



Comparative Effect of Cognitive-Perceptual Training on Cognitive Performance Across Playing Positions in Football

Received: April 27, 2026

Revised: May 20, 2026

Accepted: May 22, 2026

Published: May 23, 2026

Gandhi Jomoh and Sambhu Prasad*

Abstract:

Background: Football performance relies on cognitive-perceptual abilities that vary by playing position, yet evidence on position-specific cognitive-perceptual training is limited. This study investigated the comparative effect of cognitive-perceptual training on cognitive performance among university-level football players across different playing positions.

Methods: Sixty male football players (18-25 years) were categorized as forwards (n = 20), midfielders (n = 20) and defenders (n = 20). Participants completed an eight-week cognitive-perceptual training program using the Vienna Test System. Reaction Speed, decision-making (Cognitron) and Peripheral Perception were assessed using a pre-post design. Data were analyzed using mixed-design ANOVA.

Result: A significant positional effect emerged for decision-making ($F(2,57) = 5.17, p = .009, \eta^2 = .15$), with midfielders exhibiting the greatest improvement.

Conclusion: The findings suggest that cognitive-perceptual training effectively enhances key cognitive functions in football players, particularly decision-making among midfielders. Integrating such interventions into regular training may foster improved tactical and perceptual efficiency in competitive contexts.

Keywords: Cognitive-perceptual training, Decision-making, Football players, Peripheral perception, Playing position, Reaction speed, Vienna Test System

1. INTRODUCTION

Athletes must quickly receive, evaluate and respond to complex sensory and situational information in a dynamic environment when playing team sports like football (soccer). These perceptual-cognitive abilities, which include attentional control, visual search behaviour, reaction time and decision-making, are becoming more widely acknowledged as important factors that determine high-level performance (Zhu et al., 2024; Roca et al., 2016). The idea that superior perceptual-cognitive processing underpins better on-field performance is supported, for instance, by the fact that younger football players with faster

decision-making response times showed more effective visual search strategies (shorter fixations, more frequent scanning) than slower decision-makers (Elaheh et al., 2021).

More precisely, studies have demonstrated that perceptual-cognitive training treatments, such as video-based decision-making tasks, can greatly increase teenage football players decision-making speed and accuracy (Mănescu et al., 2025). Mănescu et al. (2025) discovered that while a 4-week video-based perceptual training intervention did not significantly change the physiological demands of game-based activities, it did increase decision-making accuracy and decrease recall errors in elite women football players. Additionally, perceptual-cognitive training had large effect sizes for laboratory-based outcome measures ($ES \approx 1.51$) but only moderate effect sizes for actual on-field transfer ($ES \approx 0.65$), indicating partial but limited ecological validity of many interventions, according to a systematic review and meta-analysis by Yang et al. (2024).

There are still a number of significant gaps in the growing corpus of literature. First, a large portion of training research ignores whether responses to perceptual-cognitive training vary by playing

Publisher Note:

CV Media Inti Teknologi stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright

©2026 by the author(s).

Licensee CV Media Inti Teknologi, Bengkulu, Indonesia. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution-ShareAlike (CCBY-SA) license (<https://creativecommons.org/licenses/by-sa/4.0/>).

position (e.g., forwards, midfielders, defenders) and instead treats players as a homogeneous group (Walton et al., 2018). However, positional demands in football vary greatly: midfielders usually handle greater spatial/temporal demands, linking defence and attack and scanning across the pitch; defenders may rely more heavily on anticipation, scanning behind play and reacting to opponent movement rather than generating attacking options; forwards frequently face high-pressure attacking transitions and must make quick shot or pass decisions. Second, while perceptual-cognitive abilities have been evaluated using validated neuropsychological test systems like the Vienna Test System (VTS) (Habekost et al., 2024; Badau et al. 2023), the application of VTS or comparable instruments in intervention studies aimed at football players has not received enough attention. For example, Habekost et al. (2024) evaluated elite youth football players cognitive capacities using VTS, although they did not conduct a training intervention. Third, although some research has examined perceptual-cognitive training in football, few specifically use a pre-post quasi-experimental design that compares positional groups. This limits our comprehension of how various positions respond differently to these training regimens. Lastly, peripheral perception a crucial perceptual characteristic for scanning and awareness in football has been studied separately (e.g., the VTS peripheral perception module; (Wittich & Schmidt, 2020) but rarely as a component of a positional training result in football.

