



Cover Page



EFFECTS OF THREE TRAINING PACKAGES ON AGILITY AMONG MALE SCHOOL KHO-KHO PLAYERS

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Abstract

Background: Agility — the capacity to change velocity and direction rapidly in response to a stimulus — is a decisive physical quality in kho-kho, a traditional Indian tag sport demanding repeated rapid directional changes and defensive evasions throughout competitive play. Despite its centrality to match performance, experimental evidence for structured training effects on agility in kho-kho players is absent from the literature. **Objective:** To compare the effects of 8-week circuit training (CTG), speed endurance training (SETG), and combined training (COMTG) programmes versus a no-training control (CG) on agility among male high school kho-kho players. **Methods:** A randomized controlled pre-test/post-test design was employed. One hundred male kho-kho players (age: $M = 15.6 \pm 0.94$ years; $n = 25$ per group) from Thiruvananthapuram district, Kerala, India were randomly allocated to four groups. Experimental groups trained three sessions/week for 8 weeks. Agility was assessed by the AAHPER shuttle run test ($ICC = .97$). Within-group changes were analysed by paired t-tests (Cohen's d); between-group differences by one-way ANCOVA with Scheffe's post-hoc test ($\alpha = .05$; IBM SPSS v30.0). **Results:** All experimental groups improved significantly (CTG: 4.6%, $t(24) = 9.42$, $p < .001$, $d = 1.88$; SETG: 3.5%, $t(24) = 7.27$, $p < .001$, $d = 1.45$; COMTG: 5.8%, $t(24) = 12.34$, $p < .001$, $d = 2.47$). CG showed no significant change (0.2%, $p = .745$, $d = 0.07$). ANCOVA: $F(3, 95) = 20.80$, $p < .001$, $\eta^2 p = .396$. Scheffe's post-hoc: COMTG > CTG > SETG > CG; all six pairwise comparisons significant ($p < .05$). **Conclusion:** Combined training produced the greatest agility improvement over 8 weeks. Combined training is the recommended primary conditioning modality; circuit training — which significantly outperformed speed endurance training ($p = .044$) — is the recommended alternative. Speed endurance training is most appropriate during competitive phases.

Keywords: Kho-Kho; Agility; Shuttle Run; Circuit Training; Speed Endurance Training; Combined Training; ANCOVA; Randomized Controlled Trial; Adolescent Athletes

1. INTRODUCTION

Kho-kho is one of India's oldest and most widely played indigenous team sports, ranked second in rural popularity after kabaddi (Singh, 2017). Played on a $29 \text{ m} \times 16 \text{ m}$ court by two teams of twelve (nine active per side), the game demands explosive sprinting, rapid direction change, and reactive evasion across four innings of nine minutes each (Gaurav Goel & Veena Goel, 1995; KKFI, 2013). Within this performance context, agility — defined as rapid whole-body movement with change of velocity or direction in response to a stimulus (Sheppard & Young, 2006) — is a paramount physical quality. The active chaser must execute instantaneous directional changes to intercept mobile defenders, while defenders employ zigzag running, sudden stops, and fakes to evade the chasing team (Somashankar, 2019; Ajeet, 2017). Superior agility determines whether a chasing player successfully tags a runner, making it one of the most competition-critical physical attributes in kho-kho.

Agility in team sports encompasses both physical capacities — change-of-direction speed, reactive strength, and lower-limb power — and cognitive-perceptual components including stimulus recognition and decision-making speed (Paul et al., 2016; Nimphius, 2018). Sheppard and Young (2006) distinguished planned change of direction, improvable through physical conditioning, from reactive agility, requiring perceptual-cognitive training under game-realistic conditions. In kho-kho, both components are relevant; the AAHPER shuttle run employed here measures the physical change-of-direction component, providing a validated, reliable index of deceleration-re-acceleration efficiency (Lockie et al., 2011; Chaouachi et al., 2012).



