



Effects of Structured Perceptual-Cognitive Training on Decision-Making Performance in Male Competitive Kabaddi Players: A Randomized Controlled Trial

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Abstract

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This randomized controlled trial evaluated the effects of a six-week structured perceptual-cognitive training programme on decision-making performance in male competitive Kabaddi players. Seventy-two male university-level Kabaddi players (aged 18–25 years) from Punjab, India, were randomly assigned in a 1:1 ratio to either an experimental group (n = 36) or a control group (n = 36). Because the sample was restricted to men, findings are specific to male athletes and should not be assumed to generalize to female Kabaddi players. The experimental group completed cognitive training (5 sessions/week, 30–40 min/session) in addition to regular practice; the control group followed routine training only, with no additional attention-matched activity of equivalent contact time. Decision-making performance was assessed pre- and post-intervention using a researcher-developed sport-specific field protocol. Decision-making scores departed significantly from a normal distribution in all four pre/post × group cells (Shapiro-Wilk, all $p < .05$), so baseline group comparability was assessed with both an independent-samples t-test ($t(70) = 1.85$, $p = .069$) and a Mann-Whitney U test ($U = 472.0$, $p = .048$) on pre-test scores; the experimental group also had significantly greater competitive Kabaddi experience than the control group (4.06 ± 1.19 vs. 3.47 ± 1.11 years, $p = .035$). A 2 (Group: control, experimental) × 2 (Time: pre, post) mixed-design repeated-measures ANOVA was used to evaluate decision-making performance. Scores improved significantly from pre- to post-test across the full sample (control: 55.67 ± 8.76 to 75.25 ± 9.63 ; experimental: 51.69 ± 9.46 to 75.78 ± 10.24 ; main effect of Time, $F(1,70) = 192.86$, $p < .001$, $\eta^2 = 0.734$). However, neither the main effect of Group, $F(1,70) = 1.15$, $p = .288$, $\eta^2 = 0.016$, nor the Group × Time interaction, $F(1,70) = 2.05$, $p = .157$, $\eta^2 = 0.028$, reached statistical significance, indicating that the magnitude of improvement did not differ significantly between the experimental and control groups. These findings indicate that decision-making performance improved substantially over the six-week period regardless of group assignment but do not provide statistical evidence that structured cognitive training conferred an additional benefit beyond routine Kabaddi training in this sample. Adequately powered trials with an active control condition are needed to determine whether structured cognitive training produces effects beyond those of standard practice.

Keywords: Perceptual-cognitive expertise, attentional control; invasion sport athletes, tactical response accuracy, university-level athletes

Introduction

Kabaddi is a unique contact sport that demands simultaneous physical confrontation and continuous perceptual-cognitive processing within a single breath cycle. Successful raiding performance depends on rapid perception-action coupling, attentional control, and efficient tactical decision-making under severe temporal pressure.¹⁻³ Elite players demonstrate superior anticipatory abilities, perceptual attunement, and enhanced perceptual-cognitive expertise, enabling faster and more accurate responses during competitive play.^{1,2,4,5}

Unlike many invasion sports, Kabaddi uniquely integrates explosive physical effort with the cognitive demand of evaluating opponent positioning, identifying scoring opportunities, and executing tactical responses all within a single expiration. These requirements necessitate efficient information processing and rapid attentional adaptation, processes that have been shown to differentiate expert from novice athletes in invasion sports.⁴⁻⁷ Raiders must continuously process complex spatial cues and select appropriate motor responses under physiological constraint, making decision-making a defining performance determinant in Kabaddi.²

From an ecological dynamics perspective, decision-making in sport emerges through continuous interaction between the athlete, task demands, and environmental constraints rather than through isolated cognitive processing alone.^{3,6,7} In invasion sports, skilled performers develop superior perception-action coupling and adaptive attunement to informational cues, enabling more effective tactical responses under rapidly changing competitive conditions.^{3,5,6} Such theoretical perspectives may be particularly relevant to Kabaddi, where athletes must continuously regulate movement, spatial positioning, and tactical choices under severe temporal and physiological constraints.