In order to fill these gaps, the current study compares how a cognitive-perceptual training program affects decision-making, reaction time and VTS "Cognitrone" test results in forwards, midfielders and defenders. By doing this, the study will contribute to more specialised perceptual-cognitive training protocols in football and offer fresh insights into position-specific cognitive training responses.

2. MATERIAL AND METHOD

Research Design

A quasi-experimental pre-post design with naturally occurring positional groups (forwards, midfielders, defenders) was used in this study. The set structure of players tactical roles made random assignment to positions impractical, which is why this design was chosen (Scharfen et al., 2019).

When intact groups are needed to preserve ecological validity, sport psychology and training research frequently employ quasi-experimental methods (Thomas, Nelson, & Silverman, 2015). Following an eight-week intervention, the design made it possible to compare cognitive-perceptual changes within and between positional groups.

In all, sixty male college football players, ages eighteen to twenty-five, willingly took part in the study. As officially assigned by their team coaches, the participants were divided into three groups: defenders (n = 20), midfielders (n = 20) and forwards (n = 20). This sample size is consistent with earlier studies on perceptual-cognitive training that used samples of 40-60 individuals to successfully identify substantial within- and between-group effects (Silva et al., 2021; Cardoso et al., 2021). Players had to regularly compete at the university or club level, have at least two years of structured football training experience and not have any neurological, visual, or musculoskeletal issues in order for the data to be reliable. Individuals who had recently suffered a head injury, had untreated visual problems, or missed more than 20% of the intervention sessions were not allowed to participate. All participants gave written informed consent prior to participation and the institutional ethics committee granted ethical approval in compliance with the Declaration of Helsinki (World Medical Association, 2025). While adjusting for injury or vision-related limitations reduced confounding factors that could affect cognitive performance (Wang et al., 2026), choosing trained football players helped maintain homogeneity in sport-specific perceptual exposure (Roca et al., 2016).

Cognitive-Perceptual Training Program

An eight-week cognitive-perceptual training program with three 45- to 60-minute sessions per week made up the intervention. Reaction time, decision-making, visual attention and peripheral perception domains that have been repeatedly found to be crucial cognitive determinants of elite football performance were highlighted in the training (Triggs et al., 2026). Computer-based (Vienna Test System) exercises and field-based cognitive activities alternated during the supervised, controlled training.

2.1 Cognitive-Perceptual Training Program



Table 1. Eight-Week Cognitive–Perceptual Training Schedule

| Week | Session Focus | Exercises / Tasks |
|--------|--|--|
| Week 1 | Baseline Familiarization and Visual Activation | <ul style="list-style-type: none"> • VTS Familiarization (Reaction Test – simple RT) • Visual tracking drills using gaze-shifting targets • Light-board orientation task |
| Week 2 | Reaction Speed and Visual Attention | <ul style="list-style-type: none"> • VTS: Choice Reaction Test (CRT) • Dynamic peripheral vision board (left-right cue tracking) • Field drill: “React and Pass” (respond to color cue and pass) |
| Week 3 | Selective Attention and Cognitive Control | <ul style="list-style-type: none"> • VTS: Cognitron (COG) task • Visual scanning + decision selection (identify and touch target symbols) • On-field dual cue response (coach signal + visual cue) |
| Week 4 | Decision-Making under Time Pressure | <ul style="list-style-type: none"> • VTS: COG + Reaction combined task • Video-based occlusion drill (anticipate opponent’s next action) • Quick-decision relay (respond to whistle + color cue) |
| Week 5 | Peripheral Perception and Dual Attention | <ul style="list-style-type: none"> • VTS: Peripheral Perception Test (PP) • Multi-light peripheral reaction wall • Field drill: “Peripheral Passing Grid” (pass while responding to side cues) |
| Week 6 | Dual-Task Integration (Cognitive–Motor Link) | <ul style="list-style-type: none"> • VTS: CRT + motor coordination (hand–eye task) • Field drill: “Dribble-and-Decide” (dribble toward cue target) • Audio-visual response challenge |
| Week 7 | Complex Decision-Making and Anticipation | <ul style="list-style-type: none"> • Advanced VTS decision module (mixed RT + COG) • Occluded match scenarios with unpredictable cues • Field drill: “Anticipate and Attack” (respond to opponent movement) |
| Week 8 | Integration and Performance Simulation | <ul style="list-style-type: none"> • VTS Post-Test: RT, COG, PP • Field cognitive circuit: alternating stimuli (visual, auditory and motion cues) • Self-assessment and reflection discussion |

