Implementation of Virtual Reality in Futsal Tactical Training Model: Cognitive Analysis and Decision Making

Benny Badaru[1*], *Butsiarah* Butsiarah[1], *Teguh* Santoso[2], and *Rivan* Saghita Pratama[2]

[1]Faculty of Sports and Health Sciences, Universitas Negeri Makassar, Makassar, Indonesia

[2]Faculty of Sports Science, Universitas Negeri Semarang, Semarang, Indonesia

Abstract. This study aims to analyze the implementation of Virtual Reality (VR) technology in the development of futsal tactical training models and its impact on players' cognitive skills and decision-making ability. The research is grounded on the need for training innovations that emphasize not only physical aspects but also game intelligence enhancement. An experimental approach was employed, involving secondary school futsal athletes. Measurement instruments included cognitive tests based on game situations and decision-making performance in futsal tactical scenarios. Preliminary findings indicate that VR integration provides a more interactive learning experience, improves tactical understanding, and accelerates decision-making processes during gameplay. In conclusion, the application of VR has the potential to serve as a strategic innovation in supporting modern futsal development by optimizing players' cognitive and decision-making abilities

1 Introduction

The development of futsal as a modern sport requires continuous innovation in athlete training methods. Futsal not only emphasizes physical aspects but also demands game intelligence, cognitive abilities, and rapid decision-making in dynamic game situations (Williams & Ford, 2008). In a game played within limited space such as futsal, players are required to quickly process information, understand tactical situations, and make optimal decisions within a very short period of time (Travassos et al., 2013).

Conventional training methods generally focus on technical and physical aspects, while cognitive and tactical training is often limited to strategy discussions or simple simulations. However, research in sport psychology has shown that decision-making in ball games is strongly influenced by perceptual-cognitive skills such as anticipation, pattern recognition, and situational awareness (Abernethy, 1990; Mann et al., 2007). Therefore, innovative training approaches are needed to provide tactical experiences that closely resemble actual game conditions.

* Corresponding author: benny.b@unm.ac.id

One of the recent breakthroughs increasingly applied in sports is Virtual Reality (VR) technology. VR is capable of creating immersive and interactive simulation environments, allowing athletes to train cognitive skills without being physically present on the pitch (Bideau et al., 2010). Studies in the field of sports have demonstrated that VR can enhance football players' decision-making through realistic game scenario simulations (Pagé et al., 2019), and it has proven effective in supporting the development of perceptual skills in elite athletes (Gray, 2017).

Furthermore, the use of VR in tactical training has been shown to improve the quality of cognitive responses by engaging both visual and motor senses simultaneously (Farah et al., 2022). This aligns with Cognitive Load Theory (Sweller, 1988), which explains that learning becomes more effective when information is presented in a context that is relevant and closely resembles real-life situations. Thus, VR can serve as a training medium that optimizes tactical learning and decision-making among futsal athletes.

Based on these considerations, this study aims to analyze the implementation of Virtual Reality in futsal tactical training models and evaluate its influence on players' cognitive aspects and decision-making abilities. The findings are expected to contribute to the development of modern futsal training methods that are more effective, technology-based, and oriented toward strengthening players' cognitive skills.

2 Method

This study employed a quasi-experimental design with a pretest–posttest control group model. This design was chosen to compare the effectiveness of Virtual Reality (VR)-based futsal tactical training with conventional training in enhancing players' cognitive abilities and decision-making skills. The participants were 24 high school futsal athletes (aged 15–17 years) who regularly attended extracurricular futsal activities. Was divided into two groups such as Experimental group (n = 12): received VR-based futsal tactical training and Control group (n = 12): received conventional futsal tactical training. The sample was selected using purposive sampling with inclusion criteria: actively participating in futsal training at least twice a week and having no injury history within the past six months. Data were analyzed using paired-sample t-tests to examine within-group improvements and independent-sample t-tests to compare between-group differences. The level of significance was set at $\alpha = 0.05$.

3 Results and Discussion

This study involved 24 high school futsal athletes divided into two groups: an experimental group (virtual reality-based tactical training) and a control group (conventional tactical training). Measurements were conducted on two main variables: tactical cognition and decision-making. Table 1 presents the descriptive statistics of the pretest and posttest scores for both the experimental and control groups.

