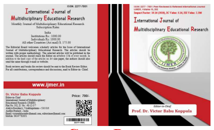
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EFFECTS OF THREE TRAINING PACKAGES ON SPRINT SPEED IN SCHOOL KHO-KHO PLAYERS

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Abstract

Background: Sprint speed is the cardinal physical quality in kho-kho, a traditional Indian tag sport that demands repeated explosive sprint efforts across competitive innings. Despite the sport's high physiological demands, experimental evidence for sport-specific training programme efficacy in kho-kho is severely limited. **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 sprint speed 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 was randomly allocated to four groups. Experimental groups trained three sessions/week for 8 weeks. Sprint speed was assessed by the 30-metre fly test (ICC = .98). 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: 4.8%, $t(24) = 8.65$, $p < .001$, $d = 1.73$; SETG: 3.3%, $t(24) = 6.38$, $p < .001$, $d = 1.28$; COMTG: 6.0%, $t(24) = 10.67$, $p < .001$, $d = 2.13$). CG showed no significant change (0.2%, $p = .722$, $d = 0.07$). ANCOVA: $F(3, 95) = 17.11$, $p < .001$, $\eta^2p = .351$. Scheffe's post-hoc: COMTG > CTG > SETG > CG; CTG vs. SETG not significant ($p = .182$). **Conclusion:** An 8-week combined training programme produced the greatest sprint speed improvement. Combined training is recommended as the primary conditioning modality; circuit training and speed endurance training are effective alternatives for different phases of the training year.

Keywords: kho-kho; sprint speed; 30-metre fly test; circuit training; speed endurance training; combined training; ANCOVA; randomized controlled trial; indigenous sports; 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 m × 16 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). Sprint speed — defined as the maximum velocity at which an athlete can propel the body through space — is universally acknowledged as the cardinal physical quality in kho-kho (Somashankar, 2019). The active chaser must cover the court at near-maximal velocity to intercept mobile defenders, while defenders use explosive sprint bursts to evade capture. Differences of even 0.2–0.3 seconds in sprint time can determine whether a chaser successfully tags a runner in competitive play (Shashi Kant, 2017).

Despite kho-kho's high physical demands and widespread school-level participation across Kerala, Maharashtra, Karnataka, and Andhra Pradesh, experimental investigations of structured training programme effects on sprint speed in kho-kho players are absent from the international literature. Existing studies have been restricted to cross-sectional comparisons: Senthil Kumar (2017) reported significant speed differences between kho-kho and kabaddi players; Parmar Gokul et al. (2014) demonstrated significant sprint improvements following structured kho-kho training; and Bhupinder Singh et al. (2014) found no significant difference in speed between runners and chasers within teams, suggesting that systematic conditioning is required beyond match practice alone. Evidence from broader team sport contexts further supports this rationale: Paul et al. (2016) demonstrated that sprint speed improvements require modality-specific structured training; Lockie et al. (2011) confirmed that different sprint training protocols produce different neuromuscular adaptation profiles

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in field sport athletes; and Gabbett et al. (2011) showed that combined conditioning approaches produced superior multi-component fitness outcomes in team sport athletes over 8 weeks.

Three training modalities are theoretically relevant. Circuit training simultaneously develops explosive power, strength endurance, and cardiorespiratory fitness through sequenced multi-station exercise (Sumathi, 2017; Walker, 2003). Speed endurance training — repeated near-maximal sprint intervals at 85–95% of maximal velocity with controlled recovery — directly targets the neuromuscular and anaerobic adaptations underlying sprint performance (Laursen & Jenkins, 2002; Oliver et al., 2014). Combined training integrates both modalities within a systematically periodised programme to produce concurrent adaptations across all determinants of sprint speed (Hickson, 1980; Leveritt et al., 1999; Fort-Vanmeerhaeghe et al., 2016). No randomised controlled trial has compared these approaches specifically for sprint speed in kho-kho players.

