no lower-limb injury in the previous six months, and active enrolment in the club's competitive programme — and were randomised. Sample anthropometric and demographic characteristics are reported in Table 1. Biological maturity status (peak-height-velocity offset) was not formally assessed at baseline; the implications of this omission, given that U-18 male players span an interval of substantial inter-individual maturation, are addressed in Section 4.5.

Table 1. Demographic and anthropometric characteristics of the participants (M \pm SD; n = 14)

Variable	Whole sample (n = 14)	Control (n = 7)	Experimental (n = 7)
Chronological age (yr)	15.64 \pm 0.81	15.57 \pm 0.79	15.71 \pm 0.95
Body height (cm)	178.14 \pm 3.26	177.86 \pm 3.39	178.43 \pm 3.41
Body mass (kg)	65.93 \pm 5.59	66.14 \pm 5.55	65.71 \pm 6.10
Training age (yr)	4.57 \pm 0.82	4.43 \pm 0.79	4.71 \pm 0.95

Note. Data are mean \pm standard deviation. Per-group means are derived from the same SPSS output used for the inferential analyses; raw data are available from the corresponding author upon request.

Sample size justification and pilot-trial framing

An a priori power analysis (G*Power 3.1; two-tailed independent t-test, $\alpha = 0.05$, $1 - \beta = 0.80$) indicated that with n = 7 per group the minimum detectable Cohen's d was approximately 1.59. Given that previously reported effects of combined or equipment-based training in adolescent basketball typically fall in the very-large range (d ≥ 1.0 –1.3; Asadi et al., 2016; Bouteraa et al., 2020; Arede et al., 2019), this constraint was accepted, with the trial explicitly framed as a pilot randomised controlled trial intended (i) to estimate feasibility (recruitment, retention, adherence, signal of effect) for a future fully-powered multi-club study and (ii) to generate exploratory effect-size point estimates rather than to confirm population-level effects. The small single-club sample is acknowledged as the principal methodological limitation and is discussed in Section 4.5.



Randomisation and blinding

The 14 eligible players were randomised 1:1 to the experimental group (integrated training with assistive equipment) or the control group (traditional coach-led training), using a computer-generated random sequence (block size = 4). Allocation was concealed in sequentially numbered opaque envelopes opened at enrolment. Outcome assessors who timed and scored the tests at pre- and post-test were blinded to group allocation. Players and the assistant coach delivering the experimental programme were not blinded due to the nature of the intervention; the potential consequences of this asymmetric blinding — including a possible Hawthorne effect in the experimental group — are addressed in the Discussion (Section 4.5).

Procedures

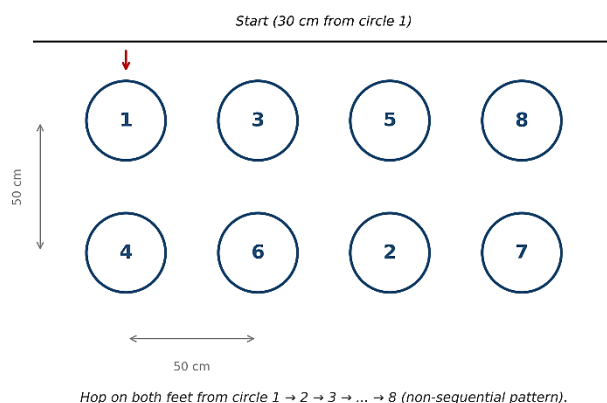
A pilot session was conducted on 5 December 2025 with three non-randomised players from the wider club squad to verify equipment and timing procedures. The pre-test was performed on 7 December 2025 at 18:00 in the team's usual sports hall; the post-test was performed under identical conditions on 17 February 2026. All testing was completed within a single 90-minute session, in the order: standardised warm-up (10 min) — eye-foot coordination test — agility test — Euro Step skill test. Each test was administered three times with two minutes of passive recovery between attempts; the best of three was retained for analysis. Players abstained from heavy training in the 24 hours before each testing session.