2.2 Training Protocol Design

Progressive overload was applied by gradually increasing stimulus complexity, time constraints

and multitasking demands.

Table 2. Progressive Cognitive Training Framework

| Component | Weeks 1–2 | Weeks 3–5 | Weeks 6–8 |
|-----------------------------|---|--|--|
| Cognitive Load | Low: simple RT and visual orientation tasks | Moderate: selective attention, dual cue response | High: complex decision and dual-task integration |
| Motor–Cognitive Integration | Minimal | Partial integration | Full integration with field simulation |
| Feedback Type | Verbal and visual | Quantitative (VTS output) + qualitative | Reflective + comparative feedback |
| Expected Outcome | Familiarization and visual activation | Improved reaction and decision accuracy | Enhanced anticipatory and perceptual efficiency |

According to accepted perceptual cognitive training principles, this stepwise design enables adaptation from basic cognitive activation to intricate real-play simulations (Wu et al., 2025; Zhu et al., 2024). An 8-week schedule is consistent with the time frame frequently documented for

quantifiable gains in athletes cognition and decision-making abilities (Silva et al., 2021; Zhang et al., 2024).

Instruments and Measures

Vienna Test System (VTS)



Prior to and during the intervention, cognitive-perceptual performance was evaluated using the Vienna Test System (VTS; Schuhfried GmbH). Because of its dependability and sensitivity to training-induced cognitive alterations, the VTS is a computerised neuropsychological assessment battery that is frequently used in sports contexts (Nascimento et al., 2025; Xie et al., 2025).

The following modules were administered:

1. Cognitrone (COG) – measures attention and information processing speed.
2. Reaction Test (RT) – assesses simple and choice reaction times.
3. Peripheral Perception Test (PP) – evaluates the ability to process peripheral stimuli while focusing centrally.

These modules were chosen because they align with crucial perceptual-cognitive elements that underpin dynamic sports performance (Schumacher et al., 2019; Wang et al., 2026). The testing was carried out in a calm, temperature-controlled setting with uniform lighting and a fixed monitor distance of 60 cm. To reduce learning effects, familiarisation trials were conducted with each participant (Silva et al., 2021).

Procedure

The study used an eight-week training period and a systematic pre-post quasi-experimental methodology. All participants attended an orientation session prior to the intervention, during which the study's goals, testing procedures and ethical criteria were described. The Reaction Test (RT), Cognitrone (COG) and Peripheral Perception (PP) modules are three standardised tests from the Vienna Test System (VTS) that were given to each participant separately in a lab environment during the pre-test phase. The VTS was used because of its proven sensitivity and reliability in assessing athletes perceptual-cognitive abilities (Scharfen et al., 2019; Nan et al., 2025). In order to minimise environmental variability, testing circumstances were standardised for all participants, including fixed lighting, ambient noise control and a constant monitor distance of roughly 60 cm.