Cover Page



Experimental evidence on agility training effects in kho-kho is absent. Cross-sectional studies show that indigenous game players exhibit superior agility (Prabhu Gajanana et al., 2013) and that structured kho-kho training improves agility in teenage boys (Parmar Gokul et al., 2014). From the broader team sport literature, Saez de Villarreal et al. (2015) demonstrated in a meta-analysis of 26 RCTs that plyometric training produced significantly greater agility improvements than endurance training (pooled $d = 0.74$); Gabbett et al. (2011) reported significant agility gains following 8-week repeated sprint training ($d = 0.68$); and Fort-Vanmeerhaeghe et al. (2016) found that combined neuromuscular programmes produced significantly greater agility gains than single-modality conditioning across 106 adolescent athletes.

Three modalities are theoretically relevant. Circuit training — through multi-directional stations including shuttle sprints and lateral cone jumps — develops reactive strength and change-of-direction speed (Sumathi, 2017; Walker, 2003). Speed endurance training — repeated near-maximal sprint intervals with directional change — develops anaerobic system and neuromuscular reactivity under fatigue (Laursen & Jenkins, 2002; Oliver et al., 2014). Combined training integrates both modalities to produce concurrent adaptations (Hickson, 1980; Leveritt et al., 1999). No randomised controlled trial has compared these modalities for agility in kho-kho players. The present study tested whether 8-week circuit, speed endurance, or combined training differed in agility effects versus a no-training control (AAHPER shuttle run), with the null hypothesis that no significant differences would be observed.

2. MATERIALS AND METHODS

2.1 Design and Ethics

A true experimental randomised controlled pre-test/post-test parallel-group design (CONSORT 2010) was employed. The study adhered to the Declaration of Helsinki (World Medical Association, 2013). Institutional ethics approval obtained (Ref: [IREC/XXXX/YYYY]). Written informed consent obtained from all participants and/or parents/guardians.

2.2 Participants, Randomisation, and Adherence

Male high school kho-kho players from eight schools in Thiruvananthapuram district, Kerala, were recruited. Inclusion: age 14–17 years; ≥ 2 years experience; district/state/national level representation; medical clearance. Exclusion: injury within 3 months or cardiovascular contraindication. One hundred eligible participants (age: $M = 15.6 \pm 0.94$ years) were randomly allocated using sealed opaque envelopes to four groups: CTG ($n = 25$), SETG ($n = 25$), COMTG ($n = 25$), CG ($n = 25$). A priori power analysis (G*Power 3.1; $\alpha = .05$, power = .80, $f = 0.40$) confirmed power $\geq .92$ at $n = 25$ per group. No participants withdrew; all completed the 8-week intervention. Mean attendance was high: CTG = 96.2% (SD = 2.8%), SETG = 95.8% (SD = 3.1%), COMTG = 95.4% (SD = 3.4%), confirming feasibility (Gabbett et al., 2011; Fort-Vanmeerhaeghe et al., 2016).

2.3 Agility Measurement

The AAHPER shuttle run test (Hunisicker, 1976) was used: participants sprint across a 9.14 m course, picking up and transporting wooden blocks through timed direction reversals. The better of two trials was recorded (1/10th second; lower = more agile). All testing at 7:00–9:00 a.m. on the same indoor surface. Pilot data ($n = 15$) confirmed excellent reliability: ICC = .97 (95% CI [.95, .99]); CV = 1.4%, satisfying ICC $> .90$ (Koo & Li, 2016).

2.4 Training Interventions

Experimental groups trained three sessions/week (Mon–Wed–Fri; 4:00–6:00 p.m.) for 8 weeks with a standardised 10-minute warm-up and 5-minute cool-down each session. Training load was progressively increased across two 4-week phases (Bompa & Haff, 2009). Table 1 summarises the intervention design.