Outcome measures

Eye-foot coordination (Numbered Circles test)

Eye-foot coordination was assessed with the Numbered Circles test (Hassanin, 1995). Eight numbered circles (30-cm diameter) were arranged in a 2×4 grid (50-cm spacing) on the gymnasium floor, with the numbers placed in a non-sequential pattern (Figure 1). Standing behind a starting line 30 cm from circle 1, the participant began on the assessor's signal and hopped on both feet from circle 1 through circle 8 in numerical order. The trial was timed to the nearest 0.01 s, from the first foot contact in circle 1 to landing in circle 8. Lower scores indicate better performance. The test is widely used in the Arabic-language sport-science literature; however, it has not been independently validated against an internationally adopted gross-motor-coordination instrument (e.g., the Körperkoordinationstest für Kinder), a constraint listed as a limitation in Section 4.5 and one of the priorities recommended for future replication work.

Figure 1. Top-down schematic of the Numbered Circles eye-foot coordination test (Hassanin, 1995). Numbers are placed in a non-sequential pattern; participants hop on both feet from circle 1 through circle 8.

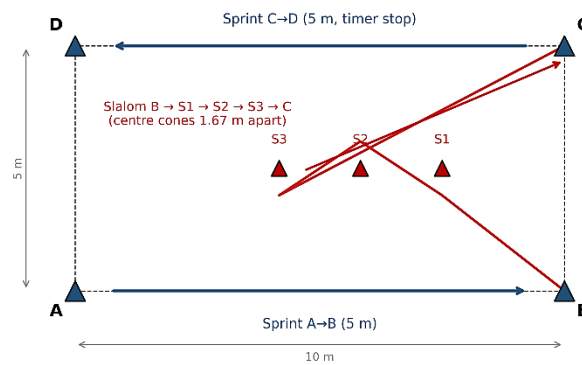


Agility test

Agility was assessed using the basketball agility protocol of Fares Sami and Luay Sami (2016; Figure 2). Four cones were placed at the corners of a 10×5 m rectangle, with three slalom cones positioned 1.67 m apart along the centre line. From cone A, the participant sprinted to cone B (5 m), weaved diagonally

through the three central cones, sprinted to cone C, and returned 5 m to cone D, where the timer was stopped. The total distance covered was approximately 30 m. Time was recorded to the nearest 0.01 s; lower scores indicate better performance. Because this protocol lacks independent international validation, the Modified Agility T-test (Sassi et al., 2009; Stojanović et al., 2019), which has well-established reliability and validity in adolescent basketball, is recommended for parallel use in future replications to allow direct comparison with the wider international literature (see Section 4.5).

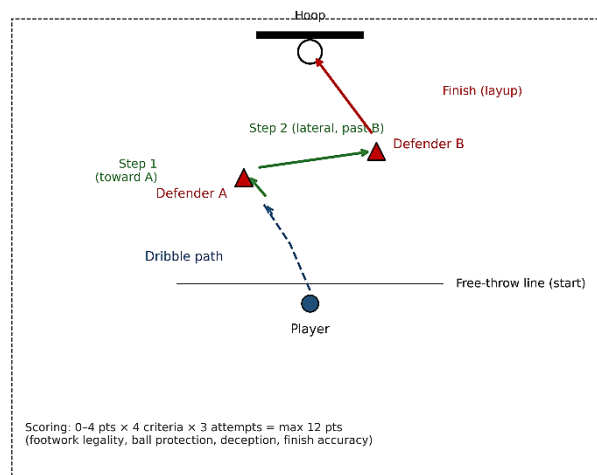
Figure 2. Agility test setup adapted from Fares Sami and Luay Sami (2016). The participant sprints A→B (5 m), slaloms through three central cones (S1, S2 S), sprints to C, and returns to D (5 m).



Euro Step skill test

The Euro Step skill was assessed with the protocol of Nasser (2021; Figure 3). The participant began behind the free-throw line, dribbled toward defender cone A, picked up the dribble between the cones, executed the Euro Step (first step toward A, second step laterally past defender cone B), and finished with a layup. Three attempts were performed; each attempt was scored 0–4 points by two independent qualified raters across four equally weighted criteria — footwork legality, ball protection, deception of the lateral step, and finish accuracy — yielding a maximum score of 12 points. Inter-rater agreement during the pilot session was ICC = 0.91. Higher scores indicate better performance.