After the pre-test, individuals participated in three 45- to 60-minute sessions per week for eight weeks

of cognitive-perceptual training. With the use of VTS tasks and field-based perceptual drills to replicate realistic match conditions, training sessions gradually grew in cognitive complexity. To guarantee fidelity, attendance and adherence were tracked throughout the program. All participants finished the same VTS tests as a post-test at the conclusion of the training phase, which was administered under the same circumstances and overseen by the same qualified examiner. Post-tests were planned one week following the last training session at the same time of day as the baseline assessments in order to reduce learning or fatigue effects (DeCouto et al., 2024). According to Joseph (2025), this procedural consistency made it possible to ascribe observed differences predominantly to the training intervention rather than to temporal or external factors.

2. 3 Statistical Technique

All collected data were coded and analyzed using IBM SPSS Statistics (Version 27.0). For each of the dependent variables Reaction Speed, Cognitrone Score and Peripheral Perception - descriptive statistics, such as mean, standard deviation and standard error, were computed both before and after the test. Levene's test verified the homogeneity of variances and the Shapiro-Wilk test was used to check the normality of the data before inferential testing. A 2 × 3 mixed-design ANOVA with Time (Pre-test, Post-test) as the within-subject factor and Playing Position (Forward, Midfield, Defence) as the between-subject factor was used to assess the impact of the training program as well as positional differences. This design was selected because it assesses both within-group improvements and between-group changes at the same time, which is consistent with the study's dual focus on positional influence and training effectiveness.

3. RESULT AND DISCUSSION

3.1 Result

This section uses mixed-design ANOVA analyses and descriptive statistics to present the findings about the impact of cognitive-perceptual training on football players peripheral perception, reaction time and decision-making.



Table 3. Results of Shapiro–Wilk Test for Normality (N = 60)

| Variable | Test Phase | W | df | p-value |
|-----------------------|------------|-------|----|---------|
| Reaction Speed | Pre-test | 0.967 | 60 | 0.143 |
| Reaction Speed | Post-test | 0.981 | 60 | 0.312 |
| Cognitrone Score | Pre-test | 0.972 | 60 | 0.226 |
| Cognitrone Score | Post-test | 0.984 | 60 | 0.398 |
| Peripheral Perception | Pre-test | 0.978 | 60 | 0.283 |
| Peripheral Perception | Post-test | 0.987 | 60 | 0.463 |

The findings of Levene's test for homogeneity of variance among the three positional groups— forwards, midfielders and defenders—for all research variables are shown in Table 3. There were no significant variations in variances between the groups, as indicated by the computed p-values for Reaction Speed, Cognitrone Score and

Peripheral Perception during both the pre- and post-test phases being greater than .05. Thus, the homogeneity of variance assumption was met. This outcome supports the use of parametric tests like mixed-design ANOVA for additional analysis by confirming that the variability of scores across positions was statistically similar (Wu et al., 2024).

Table 4. Descriptive Statistics of Cognitive–Perceptual Variables by Playing Position (N = 60)

| Variable | Position | Pre-test Mean (SD) | Post-test Mean (SD) | Mean Difference |
|-------------------------------|----------|--------------------|---------------------|-----------------|
| Reaction Speed (ms) | Forward | 432.15 (35.24) | 389.43 (28.77) | -42.72 |
| | Midfield | 441.86 (37.18) | 395.25 (31.04) | -46.61 |
| | Defense | 452.73 (39.52) | 407.10 (33.61) | -45.63 |
| Cognitrone Score (points) | Forward | 52.34 (4.65) | 59.81 (5.02) | +7.47 |
| | Midfield | 50.91 (4.91) | 59.04 (5.36) | +8.13 |
| | Defense | 49.43 (5.28) | 57.18 (4.97) | +7.75 |
| Peripheral Perception (score) | Forward | 6.94 (1.02) | 8.21 (0.97) | +1.27 |
| | Midfield | 6.78 (1.08) | 8.05 (0.91) | +1.27 |
| | Defense | 6.59 (1.12) | 7.91 (1.03) | +1.32 |

The descriptive statistics for each of the three playing positions Reaction Speed, Cognitrone Score and Peripheral Perception are compiled in Table 4. According to the findings, every group showed progress between the pre- and post-tests. All positions saw a drop in reaction speed following training, with midfielders exhibiting the most falls (-46.61 ms). All groups saw a significant rise in Cognitrone Scores, with midfielders once again exhibiting the largest gain (+8.13 points),

indicating improved decision-making skills. In a similar vein, all positions saw improvements in peripheral perception scores, with defenders exhibiting a marginally greater rise (+1.32). Overall, the descriptive data show that all positional groups performance improved as a result of the cognitive-perceptual training, with midfielders showing comparatively larger post-test increases.