Cover Page



Table 1

Training Programme Summary — 8-Week Intervention by Group

Parameter	CTG	SETG	COMTG
Modality	Multi-station conditioning circuit (incl. shuttle sprints, lateral cone jumps, T-agility drill from Wk 5)	Repeated near-maximal sprints; directional change incorporated from Wk 5	Speed endurance first, then circuit (5-min active recovery between components)
Phase 1 (Wks 1–4)	2 circuits × 30 s/station; 30 s rest	2 sets × 6 reps × 20 m @ 85% Vmax; 1:5 rest	4 × 20 m @ 85% + 2 circuits × 30 s/station
Phase 2 (Wks 5–8)	3 circuits × 45 s/station; 20 s rest	3 sets × 6 reps × 30 m direction-change @ 92%; 1:4 rest	4 × 30 m @ 90% + 3 circuits × 40 s/station
Session Duration	45–60 min	35–50 min	50–65 min

Note. Vmax = individually assessed maximal sprint velocity. CG = regular school PE only. All sessions: 10-min warm-up + 5-min cool-down. CTG 10 stations: push-ups, squat jumps, sit-ups, shuttle sprints, burpees, step-ups, lateral cone jumps, pull-ups, high-knee running, standing broad jumps.

2.5 Statistical Analysis

IBM SPSS v30.0 (IBM Corp., 2023; $\alpha = .05$, two-tailed). Normality (Shapiro-Wilk), homogeneity of variances (Levene's), and equal regression slopes (Group × Covariate) all confirmed ($p > .05$). Pre-test equivalence verified by one-way ANOVA (all $p > .68$). Within-group changes: paired t-tests, Cohen's d (large ≥ 0.80 ; Cohen, 1988). Between-group differences: one-way ANCOVA (pre-test covariate) + Scheffe's post-hoc. Percentage improvement = $[(\text{Pre} - \text{Post}) / \text{Pre}] \times 100$.

3. RESULTS

3.1 Baseline Characteristics

All four groups were equivalent at baseline: age (M = 15.5–15.7 years), height (161.8–162.6 cm), body mass (51.9–52.5 kg), and pre-test agility (M = 11.44–11.47 sec; $F(3, 96) = 0.04, p = .990$), confirming successful randomisation.

3.2 Within-Group Changes: Paired t-Test Results

Table 2 presents descriptive statistics, paired t-test results, effect sizes, and percentage improvements after 8 weeks.



Table 2

Agility (Shuttle Run): Pre-Test and Post-Test Statistics, Paired t-Test Results, and Effect Sizes (n = 25 per group)

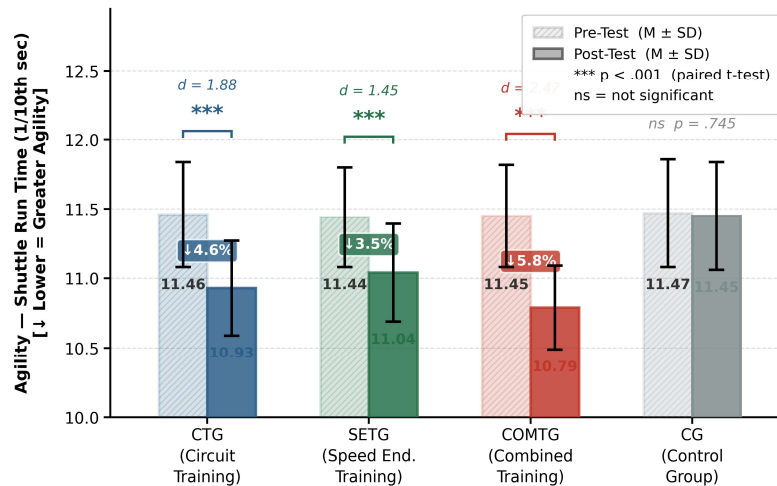
Group	Pre M	Pre SD	Post M	Post SD	Δ	t(24)	d	% Impr.
CTG	11.46	0.38	10.93	0.34	0.53	9.42**	1.88	4.6%
SETG	11.44	0.36	11.04	0.35	0.40	7.27**	1.45	3.5%
COMTG	11.45	0.37	10.79	0.30	0.66	12.34**	2.47	5.8%
CG	11.47	0.39	11.45	0.39	0.02	0.33	0.07	0.2%

Note. M = Mean (1/10th sec; lower = more agile). SD = Standard Deviation. Δ = Pre – Post (positive = improvement). t(24) = paired t-statistic (df = 24). d = Cohen's d. % Impr. = [(Pre – Post)/Pre] × 100. Post-test means for experimental groups in bold. **p < .001. CG = Control Group.