The present study therefore tested whether 8 weeks of circuit training, speed endurance training, or combined training differed in their effects on sprint speed (30-metre fly test) versus a no-training control in male high school kho-kho players. Eight weeks was selected based on evidence that meaningful neuromuscular adaptations emerge within 6–10 weeks in adolescent athletes (Bompa & Haff, 2009; Thomas et al., 2015) and its feasibility within a school term. The null hypothesis was that no significant within-group or between-group differences in sprint speed 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 or legal 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 ± 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 ≥ .92 at n = 25 per group. No participants withdrew; all 100 completed the 8-week intervention. Mean session 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 Sprint Speed Measurement

Sprint speed was assessed using the 30-metre fly test: participants accelerated over a 20-metre approach run before entering the timed 30-metre zone, providing a valid measure of maximum linear sprint velocity (Johnson & Nelson, 1986). Two trials were administered following standardised warm-up; the better time (1/10th second) was recorded. All testing at 7:00–9:00 a.m. on the same outdoor track surface, administered by the principal investigator. Pilot data (n = 15) confirmed excellent reliability: ICC = .98 (95% CI [.96, .99]); CV = 1.2%, 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.

Table 1

Training Programme Summary — 8-Week Intervention by Group

Parameter	CTG	SETG	COMTG
Modality	Multi-station conditioning circuit (10 stations incl. shuttle sprints, squat jumps, step-ups)	Repeated near-maximal sprint intervals over 20–30 m distances	Speed endurance first, then circuit (5-min active recovery between)
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 @ 92% Vmax; 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 from pre-test. 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 (10 m×4), 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 $p > .70$). Within-group changes: paired t-tests, Cohen's d (large ≥ 0.80; Cohen, 1988). Between-group: one-way ANCOVA (pre-test covariate) + Scheffe's post-hoc. Percentage improvement = [(Pre − Post) / Pre] × 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 sprint speed (M = 4.80–4.83 sec; $F(3, 96) = 0.08$, $p = .971$), 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.

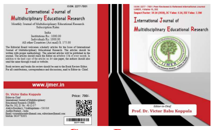
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Table 2

Sprint Speed (30-m Fly Test): 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	4.82	0.18	**4.59**	0.16	0.23	8.65**	1.73	**4.8%**
SETG	4.80	0.17	**4.64**	0.15	0.16	6.38**	1.28	**3.3%**
COMTG	4.81	0.19	**4.52**	0.14	0.29	10.67**	2.13	**6.0%**
CG	4.83	0.18	4.82	0.18	0.01	0.36	0.07	0.2%

Note. M = Mean (1/10th sec; lower = faster). SD = Standard Deviation. Δ = Pre − Post. 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.

All three experimental groups demonstrated statistically significant sprint speed improvements with large effect sizes (all d > 0.80). COMTG achieved the greatest improvement (6.0%; Δ = 0.29 sec; t(24) = 10.67, p < .001, d = 2.13), followed by CTG (4.8%; Δ = 0.23 sec; t(24) = 8.65, p < .001, d = 1.73) and SETG (3.3%; Δ = 0.16 sec; t(24) = 6.38, p < .001, d = 1.28). The CG showed a negligible, non-significant change (0.2%; Δ = 0.01 sec; p = .722, d = 0.07), confirming the necessity of structured training for speed improvement.

Figure 1 illustrates the pre- and post-test means (±1 SD) for all groups. The near-zero bar-pair change for the CG confirms absence of spontaneous speed improvement without training.