Figure 3. Euro Step skill test setup adapted from Nasser (2021). The dashed line shows the dribble path, the green arrows show the lateral two-step Euro Step, and the red arrow shows the finishing layup. Three attempts; maximum score = 12.



Interventions

Experimental group: integrated training with assistive equipment

The experimental group completed an 8-week training programme designed by the research team, delivered three times per week (Sundays, Tuesdays, Thursdays) in 75-minute sessions — a total of 24 sessions. Each session comprised: (i) a standardised 10-minute dynamic warm-up; (ii) a 35-minute integrated block performed at three rotating stations using assistive equipment (agility ladder, mini-hurdles 15–30 cm, cones, and 0.6-m plastic hoops), with each station coupling an equipment-based coordination/agility drill (e.g., Icky Shuffle, Carioca through hoops, lateral hurdle hops, slalom-and-cut) to a basketball-specific skill rehearsal of the Euro Step against cone defenders; (iii) a 20-minute small-sided 3-vs-3 game; and (iv) a 10-minute cool-down. Volume and complexity were progressed weekly: weeks 1–2 emphasised slow-tempo, accuracy-focused drills; weeks 3–4 increased speed and coupled the ball; weeks 5–6 introduced a passive defender; and weeks 7–8 progressed to a semi-active defender with light contact. Total ground contacts ranged from approximately 180 in week 1 to 320 in week 8.

Control group: detailed coach-led training programme (volume-matched)

The control group continued their regular club training programme during the same 8-week period, delivered three times per week on the same days (Sundays, Tuesdays, Thursdays) and in 75-minute sessions, so that total weekly training time and number of sessions were equated with the experimental group. Sessions were supervised by the club's head coach (a national-level qualified basketball coach with > 10 years' experience) and followed a five-block structure: (i) a 10-minute coach-led dynamic warm-up centred on jogging, gait drills (high-knees, butt-kicks, A-skips), submaximal sprints and dynamic stretching; (ii) a 25-minute block of isolated technical drills (stationary and on-the-move dribbling, two-handed and one-handed chest/bounce passing against the wall, set-shot and jump-shot from the elbows and the corner, two-foot and one-foot lay-ups); (iii) a 25-minute full-court 5-vs-5 scrimmage played to coach-officiated rules without any structured ladder, hurdle, hoop, or station-based progression; (iv) a 5-minute block of traditional conditioning (continuous court-length suicide runs, defensive slide drills, and bodyweight calisthenics — push-ups and sit-ups); and (v) a 10-minute cool-down with static stretching of the lower-limb muscle groups. The control programme therefore preserved the same weekly volume ($3 \times 75 \text{ min} = 225 \text{ min}$) and the same broad session architecture as the experimental programme, while differing in the absence of (a) station-based integration of physical and skill stimuli within a single block, (b) explicit weekly progression of equipment-based ground contacts, and (c) the rehearsal of the Euro Step against cone defenders. Estimated total ground contacts in the control sessions ranged from approximately 150 in week 1 to 200 in week 8.

Adherence to the assigned programme was high in both groups: 24 of 24 sessions (100%) were delivered to each group, and median individual attendance was 23/24 sessions (96%) in the experimental group and 23/24 sessions (96%) in the control group, with no player completing fewer than 21 of 24 sessions (88%). No participant withdrew, and no injury or other adverse event was reported during the trial. All 14 randomised participants therefore completed both the pre- and post-test, so the intention-to-treat and per-protocol analyses are identical in this trial.

Statistical analysis

Data were analysed in IBM SPSS Statistics version 27 and verified in R 4.3. Distributional assumptions were assessed with the Shapiro–Wilk test; all outcomes were normally distributed. Pre-test equivalence between groups was tested with independent-samples t-tests. Within-group pre–post change was tested with paired-samples t-tests; between-group differences at post-test were tested with independent-samples t-tests. Effect sizes were reported as Cohen's *d* (1988) using pooled SDs and the small-sample-corrected Hedges' *g* (Lakens, 2013). Approximate 95% confidence intervals for between-group *d* were calculated using the variance formula of Hedges and Olkin. Statistical significance was set at $\alpha = 0.05$ (two-tailed). All *p*-values are reported exactly except where below 0.001. Given the pilot scale of the trial and the three primary outcomes, the analysis is exploratory; we did not apply a formal correction for multiple comparisons but report exact *p*-values, confidence intervals, and standardised effect sizes for each outcome so that readers can apply whichever adjustment they consider appropriate.