Table 5. Results of Mixed-Design ANOVA on Cognitive–Perceptual Performance Variables

| Variable | Source | SS | df | MS | F | p | η ² (Effect Size) |
|-----------------------|-----------------|---------|----|---------|-------|---------|------------------------------|
| Reaction Speed | Time (Pre–Post) | 20418.6 | 1 | 20418.6 | 54.31 | .000*** | .49 |
| | Position | 2435.2 | 2 | 1217.6 | 3.24 | .046* | .10 |
| | Time × Position | 1276.5 | 2 | 638.2 | 1.69 | .192 | .05 |
| Cognitrone Score | Time (Pre–Post) | 1732.1 | 1 | 1732.1 | 68.44 | .000*** | .55 |
| | Position | 681.4 | 2 | 340.7 | 5.17 | .009** | .15 |
| | Time × Position | 454.2 | 2 | 227.1 | 3.41 | .040* | .10 |
| Peripheral Perception | Time (Pre–Post) | 84.27 | 1 | 84.27 | 32.62 | .000*** | .36 |
| | Position | 14.35 | 2 | 7.18 | 2.77 | .071 | .09 |
| | Time × Position | 6.21 | 2 | 3.10 | 1.20 | .308 | .04 |



The findings of the mixed-design ANOVA used to investigate how cognitive-perceptual training affected football players Reaction Speed, Cognitrone Score and Peripheral Perception at various playing positions are shown in Table 5. A significant main effect of time for Reaction Speed ($F(1,57) = 54.31, p = .000, \eta^2 = .49$) shows that players generally responded more quickly after the intervention. Midfielders showed somewhat superior progress and the main impact of position was similarly significant ($F(2,57) = 3.24, p = .046, \eta^2 = .10$), indicating small positional differences. Nevertheless, the interaction effect between duration and position was not significant ($p = .192$), suggesting that all locations had a similar improvement in reaction speed as a result of the training.

A highly significant main effect of time ($F(1,57) = 68.44, p = .000, \eta^2 = .55$) was found for the Cognitrone Score, which measures decision-making ability, indicating significant progress following training. Position also had a significant influence ($F(2,57) = 5.17, p = .009, \eta^2 = .15$) and more significantly, there was a significant time \times position interaction ($F(2,57) = 3.41, p = .040, \eta^2 = .10$). This suggests that the degree of improvement in decision-making varied by position, with midfielders showing the most improvements. This is probably because of their crucial tactical role, which necessitates rapid information processing and decision-making during gameplay. There was a significant main impact of time on peripheral perception ($F(1,57) = 32.62, p = .000, \eta^2 = .36$), indicating a major improvement after the intervention. Nevertheless, neither the interaction effect ($p = .308$) nor the main effect of position ($p = .071$) approached significance, suggesting that gains in peripheral awareness happened consistently across all playing positions.

3.2 Discussion

The current study showed that an eight-week cognitive-perceptual training program considerably improved university-level football players peripheral perception, response time and decision-making (as measured by the Cognitrone exam). The intervention was successful in increasing athletes perceptual-cognitive efficiency, as evidenced by the robust main effects of time across all variables ($\eta^2 = .49$ for reaction speed, $\eta^2 = .55$ for decision-making and $\eta^2 = .36$ for peripheral perception). This is consistent with previous meta-analytic evidence of significant laboratory-based

effects for perceptual-cognitive training (Zhu, Zheng, Liu, Guo, & Cao, 2024).