Recent advances in sport science have directed increased attention toward cognitive training as a structured intervention to improve perceptual-cognitive skills.⁸

Controlled intervention studies in other invasion and racket sports provide direct empirical support for this approach, beyond theoretical rationale alone. Structured perceptual-cognitive training programmes have produced measurable improvements in reaction time, visual-scanning efficiency, and decision-making accuracy among skilled athletes,⁹ and elite athletes have been shown to acquire complex, dynamic visual-perceptual skills at a faster rate than non-athletes, indicating that the perceptual-cognitive capacities central to fast-paced invasion sports are trainable rather than fixed.¹⁰ Comparable cognitive-training paradigms have likewise been associated with improved executive function and on-field decision-making performance in other team-sport athletes,^{11,12} together suggesting that similar training-related adaptations are plausible in Kabaddi, given its comparable perceptual-cognitive demands.

Emerging evidence suggests that repeated exposure to cognitively demanding sport-specific stimuli may enhance perceptual-cognitive processing efficiency, including improvements in attentional control, visual processing speed, and decision-making accuracy among skilled athletes.^{4,7,8} Such adaptations may enable athletes to manage complex competitive stimuli more effectively under dynamic performance conditions.^{4,7,9}

Although perceptual-cognitive interventions have demonstrated benefits across football, basketball, and racket sports, transferability across sport contexts remains uncertain due to differences in task constraints, spatial-temporal demands, and perceptual information sources.

Kabaddi presents a particularly distinctive performance environment characterized by continuous physical contact, rapid tactical transitions, and severe temporal restrictions imposed by the single-breath raiding rule. Consequently, sport-specific investigation is necessary to determine whether perceptual-cognitive training adaptations translate effectively within this unique invasion sport context.

Despite growing recognition of perceptual-cognitive determinants in sport performance, no controlled experimental studies have examined the causal effects of structured cognitive training on decision-making specifically in Kabaddi players. The increasing internationalization of Kabaddi through professional leagues has intensified the need for evidence-based performance enhancement strategies. This represents an important gap within the contemporary sport science literature, given the sport's distinctive cognitive demands and its rapidly professionalizing competitive structure across South Asia. The present trial focused specifically on male competitive players; the rationale for this sampling decision, and its implications for generalizability, are detailed in the Methods and Discussion. Therefore, the purpose of the present study was to examine the effect of a six-week structured cognitive training programme on decision-making performance in competitive male Kabaddi players using a randomized controlled design. It was hypothesized that the experimental group would demonstrate significantly greater improvements in decision-making performance compared to the control group following the intervention.

Methods

Participants

Participants (N = 72) were recruited using purposive convenience sampling from male University Kabaddi teams at Lovely Professional University, with a minimum of two years of competitive playing experience. Recruitment was restricted to male athletes because, during the study period, Lovely Professional University had organized competitive men's Kabaddi teams that met the study's eligibility criteria, whereas no comparable women's competitive team was available for recruitment under the same training and competition conditions. Restricting the sample to a single sex also reduced biological and performance-related heterogeneity, thereby enhancing the internal validity of the intervention. Consequently, the findings should be interpreted as applicable only to male competitive university Kabaddi players and should not be generalized to female athletes or other populations. Future studies should replicate the present design in female competitive Kabaddi players to determine the generalizability of these findings. The participant recruitment, randomization, allocation, follow-up, and analysis process is presented in Figure 1. The baseline demographic characteristics of the study participants are summarized in Table 1.

Table 1. Baseline demographic characteristics of the participants (Mean $\pm$ SD).