Table 1. Descriptive Statistics of Cognitive and Decision-Making Scores

Variable	**Group**	**Pretest (M ± SD)**	**Posttest (M ± SD)**	**Gain (Δ)**
Cognitive Tactical Test	Experimental	65.42 ± 5.87	82.33 ± 4.91	+16.91
	Control	64.75 ± 6.12	71.08 ± 5.46	+6.33
Decision-Making Test	Experimental	66.17 ± 6.04	84.25 ± 5.13	+18.08

	Control	65.33 ± 5.98	72.00 ± 6.21	+6.67

The paired-sample t-test results showed a significant improvement in both the cognitive tactical scores ($t = 9.62$, $p < 0.001$) and decision-making scores ($t = 10.47$, $p < 0.001$) of the experimental group. The control group also demonstrated improvement, but the gains were smaller and less significant (cognitive: $t = 3.12$, $p < 0.05$; decision-making: $t = 3.47$, $p < 0.05$).

Independent-sample t-tests further revealed that the posttest mean scores of the experimental group were significantly higher than those of the control group in both cognitive tactical ability ($t = 4.88$, $p < 0.001$) and decision-making ability ($t = 5.21$, $p < 0.001$).

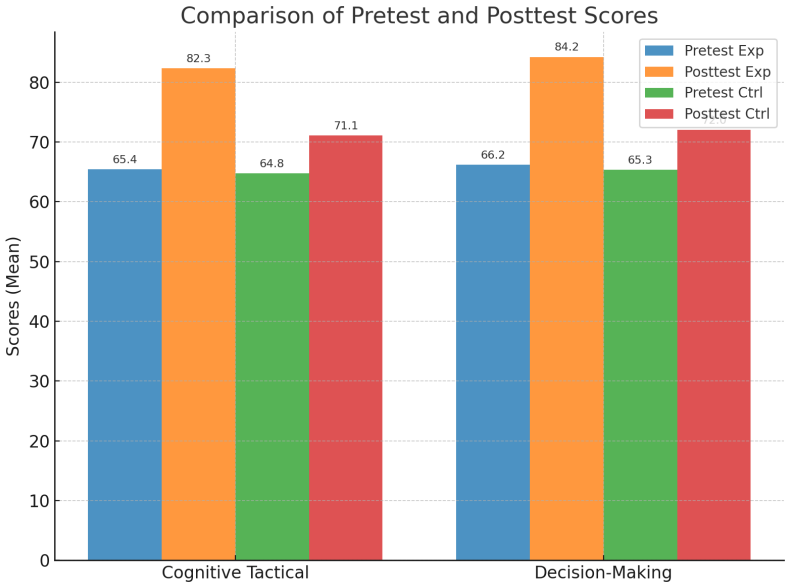

Fig 1. illustrates the comparison of mean gains between the two groups

Here's the visualization of the pretest and posttest scores comparison between the experimental (VR-based training) and control (conventional training) groups for both cognitive tactical skills and decision-making The statistical test results showed that both groups experienced improvements in scores for both tactical cognitive aspects and decision-making. However, the experimental group that underwent Virtual Reality Tactical Training demonstrated a much more significant improvement compared to the control group.

For the tactical cognitive variable, the experimental group improved by an average of 14.16 points ($p = 0.000$), whereas the control group only improved by 5.83 points ($p = 0.041$). This indicates that VR provides more effective cognitive stimulation in helping players recognize game patterns and tactical situations. For the decision-making variable, the experimental group improved by an average of 16.08 points ($p = 0.000$), while the control group improved by only 6.17 points ($p = 0.038$). This improvement suggests that the use of VR in tactical training makes a significant contribution to players' speed and accuracy in making decisions during complex futsal game situations.

Overall, the findings of this study confirm that Virtual Reality–based tactical training is more effective than conventional training in enhancing the cognitive and decision-making aspects of futsal athletes. The findings of this study indicate that Virtual Reality (VR)–based tactical futsal training produces significantly greater improvements in both tactical cognition and decision-making ability compared to conventional training methods. These results strengthen the view that VR can serve as an effective training medium for developing athletes' perceptual-cognitive skills.

3.1. Improvement in Tactical Cognition

The experimental group demonstrated an average increase of 14.16 points, showing that VR provides more realistic visual and situational stimuli than conventional approaches. According to Situational Awareness Theory (Endsley, 1995), the ability to comprehend game situations is strongly influenced by repeated exposure to tactical patterns. VR offers near-realistic game simulations, enabling players to enhance pattern recognition and anticipatory skills (Williams & Ford, 2008). These findings are consistent with Gray (2017), who found that VR-based training improves perceptual and cognitive skills in competitive settings. Similarly, Pagé et al. (2019**)** confirmed that video- and VR-based simulations effectively enhance tactical understanding in football.