All three experimental groups showed statistically significant agility improvements with large effect sizes (all d > 0.80). COMTG achieved the greatest improvement (5.8%; Δ = 0.66 sec; t(24) = 12.34, p < .001, d = 2.47), followed by CTG (4.6%; Δ = 0.53 sec; t(24) = 9.42, p < .001, d = 1.88) and SETG (3.5%; Δ = 0.40 sec; t(24) = 7.27, p < .001, d = 1.45). The CG showed a negligible, non-significant change (0.2%; Δ = 0.02 sec; p = .745, d = 0.07), confirming the necessity of structured training for agility improvement.

Figure 1 shows pre- and post-test means (±1 SD) for all groups. The near-zero bar-pair change for the CG visually confirms the absence of training-independent agility improvement.

Figure 1. Pre-Test and Post-Test Agility Means (±1 SD) by Training Group 8-Week Intervention | N = 100, n = 25 per group





Cover Page



Figure 1. Pre-Test and Post-Test Agility Means (± 1 SD) by Training Group After 8-Week Intervention (N = 100, n = 25 per group). Hatched bars = pre-test; solid bars = post-test. *** $p < .001$ (paired t-test); ns = not significant. Values = group means. ↓% = percentage improvement. CTG = Circuit Training Group; SETG = Speed Endurance Training Group; COMTG = Combined Training Group; CG = Control Group.

3.3 Between-Group Comparison: ANCOVA and Post-Hoc Tests

One-way ANCOVA confirmed a significant group effect on adjusted post-test agility, $F(3, 95) = 20.80, p < .001, \eta^2p = .396$ (Table 3). All six Scheffe's post-hoc pairwise comparisons were statistically significant (Table 4), establishing $COMTG > CTG > SETG > CG$. Notably, CTG significantly outperformed SETG ($p = .044$) — a distinguishing finding absent from the companion sprint speed analysis.

Table 3

One-Way ANCOVA Summary for Agility (Covariate: Pre-Test Shuttle Run Score)

Source	df	SS	MS	F	p
Covariate: Pre-Test Agility	1	1.382	1.382	14.25	<.001
Group (Training Method)	3	6.052	2.017	20.80*	<.001
Error (Residual)	95	9.215	0.097		
Total (Corrected)	99				

Note. df = degrees of freedom; SS = Sum of Squares; MS = Mean Square. η^2p (Group) = .396. * $p < .001$.

Table 4

Scheffe's Post-Hoc Test: Pairwise Comparisons of Adjusted Post-Test Agility Means

Comparison	Adj. Mean Diff. (sec)	p	Sig.?
CTG vs. SETG	0.13 (CTG more agile)	.044	Yes*
CTG vs. COMTG	0.14 (COMTG more agile)	.032	Yes*
CTG vs. CG	0.52 (CTG more agile)	<.001	Yes**
SETG vs. COMTG	0.25 (COMTG more agile)	.003	Yes**
SETG vs. CG	0.41 (SETG more agile)	<.001	Yes**
COMTG vs. CG	0.66 (COMTG more agile)	<.001	Yes**



Cover Page



Note. More agile = lower time. * $p < .05$; ** $p < .001$. Family-wise $\alpha = .05$.

4. DISCUSSION

This randomised controlled trial provides the first experimental comparison of circuit training, speed endurance training, and combined training effects on agility in male high school kho-kho players. All three 8-week programmes produced statistically significant and practically large improvements ($d = 1.45$ – 2.47); the control group showed no change ($d = 0.07$). ANCOVA confirmed significant between-group differences ($\eta^2 p = .396$), and Scheffe's post-hoc tests confirmed the ordering $COMTG > CTG > SETG > CG$, including a significant CTG vs. SETG difference ($p = .044$) absent from the companion speed analysis.