Variable	Experimental (n=36)	Control (n=36)	t	P
Age (years)	21.33 $\pm$ 2.47	21.19 $\pm$ 2.35	0.24	0.808
Height (cm)	176.53 $\pm$ 1.84	176.56 $\pm$ 1.86	0.06	0.949
Body mass (kg)	70.75 $\pm$ 1.52	70.75 $\pm$ 1.16	0.00	1.000
Years of competitive Kabaddi experience	4.06 $\pm$ 1.19	3.47 $\pm$ 1.11	2.15	0.035

The experimental and control groups were comparable with respect to age (21.33 $\pm$ 2.47 vs. 21.19 $\pm$ 2.35 years, p = 0.808), height (176.53 $\pm$ 1.84 vs. 176.56 $\pm$ 1.86 cm, p = 0.949), and body mass (70.75 $\pm$ 1.52 vs. 70.75 $\pm$ 1.16 kg, p = 1.000). However, the experimental group had significantly greater competitive Kabaddi experience than the control group (4.06 $\pm$ 1.19 vs. 3.47 $\pm$ 1.11 years, t = 2.15, p = 0.035); we address the implications of this pre-existing imbalance in the Limitations.

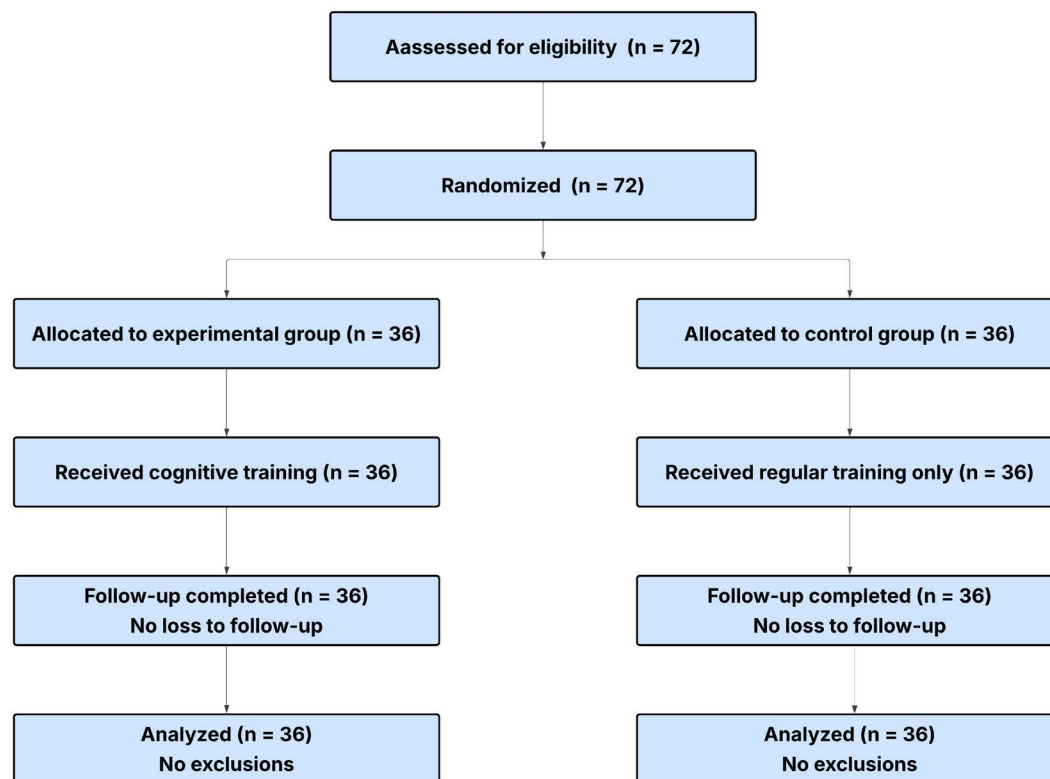


Figure 1. CONSORT flow diagram of participant recruitment, randomization, allocation, follow-up, and analysis.