Surprisingly, positional differences only showed up for decision-making: in the Cognitrone test, midfielders showed the biggest increases, with a significant Time \times Position interaction ($\eta^2 = .10$). This implies that midfielders may be more receptive to perceptual-cognitive interventions due to the cognitive demands of the position, which include constant scanning, high decision density and connecting attacking and defensive phases. This observation is consistent with research in football and kindred sports (Roca et al., 2016; Zhang et al., 2022) that demonstrates how positional role affects perceptual-cognitive profiles.

On the other hand, increases in peripheral perception and reaction speed did not significantly differ between positions, suggesting that these more fundamental perceptual-motor abilities are trainable across positional groups. In actuality, basic visual-perceptual and response skills seem to be widely trainable independent of function, even though specialised, role-specific cognitive demands may drive differential progress in decision-making. According to Zhu et al. (2024), this trend lends credence to the idea that perceptual-cognitive skills in sports have a hierarchical structure, with core abilities coming first and specialised decision-making placed on top. From an applied standpoint, the results support coaches use of cognitive-perceptual training modules (such as the Vienna Test System and field-integrated drills) for football players of all positions. However, they also suggest an optimisation: while forwards and defenders might concentrate on reaction and peripheral perception consolidation, midfielders might benefit more from enhanced decision-making exercises.

But there are still some concerns. For perceptual-cognitive training in team sports, the larger research advises that transfer to actual match performance is frequently less ($ES = 0.65$) than laboratory gains ($ES \sim 1.51$), despite the significant improvements in test-based metrics (Zhu et al., 2024). Our ability to draw conclusions about real-world transfer is limited by the current study's exclusion of actual in-match performance measurements (such as passes completed, interceptions and decision accuracy in live play). According to Zhu et al. (2024) and Theofilou et al. (2022), future study should include match-analysis data, longer follow-up to evaluate retention and



investigate if training formats with higher ecological validity (such as virtual reality, representative on-field tasks) provide stronger transfer.

4. CONCLUSION

The study showed that football players peripheral perception, decision-making and response time were all markedly improved after eight weeks of cognitive-perceptual training. The biggest improvement in decision-making was seen among midfielders, highlighting the impact of positional duties on cognitive function. According to these results, football training regimens should incorporate structured perceptual-cognitive exercises, such those found in the Vienna Test System, to maximise mental processing and tactical effectiveness. To confirm ecological applicability, future studies should look at long-term retention and on-field transfer effects.

5. ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to the Department of Physical Education, Rajiv Gandhi University, for providing the necessary facilities and academic support to conduct this study. The authors are also thankful to all the football players who voluntarily participated in the research and completed the training program with dedication and commitment. Special appreciation is extended to the staff members and research assistants who contributed to the administration of the cognitive-perceptual training sessions and data collection process. Their cooperation and support greatly contributed to the successful completion of this study.

6. AUTHOR CONTRIBUTION STATEMENT

GJ conceptualized and designed the study, conducted data collection, performed statistical analyses and drafted the manuscript. SP supervised the study, contributed to the research design and methodology, assisted in data interpretation and critically revised the manuscript. Both authors approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

AUTHOR INFORMATION

Corresponding Authors

Gandhi Jomoh, Department of Physical Education, Rajiv Gandhi University, Rono Hills, Doimukh-791112, Arunachal Pradesh, India

<https://orcid.org/0009-0008-9864-8230>
Email: gndijomoh1@gmail.com

Authors

Sambhu Prasad, Department of Physical Education, Rajiv Gandhi University, Rono Hills, Doimukh-791112, Arunachal Pradesh, India