Results

Pre-test equivalence

No significant pre-test differences were observed between the control and experimental groups on any outcome (Table 2), confirming successful randomisation and supporting the validity of the post-test contrasts.

Table 2. Pre-test equivalence between groups (independent t-test, df = 12)

Outcome	Unit	Control (n = 7)	Experimental (n = 7)	t	p	Cohen's d (95% CI)
Eye-foot coordination	s	9.395 ± 0.382	9.295 ± 0.220	0.600	0.560	0.32 [-0.74, 1.38]
Agility	s	10.858 ± 0.301	10.664 ± 0.318	1.172	0.264	0.63 [-0.46, 1.71]
Euro Step	points	7.143 ± 1.215	7.429 ± 1.272	-0.430	0.675	-0.23 [-1.28, 0.83]

Note. Negative d for the Euro Step indicates the experimental group scored slightly higher than control at baseline. All p > 0.20.

Within-group changes

Both groups improved significantly on all three outcomes from pre-test to post-test, but the magnitude of change differed substantially. Within-group changes are presented for the control group in Table 3 and for the experimental group in Table 4. Because of the very small per-group sample (n = 7), within-group Cohen's d values exceeding the conventional very-large threshold — and especially the values d > 2.0 observed in the experimental group — should be interpreted as upper-bound estimates of effect: small samples reduce the denominator of d (the pooled SD) and amplify the influence of individual responders, both of which inflate the standardised effect (Lakens, 2013). The between-group post-test estimates with 95% confidence intervals reported in Table 5 are therefore the more conservative inferential anchor for this pilot trial.

Table 3. Within-group pre-post comparison: Control group (paired t-test, n = 7, df = 6)

Outcome	Unit	Pre (M ± SD)	Post (M ± SD)	Δ%	t	p	Cohen's d	Hedges' g
Eye-foot coord.	s	9.395 ± 0.382	9.018 ± 0.314	-4.01	5.936	0.001	1.08	0.93
Agility	s	10.858 ± 0.301	10.331 ± 0.251	-4.86	18.020	<0.001	1.90	1.64
Euro Step	points	7.143 ± 1.215	8.286 ± 1.254	+16.00	4.382	0.005	0.93	0.80

Note. Δ% = relative change from pre to post (sign-corrected so that negative Δ% on time-based outcomes represents improvement).

Table 4. Within-group pre-post comparison: Experimental group (paired t-test, n = 7, df = 6)

Outcome	Unit	Pre (M ± SD)	Post (M ± SD)	Δ%	t	p	Cohen's d	Hedges' g
Eye-foot coord.	s	9.295 ± 0.220	7.874 ± 0.359	-15.29	12.924	<0.001	4.77	4.12
Agility	s	10.664 ± 0.318	8.347 ± 0.207	-21.72	21.772	<0.001	8.64	7.46
Euro Step	points	7.429 ± 1.272	10.714 ± 1.496	+44.21	17.816	<0.001	2.37	2.04

Note. Within-group effect sizes for the experimental group exceeded the conventional very-large threshold (d > 1.30) on all three outcomes. Cohen's d values reaching d > 2 in the experimental group should be interpreted as upper-bound estimates of effect, given the small per-group sample (n = 7); the more conservative between-group estimates with 95% confidence intervals are presented in Table 5.

Between-group post-test comparison

At post-test, the experimental group significantly outperformed the control group on every outcome (Table 5). Effect sizes were large for the Euro Step (d = 1.76) and very large for eye-foot coordination (d = 3.39) and agility (d = 8.63). Confidence intervals were wide — a direct consequence of the small sample — but excluded zero on every outcome.