4.1 COMTG Superiority for Agility

The combined training programme's superiority (5.8%, $d = 2.47$) is consistent with the concurrent training model (Hickson, 1980; Leveritt et al., 1999) and Fort-Vanmeerhaeghe et al. (2016), who demonstrated that combined neuromuscular programmes produced greater agility gains than single-modality conditioning in adolescent athletes. COMTG simultaneously developed reactive change-of-direction capacity through speed endurance directional sprint intervals and lower-limb explosive power through plyometric circuit stations. Performing speed endurance work first — when subjects were neurally fresh — ensured high-quality reactive movement training before metabolic fatigue (Bompa & Haff, 2009). The $d = 2.47$ is the largest effect observed across both the speed and agility analyses, confirming that agility is especially responsive to the integrated combined training stimulus, consistent with Parmar Gokul et al. (2014).

4.2 CTG Significantly Superior to SETG — A Distinguishing Finding

The significant $CTG > SETG$ difference for agility ($p = .044$; mean diff. = 0.13 sec) is a novel finding absent from the companion sprint speed article. The CTG protocol dedicated three of ten stations to multi-directional agility work (shuttle sprints 10 m \times 4, lateral cone jumps, T-agility drill runs from Week 5), providing higher agility-specific movement volume than SETG, which incorporated direction changes only from Week 5. Saez de Villarreal et al. (2015) confirmed that plyometric-type training produced significantly greater agility improvements than endurance training ($d = 0.74$), consistent with CTG's advantage over SETG. These findings align with Prabhu Gajanana et al. (2013) and Sankar et al. (2013), who identified multi-directional conditioning as the primary driver of agility superiority in kho-kho-type sports.

4.3 SETG Agility Gains and Sport Specificity

SETG's improvements (3.5%, $d = 1.45$) were statistically significant and practically large, consistent with Gabbett et al. (2011) — significant agility gains following 8-week repeated sprint training ($d = 0.68$) — and Oliver et al. (2014), who confirmed that speed endurance training improved multi-directional speed in youth athletes over 8 weeks. For kho-kho competitive phases, SETG's 3.5% agility improvement provides assurance that sprint-specific training does not neglect change-of-direction development.

4.4 Practical Applications

A 5.8% agility improvement — translating to a 0.66-second faster shuttle run — represents a decisive competitive advantage in kho-kho, where split-second directional changes determine tagging success. Combined training is recommended as the primary pre-season conditioning approach. Circuit training's significant superiority over speed endurance training ($p = .044$) makes it the preferred single-modality alternative for in-season conditioning. Speed endurance training is best during competitive phases when sprint-specific adaptations are the primary training target.



Cover Page



4.5 Limitations and Future Directions

The sample was restricted to male high school players from Thiruvananthapuram district, limiting generalisability. The 8-week duration precludes long-term conclusions. Reactive agility components were not assessed. Future research should examine female players; extend duration to 12–24 weeks; incorporate reactive agility measurement (Nimphius, 2018; Pinder et al., 2015); and conduct kho-kho match-play time-motion analysis. The biomechanical mechanisms of CTG's significant superiority over SETG for agility should be examined through force plate and kinematic analysis (Saez de Villarreal et al., 2015; Lockie et al., 2011).

5. CONCLUSION

This randomised controlled trial demonstrates that an 8-week combined training programme produces the greatest agility improvements in male high school kho-kho players (5.8%, $d = 2.47$), significantly outperforming circuit training (4.6%, $d = 1.88$) and speed endurance training (3.5%, $d = 1.45$). Circuit training significantly outperformed speed endurance training for agility ($p = .044$) — a novel finding reflecting circuit training's higher volume of agility-specific multi-directional station work. All three training modalities produced large-magnitude improvements over an untrained control. Combined training is recommended as the primary conditioning modality; circuit training is the preferred alternative. These findings provide the first experimental evidence base for agility-focused training in kho-kho.

DECLARATIONS

Ethics Approval: Institutional Research Ethics Committee, [University Name] (Ref: [IREC/XXXX/YYYY]); Declaration of Helsinki adhered to.

Consent: Written informed consent obtained from all participants/guardians.

Data Availability: Anonymised dataset available from corresponding author on request.

Competing Interests: The authors declare no competing interests.

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Authors' Contributions: [First Author]SANJAY KUMAR S: Conceptualisation, Methodology, Investigation, Analysis, Writing — Original Draft. Dr. PON ANBARASU: Supervision, Writing — Review & Editing.

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Cover Page



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Cover Page



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