An a priori power analysis conducted using G*Power 3.1.9.7 indicated that a minimum sample of 68 participants was required to detect a moderate effect size ($d = 0.50$) at an alpha level of 0.05 with 0.80 power for an independent-samples t-test. The moderate effect-size estimate and the conventional 0.80 power criterion were selected a priori based on effect sizes reported for analogous executive-function and perceptual-cognitive training interventions in other invasion-sport athletes,^{11,13} in the absence of any published Kabaddi-specific decision-making intervention data at the time of study design; 0.80 reflects the power threshold conventionally recommended for behavioral research.¹³ Participants were randomly allocated to an experimental group ($n = 36$) or control group ($n = 36$) using a computer-generated randomization sequence. Baseline decision-making assessments were completed for all participants before this randomization sequence was generated and applied by an independent researcher not involved in testing or training delivery, so that allocation could not be influenced by participants' baseline scores. A simple (non-stratified) randomization procedure was used, baseline decision-making score was not used as a stratification variable, which we acknowledge as a limitation. Allocation was concealed via sequentially numbered, sealed opaque envelopes prepared by an independent researcher. Post-intervention assessors were blinded to group allocation to minimize assessment bias; participant blinding was not feasible given the nature of the intervention. Because participants trained within the same university squads and shared common practice facilities, contamination between groups and psychosocial comparison effects (e.g., compensatory rivalry among control participants or resentful demoralization) could not be ruled out; only assessors, not participants, were blinded to allocation.

Inclusion criteria required active university-level competitive status, a minimum of two years of playing experience, and no concurrent participation in other structured cognitive training

programmes.⁸ Participants with any diagnosed neurological or psychological conditions were excluded. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and complied with internationally accepted standards for research involving human participants.¹⁴ Prior to data collection, institutional administrative permission and departmental research committee approval were obtained in accordance with institutional research guidelines.

All participants were informed about the purpose, procedures, and potential risks of the study before participation. Written informed consent was obtained from all participants, and participation was entirely voluntary. Participants were informed of their right to withdraw from the study at any stage without any consequences.

All personal information and participant data were anonymized, and confidentiality was strictly maintained throughout the research process. This research was carried out fully in accordance with the ethical standards of the International Journal of Exercise Science.¹⁵

Protocol

The experimental group completed a six-week cognitive training programme (5 sessions per week, 30–40 minutes per session) in addition to their regular Kabaddi practice. Training sessions incorporated structured sport-specific perceptual-cognitive drills targeting reaction time, visual scanning, attentional shifting, and situational judgment under progressively increasing cognitive demands. Intervention tasks included rapid stimulus-response drills using coach-directed movement cues, dynamic visual search activities requiring identification of multiple moving opponents, and simulated raiding scenarios involving time-constrained tactical decision-making under defensive pressure.

To support replication, session structure followed a standardized weekly template: sessions 1–2 emphasized foundational reaction-time and visual-scanning drills using coach-issued directional and colour cues at fixed response windows; sessions 3–4 introduced dynamic multi-opponent visual-search tasks requiring identification and tracking of 2–3 simulated defenders; sessions 5 integrated full simulated raiding scenarios combining time-constrained tactical decision-making with defensive pressure. The programme is summarized below by phase. The structure and progression of the six-week cognitive training programme are summarized in Table 2.

Table 2. Phase wise six-week cognitive training programme.

Phase	Weeks	Focus	Drill detail
1	1–2	Foundational reaction time & visual scanning	Simple and choice reaction-time drills using coloured light stimuli and directional visual cues (FitLight/BLAZEPOD or coloured cone/flash-card drills), peripheral vision scanning, rapid target identification, hand-/foot-touch response tasks. 4–5 drills per session (30–45s, 3 sets, 30s recovery), progressive stimulus frequency.
2	3–4	Dynamic visual search & attentional shifting	Multiple-object tracking, dynamic visual search, selective attention and attentional-shifting tasks combined with sport-specific footwork; moving visual stimuli, colour-number decision tasks, dual-choice responses, agility-ladder movements with unpredictable cues. 5–6 drills per session (45–60s, 3 sets), increasing cognitive load and reduced stimulus time.
3	5–6	Simulated raiding under defensive pressure (dual-task)	Game-specific cognitive-motor drills simulating Kabaddi raids: rapid tactical decisions against live defenders or coach-generated visual/verbal cues, optimal attacking-route selection, feint recognition, decision-making under time pressure with continuous movement. 6–8 raiding trials per session (30–60s, 3 sets), increasing defensive complexity.