Table 5. Between-group post-test comparison (independent t-test, df = 12)

Outcome	Unit	Control (M ± SD)	Experimental (M ± SD)	Mean diff.	t	p	Cohen's d (95% CI)
Eye-foot coord.	s	9.018 ± 0.314	7.874 ± 0.359	1.144	6.339	<0.001	3.39 [1.76, 5.03]
Agility	s	10.331 ± 0.251	8.347 ± 0.207	1.984	16.092	<0.001	8.63 [5.27, 12.00]
Euro Step	points	8.286 ± 1.254	10.714 ± 1.496	2.428	3.305	0.006	1.76 [0.53, 3.00]

Note. Between-group t for the Euro Step was recomputed from the reported post-test means and SDs (n = 7 per group).



Visual summary of pre-post performance and effect sizes

The pattern of pre- and post-test performance across both groups is summarised in Figure 4. The experimental group's relative improvements were 3.8× (eye-foot coordination), 4.5× (agility), and 2.8× (Euro Step) larger than those of the control group (Figure 5). Within- and between-group effect sizes are visualised as a forest plot in Figure 6.

Figure 4. Pre- vs post-test performance (M ± SD) by outcome and group. Black brackets denote within-group pre/post contrasts (paired t); red brackets denote between-group post-test contrasts (independent t). *** p < 0.001; ** p < 0.01.

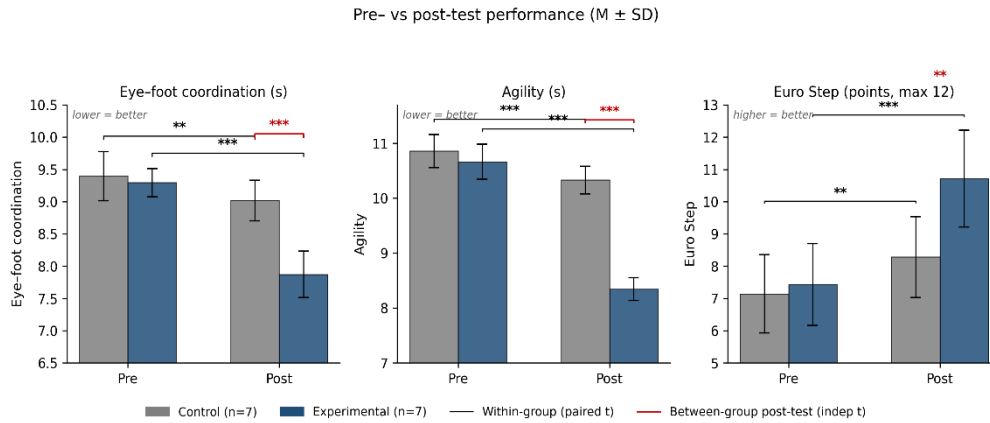


Figure 5. Relative improvement (%) from pre- to post-test, by group and outcome. Annotations indicate the ratio between experimental and control group improvements. Sign-corrected so that improvement is always shown as positive.

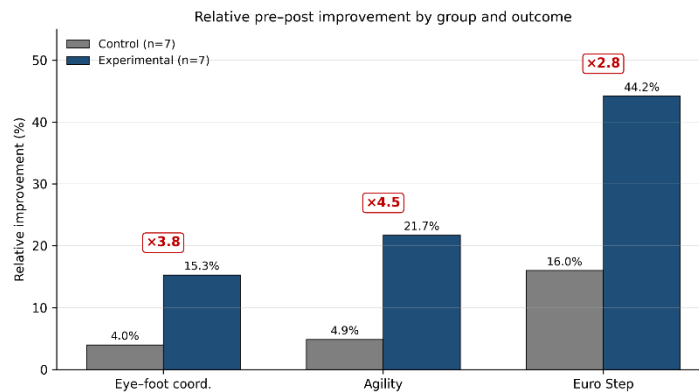
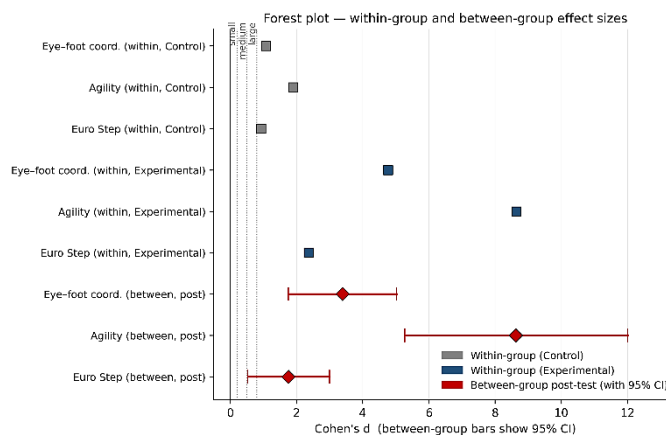