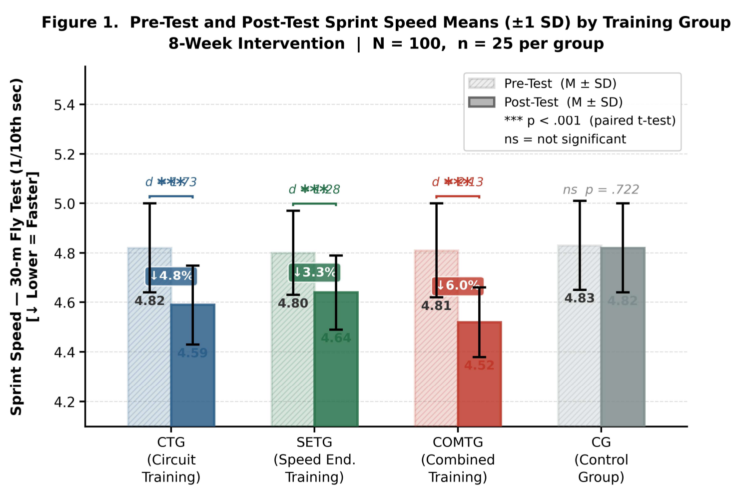
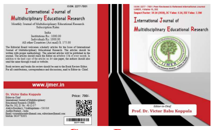


Figure 1. Pre-Test and Post-Test Sprint Speed Means (±1 SD) by Training Group After 8-Week Intervention (N = 100, n = 25 per group). Hatched bars = pre-test; solid bars = post-test. *** p < .001 (paired t-test); ns = not significant. Values = group means. ↓% = percentage improvement. CTG = Circuit Training Group; SETG = Speed Endurance Training Group; COMTG = Combined Training Group; CG = Control Group.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3.3 Between-Group Comparison: ANCOVA and Post-Hoc Tests

One-way ANCOVA confirmed a significant group effect on adjusted post-test sprint speed, $F(3, 95) = 17.11$, $p < .001$, $\eta^2p = .351$ (Table 3). Scheffe's post-hoc comparisons (Table 4) confirmed COMTG > CTG > SETG > CG, though the CTG vs. SETG comparison did not reach significance ($p = .182$).

Table 3

One-Way ANCOVA Summary for Sprint Speed (Covariate: Pre-Test Score)

Source	df	SS	MS	F	p
Covariate: Pre-Test Speed	1	0.347	0.347	14.59	<.001
Group (Training Method)	3	1.220	0.407	**17.11***	**<.001**
Error (Residual)	95	2.260	0.024		
Total (Corrected)	99				

Note. df = degrees of freedom; SS = Sum of Squares; MS = Mean Square. η^2p (Group) = .351. *$p < .001$.

Table 4

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

Comparison	Adj. Mean Diff. (sec)	p	Sig.?
CTG vs. SETG	0.07 (CTG faster)	.182	No
CTG vs. COMTG	0.07 (COMTG faster)	.048	**Yes***
CTG vs. CG	0.23 (CTG faster)	<.001	**Yes****
SETG vs. COMTG	0.12 (COMTG faster)	.006	**Yes****
SETG vs. CG	0.18 (SETG faster)	<.001	**Yes****
COMTG vs. CG	0.30 (COMTG faster)	<.001	**Yes****

Note. More agile = lower time. *$p < .05$; **$p < .001$. Family-wise $\alpha = .05$. CTG vs. SETG not statistically significant.

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Five of the six pairwise comparisons were statistically significant. The CTG vs. SETG comparison was not significant ($p = .182$), indicating that while CTG showed numerically faster times, the difference between these two modalities was insufficient to reach significance on the sprint speed outcome. This contrasts with the companion agility article where CTG significantly outperformed SETG ($p = .044$), reflecting the greater specificity of SETG's sprint-specific content for linear speed.

4. DISCUSSION

This randomised controlled trial provides the first experimental comparison of circuit training, speed endurance training, and combined training effects on sprint speed in male high school kho-kho players. All three 8-week programmes produced statistically significant and practically large improvements ($d = 1.28–2.13$); the control group showed no change ($d = 0.07$). ANCOVA confirmed significant between-group differences ($\eta^2p = .351$), with Scheffe's post-hoc tests establishing COMTG > CTG > SETG > CG. The non-significant CTG vs. SETG difference ($p = .182$) contrasts with the significant CTG > SETG finding in the companion agility analysis, reflecting the greater specificity of SETG's sprint training content for linear velocity development.