Task complexity was systematically progressed across the six-week intervention by manipulating stimulus speed, spatial uncertainty, response-selection demands, and dual-task requirements to increase cognitive load while preserving sport-specific ecological validity. All training sessions were supervised by the research team and standardized using a pre-defined intervention framework to ensure procedural consistency across participants. The control group continued their routine Kabaddi training only, without any supplementary cognitive training component. The control group received no additional attention-matched activity (e.g., a non-cognitive supplementary session of equivalent duration and supervision); consequently, the design cannot fully separate the specific effect of the cognitive-training content from a general effect of additional supervised contact time, which we acknowledge explicitly as a limitation. Although the intervention protocol was standardized, formal adherence tracking and fidelity monitoring procedures were not implemented, which may limit verification of intervention consistency across sessions and should therefore be considered when interpreting the findings.

The assessment protocol was developed through expert consultation to maximize sport-specific ecological relevance. Although formal psychometric validation was beyond the scope of the present investigation, future studies should further examine reliability and construct validity characteristics.

Decision-making performance was assessed using a researcher-developed sport-specific field protocol designed to evaluate tactical response accuracy and response-selection speed during simulated Kabaddi raiding situations. The assessment tasks were developed in consultation with experienced Kabaddi coaches and sport science faculty to enhance content relevance, procedural clarity, and sport-specific applicability. Although the protocol was structured to reflect match-specific perceptual-cognitive demands, formal psychometric evaluation, including reliability and validity testing, was not conducted prior to implementation. Consequently, findings should be interpreted with appropriate caution, and future research should establish the instrument's test-retest reliability, inter-rater reliability, and construct validity.

Statistical Analysis

Data were analysed using IBM SPSS Statistics for Windows, Version 26 (IBM Corp., Armonk, NY, USA). Descriptive statistics are presented as mean $\pm$ standard deviation (SD). The normality of the data distribution was assessed using the Shapiro-Wilk test, and homogeneity of variances was evaluated using Levene's test. Independent-samples t-tests were performed to compare baseline demographic characteristics and pre-intervention outcome measures between the control and experimental groups. To evaluate the effects of the intervention, a 2 (Group: control vs. experimental) $\times$ 2 (Time: pre-test vs. post-test) mixed-design repeated-measures analysis of variance (ANOVA) was conducted for decision-making performance. Effect sizes for the ANOVA are reported as partial eta squared (η^2). Shapiro-Wilk tests indicated that decision-making scores departed significantly from a normal distribution in all four pre/post $\times$ group cells (experimental pre-test: $W = 0.893$, $p = .002$; control pre-test: $W = 0.935$, $p = .037$; experimental post-test: $W = 0.889$, $p = .002$; control post-test: $W = 0.908$, $p = .006$). Levene's test indicated that the assumption of homogeneity of variance was met for both pre-test ($p = .707$) and post-test ($p = .175$) scores. Because the normality assumption was violated, non-parametric sensitivity analyses, Wilcoxon signed-rank tests for within-group pre-to-post change and a Mann-Whitney U test for the between-group comparison of change scores were conducted alongside the primary ANOVA to verify the robustness of the main findings. Statistical significance was set at $p < .05$.

Results

The descriptive statistics for decision-making performance before and after the intervention are presented in Table 3.

Table 3. Descriptive statistics for decision-making performance before and after the intervention.

Group	Pre-test (Mean $\pm$ SD)	Post-test (Mean $\pm$ SD)
Control (n = 36)	55.67 $\pm$ 8.76	75.25 $\pm$ 9.63
Experimental (n = 36)	51.69 $\pm$ 9.46	75.78 $\pm$ 10.24

At baseline, the control and experimental groups' decision-making scores differed by approximately one-half SD; because scores departed significantly from a normal distribution (Shapiro-Wilk, all $p < .05$, reported below), this baseline difference was tested with both an independent-samples t-test ($t(70) = 1.85$, $p = .069$) and a Mann-Whitney U test ($U = 472.0$, $p = .048$) the two tests disagree at the conventional $\alpha = .05$ threshold, and this is addressed in the Limitations. The experimental group also began with significantly more years of Kabaddi experience (Table 1). Following the intervention, both groups demonstrated markedly higher post-test scores, converging on a similar post-test mean. The statistical significance of these changes was evaluated using a 2 $\times$ 2 mixed-design repeated-measures ANOVA, below.