Figure 6. Forest plot of within-group (paired) and between-group (independent, with 95% confidence intervals) Cohen's d effect sizes. Vertical reference lines correspond to Cohen's thresholds (small 0.2, medium 0.5, large 0.8). Within-group paired d are reported without 95% CI because the pre-post correlation r was not modelled.



Discussion

The principal finding of this pilot trial was that an 8-week integrated training programme using assistive equipment produced significantly greater improvements than a strictly volume-matched coach-led control programme in all three measured outcomes — eye-foot coordination, agility, and the Euro Step skill — in male U-18 basketball players. Pre-test data demonstrated that the two groups were not significantly different on any outcome, supporting the validity of the post-test contrast. Within-group, the experimental programme yielded very large pre-post effects for coordination ($\Delta = -15.3\%$, $d = 4.77$), agility ($\Delta = -21.7\%$, $d = 8.64$), and the Euro Step ($\Delta = +44.2\%$, $d = 2.37$); the control group also improved but to a substantially smaller extent ($\Delta = -4.0\%$, -4.9% , and $+16.0\%$, respectively). The between-group post-test contrasts were large and statistically significant ($d = 3.39$, 8.63 , and 1.76 , respectively). Three points warrant discussion: (i) the magnitude and plausibility of the effects relative to the literature, including the studies whose findings do not converge on the present results; (ii) the neuromuscular and motor-learning mechanisms most likely to explain them; and (iii) the practical and methodological limitations that constrain generalisation.

Eye-foot coordination

The experimental group reduced Numbered Circles test time by 15.3%, with a between-group post-test difference of 1.14 s ($d = 3.39$). Direct comparators are scarce because the Numbered Circles test is an Arabic-literature instrument; however, the underlying construct — coordinated foot placement to visual targets — is closely related to the gross motor coordination tasks evaluated by the Körperkoordinationstest für Kinder, where structured multi-modal interventions in 6- to 13-year-olds have produced medium-to-large effects on motor quotient (Vandorpe et al., 2011; Fransen et al., 2012). Within basketball, a recent 12-week coordination training programme using ladders, cones, and reaction tasks in 10- to 13-year-olds produced significant improvements in the 10 × 5 m shuttle, T-test, and standing long jump, with no transfer to linear sprint speed or flexibility (Koci & Kotorri, 2025). Our larger relative improvement is directionally consistent with these comparators, though its magnitude is almost certainly amplified by the small sample size — a phenomenon now well documented in pilot designs (Lakens, 2013) and discussed at length in Section 4.5.

Agility

The 21.7% reduction in agility-test time in the experimental group (10.66 → 8.35 s) is larger than typically reported in adolescent basketball trials. Bouteraa et al. (2020) reported a 6.7% improvement in modified Illinois COD time after 8 weeks of combined balance + plyometric training; Arede et al. (2019) reported substantial Pro Agility test improvements ($d \approx 1.0$ – 1.3) after 8 weeks of combined strength and conditioning; León-Muñoz et al. (2024), in a randomised controlled trial in Retos, similarly observed that combining plyometric, strength, sprint, and change-of-direction work — rather than any single modality in isolation — produced the largest gains in vertical jump and change-of-direction performance in youth male players; and the systematic review by Quintero et al. (2025) reported pooled Hedges' g values of approximately 1.0–1.2 for combined agility-training methods in basketball.