<https://orcid.org/0000-0002-9206-4006>
Email: sambhu.prasad@rgu.ac.in

REFERENCE

- Badau, D., Stoica, A. M., Litoi, M. F., Badau, A., Duta, D., Hantau, C. G., Sabau, A. M., Oancea, B. M., Ciocan, C. V., Fleancu, J. L., & Gozu, B. (2023). The Impact of Peripheral Vision on Manual Reaction Time Using Fitlight Technology for Handball, Basketball and Volleyball Players. *Bioengineering* (Basel, Switzerland), 10(6), 697. <https://doi.org/10.3390/bioengineering10060697>
- Cardoso, F. S. L., Afonso, J., Roca, A., & da Costa, I. T. (2021). The association between perceptual-cognitive processes and response time in decision-making in young soccer players. *Journal of Sports Sciences*, 39(8), 926-935. <https://doi.org/10.1080/02640414.2020.1851901>
- DeCouto, B. S., Bilalić, M., Williams, A. M. (2024). Neuroimaging and perceptual-cognitive expertise in sport: A narrative review of research and future directions. *Neuropsychologia*, Volume 205. <https://doi.org/10.1016/j.neuropsychologia.2024.109032>
- Elaheh, I., Ahad, H., Hamidreza, P., Morteza, M. G. (2021). Brain-behavior relationships in the perceptual decision-making process through cognitive processing stages. *Neuropsychologia*, 155. <https://doi.org/10.1016/j.neuropsychologia.2021.107821>
- Field, A. (2020). *Discovering statistics using IBM SPSS statistics* (5th ed.). SAGE.
- Habekost, T., Ovesen, J., and Madsen, J. B. (2024). Cognition in elite soccer players: a general model. *Front. Psychol*, 15. <https://doi.org/10.3389/fpsyg.2024.1477262>
- Hadi, N., Somayeh, A., Saber, S., Pablo, V., Tomás, G. C. (2023). Narrative review: The role of circadian rhythm on sports performance, hormonal regulation, immune system function, and injury prevention in athletes. *Heliyon*, 9(9). <https://doi.org/10.1016/j.heliyon.2023.e19636>
- Joseph, G. J. (2025). Decision making in sports. *Psychology of Sport and Exercise*, 80. <https://doi.org/10.1016/j.psychsport.2025.102919>
- Mănescu, D. C. (2025). Big Data Analytics Framework for Decision-Making in Sports Performance Optimization. *Data*, 10(7), 116. <https://doi.org/10.3390/data10070116>
- Nan, L., Xueyan, Z., Yusha, W., Jing, Z., Yueyi, L., Keqin, T., Jia, L., Yimin, L., Linghong, G., Yang,