The results of the within-subjects effects (Time and Group $\times$ Time interaction) from the mixed-design ANOVA are presented in Table 4.

Table 4. Tests of within-subjects effects (Time and Group $\times$ Time).

Effect	F	df	p	Partial η^2	Interpretation
Time	192.86	1,70	< .001	0.734	Significant improvement over time
Time $\times$ Group	2.05	1,70	.157	0.028	Not significant

The between-subjects effect (Group) obtained from the mixed-design ANOVA is presented in Table 5.

Table 5. Test of between-subjects effects (Group).

Effect	F	df	p	Partial η^2	Interpretation
Group	1.15	1,70	.288	0.016	No overall group difference

A 2 (Group: control vs. experimental) $\times$ 2 (Time: pre-test vs. post-test) mixed-design repeated-measures ANOVA revealed a significant main effect of Time, $F(1,70) = 192.86$, $p < .001$, $\eta^2 = 0.734$, indicating that decision-making scores improved significantly from pre-test to post-test across all participants. The main effect of Group was not significant, $F(1,70) = 1.15$, $p = .288$, $\eta^2 = 0.016$, indicating no overall difference between the experimental and control groups. The Group $\times$ Time interaction was also not significant, $F(1,70) = 2.05$, $p = .157$, $\eta^2 = 0.028$, indicating that the magnitude of improvement over time did not differ significantly between the two groups. In other words, both groups improved substantially over the six-week period, but this trial does not provide statistical evidence that the addition of structured cognitive training produced a significantly greater improvement in decision-making performance than routine Kabaddi training alone.

Because decision-making scores departed significantly from a normal distribution (Statistical Analysis, above), non-parametric sensitivity analyses were conducted to verify these conclusions.

Wilcoxon signed-rank tests confirmed significant within-group improvement in both the experimental ($p < .001$) and control ($p < .001$) groups, consistent with the ANOVA's main effect of Time. A Mann-Whitney U test on individual pre-to-post change scores found no significant difference between groups ($U = 778.5$, $p = .143$; median change: experimental = 23.5, control = 20.5), corroborating the non-significant Group $\times$ Time interaction from the ANOVA. The primary conclusion that decision-making improved substantially in both groups without a significant between-group difference in the amount of improvement therefore held under both parametric and non-parametric approaches.

Discussion

The primary finding of the present study is that decision-making performance improved significantly over a six-week period among competitive male Kabaddi players, regardless of whether athletes received the structured cognitive training programme in addition to routine practice or continued routine practice alone. The magnitude of improvement was numerically similar between the experimental group (51.69 $\rightarrow$ 75.78) and the control group (55.67 $\rightarrow$ 75.25), and the Group $\times$ Time interaction was not statistically significant ($p = .157$). This trial therefore does not provide statistical evidence that structured cognitive training conferred an additional benefit in decision-making performance beyond that produced by routine sport-specific practice over the same period.

Several non-mutually-exclusive explanations may account for the substantial improvement observed across both groups. Repeated exposure to the field-based decision-making assessment itself may have produced a practice or test-familiarity effect, independent of any training content.¹ Continued participation in regular, in-season competitive Kabaddi training may itself provide sufficient perceptual-cognitive stimulation to drive comparable gains in tactical decision-making, consistent with an ecological dynamics view in which skill emerges through everyday task-representative practice rather than requiring an isolated cognitive-training add-on.³ It is also possible that the six-week window and/or the sample size, while adequately powered for the originally planned between-groups comparison, was underpowered to detect a Group $\times$ Time interaction of the magnitude actually present; the observed interaction effect size ($\eta^2 = 0.028$) is small, and a substantially larger sample would be required to determine whether a true, smaller interaction effect exists. We did not measure underlying neurocognitive mechanisms directly, so any explanation for the shared improvement across groups remains inferential; future studies incorporating neurocognitive testing (e.g., choice-reaction-time tasks, eye-tracking of visual search patterns, or event-related potential measures), an active control condition, and a larger sample would help distinguish between these explanations.