Critically, however, not all comparable interventions have produced positive effects. Padrón-Cabo et al. (2020), in a six-week randomised trial of agility-ladder training in 12-year-old male soccer players, found no significant pre-to-post or between-group differences in the agility test, dribbling speed test, slalom dribbling test, or skill index, and concluded that coordination training with the agility ladder alone is not effective for improving physical fitness or dribbling. The discrepancy between that null result and the positive findings of the present trial is most parsimoniously explained by three differences: (a) Padrón-Cabo et al. used the ladder in isolation, whereas our programme integrated the ladder with hurdles, hoops, cones, and skill-coupled drills within every session; (b) their participants were pre-pubertal soccer players whereas ours were post-pubertal sub-elite basketball players within the YPD-defined sensitive window for agility; and (c) their intervention lasted six weeks at unspecified weekly frequency whereas ours lasted eight weeks at three sessions per week with explicit weekly progression of volume and complexity. These differences are consistent with the broader pattern in the literature, in which the ladder appears to drive adaptation only when it is coupled with additional stimuli that load the stretch-shortening cycle and the visual-motor system simultaneously.



Our larger relative gain is therefore most parsimoniously explained by three converging factors. First, the integrated combination of agility-ladder, hurdle, cone, and skill-coupled drills exposes the neuromuscular system simultaneously to fast eccentric–concentric coupling, multi-planar foot placement, and visual–motor integration — the same combinations that drive the largest pooled effects in the meta-analytic literature (Asadi et al., 2016; Guo et al., 2024; Ramírez-Campillo et al., 2023). Second, our participants had a mean training age of approximately 4.6 years and were within the YPD-defined sensitive period for agility (Lloyd & Oliver, 2012). Third, however, very small samples are known to produce inflated effect-size estimates due to limited variance and the increased influence of individual responders (Lakens, 2013; Hopewell et al., 2025); we therefore present our gains as upper-bound estimates and recommend replication in larger samples.

Euro Step skill

The experimental group improved Euro Step performance from 7.4 to 10.7 (out of 12) — a 44.2% relative gain — and significantly outperformed the control group at post-test (10.7 vs 8.3; $d = 1.76$). To our knowledge, this is the first peer-reviewed evaluation of the Euro Step as a trainable outcome in U-18 male basketball. The improvement is consistent with three lines of evidence. First, finishing skills under reactive and decelerative conditions are constrained by the same lateral COD and eccentric-strength qualities that integrated equipment-based training reliably develops (Sheppard & Young, 2006; Spiteri et al., 2015; Scanlan et al., 2021). Second, biomechanical analyses of lateral cutting and false-step manoeuvres in basketball have shown that the action requires substantial lateral ground-reaction-force absorption, eccentric strength of the support limb, and trunk control under unpredictable conditions (Golden et al., 2009; Kameda et al., 2019); these qualities are precisely those targeted by the ladder, hurdle, and hoop drills used in our experimental programme. Third, in basketball small-sided games and complex training studies that couple physical work with technical execution, technical-skill measures (dribbling, shooting, and passing) consistently improve in parallel with agility (Delextrat & Martinez, 2014; Koci & Kotorri, 2025). The plausible mechanism is therefore coordinative transfer: by drilling lateral, asymmetric foot patterns through ladders, hurdles, and hoops while simultaneously rehearsing the gather–step–step–finish sequence of the Euro Step against cone defenders, the experimental group consolidated a more stable motor representation of the skill, supported by improved eye–foot coupling and lateral COD capacity.

Mechanisms

The neuromuscular mechanisms most likely to underpin our findings include: (a) increased rate of force development and improved eccentric braking through repeated stretch-shortening exposures during ladder, hurdle, and hoop work (Ramírez-Campillo et al., 2023); (b) enhanced inter- and intra-muscular coordination of agonist–antagonist groups during rapid lateral foot placements (Bouteraa et al., 2020); and (c) perceptual–motor integration improvements from repeatedly coupling foot placement to visual targets, consistent with cognitive-coordination training findings (Lucia et al., 2023). For the Euro Step specifically, the integration of physical and skill stimuli within the same session is consistent with a constraints-led, task-oriented approach that has been shown to accelerate complex motor-skill acquisition in youth (Williams et al., 2024).