4.1 COMTG Superiority for Sprint Speed

The combined training programme's superiority (6.0%, $d = 2.13$) is consistent with the concurrent training model (Hickson, 1980; Leveritt et al., 1999) and Fort-Vanmeerhaeghe et al. (2016), who demonstrated superior multi-component fitness gains from combined versus single-modality training in adolescent athletes. The COMTG programme simultaneously developed sprint-specific neuromuscular adaptations through speed endurance intervals and lower-limb explosive power through plyometric circuit stations, addressing all major physiological determinants of sprint velocity within each session. Performing speed endurance work first — when subjects were neurally fresh — ensured maximum sprint quality training before metabolic fatigue (Bompa & Haff, 2009). The $d = 2.13$ reflects the additive neuromuscular and metabolic adaptations from the integrated programme, consistent with Parmar Gokul et al. (2014), who found the greatest sprint improvements following structured multi-component kho-kho training.

4.2 CTG and SETG Sprint Speed Findings

CTG's improvements (4.8%, $d = 1.73$) reflect the contribution of shuttle sprint and squat jump circuit stations to neuromuscular sprint performance, consistent with Walker (2003) and Sumathi (2017). CTG's numerical advantage over SETG — though statistically non-significant ($p = .182$) — likely reflects the additional lower-limb explosive power gains from plyometric circuit stations that underpin sprint acceleration mechanics (Baechle & Earle, 2008; Saez de Villarreal et al., 2015). SETG's improvements (3.3%, $d = 1.28$), while the smallest, were statistically significant and practically large, consistent with Laursen and Jenkins (2002) and Oliver et al. (2014), confirming that repeated near-maximal sprint intervals produce meaningful speed adaptations in adolescent team sport athletes. The non-significant CTG vs. SETG comparison ($p = .182$) reflects the complementary but overlapping mechanisms through which both modalities develop sprint velocity.

4.3 Control Group and Practical Implications

The CG's negligible speed change (0.2%, $p = .722$, $d = 0.07$) confirms that regular school physical education is insufficient to develop sprint speed in adolescent kho-kho players. A 6.0% sprint improvement over 8 weeks — translating to a 0.29-second advantage over 30 metres — represents a meaningful competitive edge in kho-kho, where the chaser's sprint speed directly determines tagging success. Combined training is recommended as the primary pre-season conditioning modality; circuit training as an in-season alternative; speed endurance training as the primary competitive phase approach when sprint-specific performance is the immediate priority. All three programmes require minimal specialised equipment and can be implemented in standard school facilities.

4.4 Limitations and Future Directions

The sample was restricted to male high school players from one district, limiting generalisability to female, collegiate, and senior players. The 8-week duration precludes long-term conclusions. Objective training load monitoring was absent. Future research should examine female kho-kho players; extend duration to 12–24 weeks; incorporate GPS and blood lactate monitoring for precise dose-response characterisation (Nimphius, 2018); and conduct time-motion analysis of kho-kho match play to establish ecological validity of the observed sprint improvements. The biomechanical mechanisms differentiating CTG and SETG sprint adaptations should be examined through kinematic analysis (Lockie et al., 2011; Saez de Villarreal et al., 2015).

5. CONCLUSION

This randomised controlled trial demonstrates that an 8-week combined training programme produces the greatest sprint speed improvements in male high school kho-kho players (6.0%, d = 2.13), significantly outperforming circuit training (4.8%, d = 1.73) and speed endurance training (3.3%, d = 1.28). The non-significant CTG vs. SETG difference for sprint speed (p = .182) — contrasting with the significant CTG > SETG finding in the companion agility analysis — indicates that speed endurance training's sprint-specific content provides comparable linear velocity adaptations to circuit training, while circuit training's advantage lies in broader fitness components including agility. All three modalities produced large-magnitude improvements over an untrained control. Combined training is the recommended primary conditioning modality for kho-kho sprint speed development; circuit training and speed endurance training are effective alternatives for different training phases. These findings provide the first experimental evidence base for sprint speed 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 and/or parents/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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