These findings carry implications for practitioners working in Kabaddi and related invasion sports. While the present trial does not demonstrate an additive benefit of the specific structured cognitive-training programme tested here, it does show that decision-making performance is trainable/improvable over a relatively short period within an active competitive season, which is itself consistent with prior theoretical work on perceptual-cognitive expertise in sport.¹¹ Whether structured, supplementary cognitive drills of the kind used here offer benefit beyond routine practice remains an open empirical question that this trial, as designed and powered, cannot resolve.

Several limitations should be considered when interpreting the findings of the present study. First, the sample was restricted to male university-level Kabaddi players recruited from Lovely

Professional University, Punjab, India. Recruitment was limited to male athletes because, during the study period, only organized competitive men's Kabaddi teams meeting the study's eligibility criteria were available at the study site. Consequently, the findings are applicable only to male competitive university Kabaddi players and should not be generalized to female athletes or athletes from other competitive levels without further empirical evidence.

Second, the study population was limited to university athletes from a single institution, which may reduce the external validity of the findings across different geographical regions, age groups, and levels of competition. Third, the intervention was conducted over a relatively short duration, and no long-term follow-up assessment was performed to determine the retention of training-induced improvements. The absence of formal psychometric validation for the decision-making assessment protocol represents a noteworthy methodological limitation, and the lack of formal adherence tracking introduces uncertainty regarding intervention fidelity in the experimental group.

Critically, the trial's primary hypothesis test the Group $\times$ Time interaction was not statistically significant, and the main effect of Group was likewise non-significant. This trial therefore did not find evidence that structured cognitive training produced a benefit beyond routine training. Several design features may have limited our ability to detect a true between-group effect, if one exists: the control group received no attention-matched activity of equivalent contact time, so any true training-specific effect may have been partially masked by non-specific benefits of additional supervised contact experienced by the experimental group (working in the opposite direction of the null result actually observed, which somewhat strengthens confidence in it), the experimental group began the study with significantly more competitive Kabaddi experience than the control group (Table 1), a baseline imbalance we could not statistically adjust for in the present ANOVA, decision-making scores also departed significantly from a normal distribution, and while non-parametric sensitivity analyses corroborated the ANOVA's non-significant Group $\times$ Time interaction, baseline pre-test equivalence itself was more equivocal significant by Mann-Whitney U ($p = .048$) but not by independent-samples t-test ($p = .069$) so baseline non-equivalence cannot be fully ruled out, participant-level randomization within shared university squads could not fully rule out contamination or psychosocial comparison effects between groups, and the sample, while adequately powered for the originally planned t-test comparison, may be underpowered to detect a smaller true interaction effect. Cluster-randomized (team-level) allocation, an active control condition, statistical adjustment for baseline experience and baseline score (e.g., via ANCOVA), and a larger sample are recommended for future trials seeking to more definitively test whether structured cognitive training adds value beyond routine Kabaddi practice.

Future research should address these limitations by employing validated assessment instruments, incorporating longitudinal follow-up measures, extending samples to include female and elite-level athletes, and implementing systematic fidelity monitoring. It is also possible that participation in Kabaddi itself provides sufficient perceptual-cognitive stimulation to produce the improvements observed in both groups; this possibility is consistent with the more experienced experimental group's higher baseline decision-making score and the apparent convergence of both groups toward a similar post-test level, suggestive of a potential ceiling effect. Future studies may therefore benefit from comparing Kabaddi players to practitioners of other sports at comparable skill levels (e.g., novice or intermediate-level athletes within each sport) to better isolate any incremental effect of structured cognitive training from the perceptual-cognitive demands of Kabaddi participation itself.