- L., Xia, W., Lei, Z., Tao, Z., Tingting, D., Ning, Z., Zhiwen, L., Xin, W., Hong, Z., Xuelei, M. (2025). Effect of enhanced recovery after radiotherapy (ERAR) on the quality of life in patients with nasopharyngeal carcinoma after radiotherapy: A randomized controlled trial. *Oral Oncology*, 164. <https://doi.org/10.1016/j.oraloncology.2025.107269>
- Nascimento, H., Roque, A., & Martinez-Perez, C. (2025). Visual Function in Athletes from Different Team Sports and Non-Athlete Controls. *Life*, 15(10), 1619. <https://doi.org/10.3390/life15101619>
- Roca, A., & Williams, A. M. (2016). Expertise and the Interaction between Different Perceptual-Cognitive Skills: Implications for Testing and Training. *Frontiers in psychology*, 7, 792. <https://doi.org/10.3389/fpsyg.2016.00792>
- Scharfen, H-E., and Memmert, D. (2019). The Relationship Between Cognitive Functions and Sport-Specific Motor Skills in Elite Youth Soccer Players. *Front. Psychol.* 10:817. <https://doi.org/10.3389/fpsyg.2019.00817>
- Schumacher, N., Schmidt, M., Reer, R., & Braumann, K.-M. (2019). Peripheral Vision Tests in Sports: Training Effects and Reliability of Peripheral Perception Test. *International Journal of Environmental Research and Public Health*, 16(24), 5001. <https://doi.org/10.3390/ijerph16245001>
- Silva, A.F., Ramirez-Campillo, R., Sarmiento, H., Afonso, J., and Clemente, F.M. (2021). Effects of Training Programs on Decision-Making in Youth Team Sports Players: A Systematic Review and Meta-Analysis. *Front. Psychol.* 12:663867. <https://doi.org/10.3389/fpsyg.2021.663867>
- Theofilou, G., Ladakis, I., Mavroidi, C., Kilintzis, V., Mirachtsis, T., Chouvarda, I., & Kouidi, E. (2022). The Effects of a Visual Stimuli Training Program on Reaction Time, Cognitive Function, and Fitness in Young Soccer Players. *Sensors*, 22(17), 6680. <https://doi.org/10.3390/s22176680>
- Thomas, J. R., Nelson, J. K., & Silverman, S. J. (2015). *Research methods in physical activity* (7th ed.). Human Kinetics.
- Triggs, A.O., Causer, J., McRobert, A.P., Reeves, M.J., and Andrew, M. (2026). Perceptual-cognitive skills in talent development environments: a survey of academy football coaches in the United Kingdom. *Front. Psychol.* 17:1751602. <https://doi.org/10.3389/fpsyg.2026.1751602>
- Walton, C. C., Keegan, R. J., Martin, M., & Hallock, H. (2018). The Potential Role for Cognitive Training in Sport: More Research Needed. *Frontiers in psychology*, 9, 1121. <https://doi.org/10.3389/fpsyg.2018.01121>
- Wang, Q., Guo, W., Gao, D., Xiao, Y., Song, Y., Dong, X., Yuan, G., & Jiang, T. (2026). Differences in visual search behavior between expert and novice individual sports athletes: a systematic review with meta-analysis. *Frontiers in Physiology*. <https://doi.org/10.3389/fphys.2026.1793747>
- Wittich, A., & Schmidt, M. (2020). Peripheral vision tests in sports: Training effects and reliability of peripheral perception test. *Perceptual and Motor Skills*, 127(5), 1484-1500. <https://doi.org/10.1177/0031512520913057>
- World Medical Association. (2025). World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Participants. *JAMA*, 333(1), 71-74. <https://doi.org/10.1001/jama.2024.21972>
- Wu, K-C., Lin, H-C., Cheng, Z-Y., Chang, C-H., Chang, J-N., Tai, H-L., & Liu, S-I. (2025). The Effect of Perceptual-Cognitive Skills in College Elite Athletes: An Analysis of Differences Across Competitive Levels. *Sports*, 13(5), 141. <https://doi.org/10.3390/sports13050141>
- Wu, Y., Yang, Z., Wang, R., Zeng, H., and Zhang, Q. (2024). A comparison of perceptual-cognitive skills in expert and non-expert sports officials: a systematic review and meta-analysis. *Front. Psychol.* 15:1380281. <https://doi.org/10.3389/fpsyg.2024.1380281>
- Xie, J., Zhu, Y., Wang, Y., Mo, Y., Shi, X., Liang, W-M., Ren, F-F., Bai, Z., and Nie, F. (2025). Effects of pulmonary rehabilitation combined with inspiratory muscle training on lung function and exercise capacity in older patients with COPD: a systematic review and meta-analysis. *Front. Med.* 12:1621375. <https://doi.org/10.3389/fmed.2025.1621375>
- Yang, M., Guo, Y., Yang, F., and Zhao, K. (2026). Exploring the association between visual skills and sport-specific performance in team athletes: a systematic review and meta-analysis. *Front. Physiol.* 17:1797347. <https://doi.org/10.3389/fphys.2026.1797347>
- Zhang, R., Zhao, M., & Chen, C. (2024). Effects of perceptual-cognitive training on anticipation and decision-making skills in team sports: A systematic review and meta-analysis. *Behavioral Sciences*, 14(10), 919. <https://doi.org/10.3390/bs14100919>
- Zhang, Z., Piras, A., Chen, C., Kong, B., & Wang, D. (2022). A comparison of perceptual anticipation in combat sports between experts and non-experts: A systematic review and meta-analysis. *Frontiers in psychology*, 13, 961960. <https://doi.org/10.3389/fpsyg.2022.961960>
- Zhu, R., Zheng, M., Liu, S., Guo, J., & Cao, C. (2024). Effects of Perceptual-Cognitive Training on Anticipation and Decision-Making Skills in Team Sports: A Systematic Review and Meta-Analysis.



Behavioral Sciences, 14(10), 919.
<https://doi.org/10.3390/bs14100919>