Limitations and methodological caveats

Several constraints temper interpretation of these findings. First, the small sample ($n = 7$ per group, 14 total) reduces statistical precision and almost certainly inflates the within-group effect-size estimates; future trials should include ≥ 15 –20 per group with a priori power calculations based on the present d values (Lakens, 2013). Second, the trial was single-sex, single-club, and single-region, limiting generalisability; replication in mixed-club and mixed-region samples is needed. Third, biological maturity status (e.g., peak-height-velocity offset, predicted years from PHV per Mirwald et al.) was not assessed at baseline; given that the U-18 male window spans a substantial maturational interval (Carvalho et al., 2012; Lloyd & Oliver, 2012), unmeasured between-individual differences in biological maturity may have contributed to differential responsiveness and should be controlled in future replications. Fourth, the Numbered Circles, Fares & Luay, and Nasser tests are validated within the Arabic-language sport-science literature but lack independent international validation; adopting parallel internationally validated instruments — e.g., the Modified Agility T-test (Sassi et al., 2009; Stojanović et al., 2019) and the V-Cut Dribbling Test (Jódar-Portas et al., 2023) — in future work would strengthen comparability. Fifth, no



follow-up assessment was conducted; whether the gains persist after detraining is unknown. Sixth, although total weekly training volume was matched between groups ($3 \times 75 \text{ min} = 225 \text{ min}$) and adherence was high in both arms ($\geq 88\%$ of sessions for every player), the experimental and control sessions were not equated in terms of total ground contacts or perceived training load. The experimental sessions necessarily entailed a higher density of plyometric-type foot contacts (180–320 per session) than the control sessions ($\approx 150\text{--}200$ per session). Seventh, the participants and the assistant coach delivering the experimental programme were not blinded to allocation; the consequent possibility of a Hawthorne effect cannot be excluded. Eighth, although all 14 randomised players completed both assessments, in larger replications with the inevitable possibility of drop-out, an explicit ITT analysis with multiple imputation for missing post-test data should be pre-specified. Ninth, the trial was retrospectively rather than prospectively registered, a CONSORT-flagged deviation that future replications should correct. Tenth, given the three primary outcomes, a formal correction for multiple comparisons was not applied; exact p-values and 95% confidence intervals are reported so that readers can apply their preferred adjustment if they wish.

Practical applications

For U-18 male basketball coaches operating in resource-limited contexts, an 8-week, three-times-weekly integrated training programme using widely available assistive equipment (ladders, mini-hurdles, cones, and hoops) is a feasible, low-cost intervention that, within the limits of this small pilot trial, produced substantially larger improvements in eye-foot coordination, agility, and Euro Step proficiency than a volume-matched coach-led control programme. Practitioners are encouraged to: (i) couple equipment-based drills to the technical move within the same session, rather than separating physical and skill work; (ii) progress volume and complexity weekly; and (iii) monitor individual responders, given the typical between-athlete variability observed in youth complex-training studies (Williams et al., 2024).

Conclusions

An 8-week integrated training programme using assistive equipment produced substantially larger improvements in eye-foot coordination, agility, and Euro Step skill than a strictly volume-matched coach-led control programme in male U-18 basketball players, with very large between-group effect sizes on all three outcomes and 95% confidence intervals that excluded zero. The integration of coordination, agility, and skill stimuli within the same training unit — rather than their separation across isolated blocks — appears to be the operative principle, a position consistent with the broader pattern in the literature whereby ladder, hurdle, cone, and hoop work drives adaptation when combined but is less reliably effective in isolation (Padrón-Cabo et al., 2020, 2021). Given the pilot scale of the trial, the inflated within-group effect-size estimates, and the volume/load asymmetry between conditions, the trial should be read as hypothesis-generating: replication in larger, multi-club, mixed-region samples with independently validated international test batteries, formal control of training volume and biological maturity, prospective trial registration, and pre-specified intention-to-treat analyses is the priority next step.

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Conflicts of interest

The authors declare no conflicts of interest.

Ethics approval Granted by the institutional Research Ethics Committee of the Faculty of Physical Education and Sports Sciences, University of Kufa.

Consent to participate: written informed assent and parental consent were obtained from every participant.

Data availability: anonymised raw data are available from the corresponding author upon reasonable request.

Author contributions: both authors contributed to the design of the trial, supervision of data collection, statistical analysis, and drafting of the manuscript, and approved the final version.

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Authors and translators' details:

Akram Mustafa Naji
Ahmed Aboodee Hussein

Akram.alkemiawi@student.uokufa.edu.iq
ahmeda.hussein@uokufa.edu.iq

Autor/a
Autor/a