Conclusion

The present study found that decision-making performance improved significantly over a six-week period among competitive male Kabaddi players but did not find statistical evidence that a structured cognitive training programme produced a significantly greater improvement than routine Kabaddi training alone (Group $\times$ Time interaction: $F(1,70) = 2.05$, $p = .157$). These findings should be interpreted as a preliminary, non-significant result rather than as evidence against a possible training effect: several design limitations including the absence of an active control condition, a baseline imbalance in playing experience, and potentially limited power to detect a smaller interaction effect mean that a true additive benefit of structured cognitive training cannot be ruled out. Coaches and sport scientists should treat the additive value of structured perceptual-cognitive drills in Kabaddi as an open question pending larger, more rigorously controlled trials, ideally incorporating an active control condition, stratified randomization on playing experience, and objective neurocognitive outcome measures. These conclusions are specific to male, university-level competitive players, extension to female and elite-level cohorts remains an important direction for future research.

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Conflict of interest notification

The authors declare no conflicts of interest, financial or otherwise, with respect to the research, authorship, or publication of this article.

References

1. Raab M. Simple heuristics in sports. *Int Rev Sport Exerc Psychol.* 2012;5(2):104-120. <https://doi.org/10.1080/1750984X.2012.654810>
2. Williams AM, Ford PR. Expertise and expert performance in sport. *Int Rev Sport Exerc Psychol.* 2008;1(1):4-18. <https://doi.org/10.1080/17509840701836867>
3. Araújo D, Davids K, Hristovski R. The ecological dynamics of decision making in sport. *Psychol Sport Exerc.* 2006;7(6):653-676. <https://doi.org/10.1016/j.psychsport.2006.07.002>
4. Mann DTY, Williams AM, Ward P, Janelle CM. Perceptual-cognitive expertise in sport: A meta-analysis. *J Sport Exerc Psychol.* 2007;29(4):457-478. <https://doi.org/10.1123/jsep.29.4.457>
5. Williams AM, Jackson RC. Anticipation and decision making in sport. In: Tenenbaum G, Eklund RC, eds. *Handbook of Sport Psychology*. 4th ed. Wiley; 2019:248-273.
6. Hodges NJ, Williams AM, eds. *Skill Acquisition in Sport: Research, Theory and Practice*. 2nd ed. Routledge; 2012.
7. Davids K, Araújo D, Vilar L, Renshaw I, Pinder R. An ecological dynamics approach to skill acquisition: Implications for development of talent in sport. *Talent Dev Excell.* 2013;5(1):21-34.
8. Voss MW, Kramer AF, Basak C, Prakash RS, Roberts B. Are expert athletes “expert” in the cognitive laboratory? A meta-analytic review of cognition and sport expertise. *Appl Cogn Psychol.* 2010;24(6):812-826. <https://doi.org/10.1002/acp.1588>

9. Faubert J, Sidebottom L. Perceptual-cognitive training of athletes. *J Clin Sport Psychol.* 2012;6(1):85-102. <https://doi.org/10.1123/jcsp.6.1.85>
10. Faubert J. Professional athletes have extraordinary skills for rapidly learning complex dynamic visual scenes. *Sci Rep.* 2013;3:1154. <https://doi.org/10.1038/srep01154>
11. Vestberg T, Reinebo G, Maurex L, Ingvar M, Petrovic P. Core executive functions are associated with success in young elite soccer players. *PLoS ONE.* 2017;12(2):e0170845. <https://doi.org/10.1371/journal.pone.0170845>
12. Herold F, Hamacher D, Schega L. Thinking while moving or moving while thinking: Concepts of motor-cognitive training for cognitive performance enhancement. *Front Aging Neurosci.* 2018;10:228. <https://doi.org/10.3389/fnagi.2018.00228>
13. Cohen J. Statistical Power Analysis for the Behavioral Sciences. 2nd ed. Lawrence Erlbaum Associates; 1988.
14. World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA.* 2013;310(20):2191-2194. <https://doi.org/10.1001/jama.2013.281053>
15. Navalta JW, Stone WJ, Lyons TS. Ethical issues relating to scientific discovery in exercise science. *Int J Exerc Sci.* 2019;12(1):1-8. <https://doi.org/10.70252/EYCD6235>