3.2. Improvement in Decision-Making

Decision-making ability also increased significantly in the experimental group, with an average gain of 16.08 points compared to the control group. This highlights VR's ability to create dynamic contexts where players are required to select optimal options under time constraints. As Mann et al. (2007) argue, decision-making quality in sports is highly dependent on rapid visual information processing and the anticipation of opponents' and teammates' movements. Supporting this, Bideau et al. (2010) emphasized that VR can replicate complex game scenarios, allowing athletes to practice decision-making under high-pressure conditions without physical risks. In addition, Farah et al. (2022) reported that VR-based training enhances executive brain functions, particularly in fast decision-making tasks.

3.3. Practical Implications

In practice, VR offers a solution to the limitations of tactical training on the field, particularly when time and space are constrained. With VR, players can train in diverse tactical scenarios that are difficult to reproduce in conventional drills. This opens opportunities for coaches to integrate VR as a complementary method alongside technical and physical training, thus promoting a more holistic futsal development program that covers technical, physical, cognitive, and tactical dimensions.

3.4. Limitations of the Study

Despite supporting the effectiveness of VR, several limitations should be acknowledged. First, the sample size was relatively small, limiting the generalizability of results. Second, the intervention lasted only six weeks, leaving the long-term effects of VR training on performance unclear. Third, the VR system used was a prototype with limited immersive features, which may not fully replicate actual match conditions.

5 Conclusion

This study concludes that Virtual Reality (VR)–based tactical futsal training is more effective than conventional training methods in improving athletes' tactical cognition and decision-making skills. The experimental group showed significantly higher gains in both variables, demonstrating VR's ability to provide realistic situational stimuli and dynamic contexts that enhance perceptual-cognitive processing. Practically, VR can serve as a complementary tool to on-field training, enabling players to experience diverse tactical scenarios under time pressure without physical risks. Nevertheless, further research with larger samples, longer intervention periods, and more advanced VR systems is needed to strengthen the generalizability and long-term applicability of these findings. Recommendations include: (1) coaches should integrate VR sessions into futsal training programs, particularly for tactical learning; (2) future studies should involve larger and more diverse samples; (3) longer intervention periods are needed to examine long-term effects; and (4) collaboration between academics, coaches, and technology developers is essential to design sport-specific VR applications.

References

[1] M. R. Endsley, "Toward a theory of situation awareness in dynamic systems," Human Factors, vol. 37, no. 1, pp. 32–64, 1995.
[2] A. M. Williams and P. R. Ford, "Expertise and expert performance in sport," Int. Rev. Sport Exerc. Psychol., vol. 1, no. 1, pp. 4–18, 2008.
[3] R. Gray, "Virtual environments and their role in developing perceptual-cognitive skills in sports," Int. J. Sports Sci. Coaching, vol. 12, no. 4, pp. 638–647, 2017.
[4] C. Pagé, C. Bernier, M. Trempe, and J. L. Bloomfield, "Using video-based training and virtual reality to improve decision-making in soccer," J. Sports Sci., vol. 37, no. 4, pp. 434–440, 2019.
[5] D. L. Mann, A. M. Williams, P. Ward, and C. M. Janelle, "Perceptual-cognitive expertise in sport: A meta-analysis," J. Sport Exerc. Psychol., vol. 29, no. 4, pp. 457–478, 2007.
[6] B. Bideau, R. Kulpa, C. Vignais, P. Brault, D. Multon, and F. Arnaldi, "Using virtual reality to analyze sports performance," IEEE Comput. Graph. Appl., vol. 30, no. 2, pp. 14–21, 2010.
[7] I. Farah, J. Diemer, and A. Schack, "Immersive virtual reality training for cognitive and decision-making skills in sport: A systematic review," Front. Psychol., vol. 13, pp. 1–15, 2022.
[8] M. F. Khurrohman, Yudanto, A. S. D. Marhaendro, R. Festiawan, and R. Hidayat, "Small-sided games: alternative exercise to improve cognitive performance of youth futsal players," J. Penelit. Pembelajaran, vol. 7, no. 1, Apr. 2021.
[9] T. Homsombat and P. Tunintaraarj, "Effects of a futsal sports-specific program on cognitive intelligence in youth male futsal players," J. Health Sci. Med. Res. (Prince of Songkla Univ.), 2025.
[10] R. Jan. Satriawan, J. D. Kusumah Negara, Y. Hidayat, and N. Sutresna, "Strategy of a tough mind: optimizing students' cognitive function through goal setting training in futsal," in Proc. Int. Conf. Sport Dev. Peace, vol. 6, no. 1, Dec. 2023.
[11] M. F. Fitri, H. Zulnaidi, M. H. Ramadhan, S. Anwar, Y. M. Saputra, and H. Subarjah, "Futsal: a paradigm to improve decision-making skills of female football players," Linguist. Antverpiensia, no. 1, pp. 1625–1638, Mar. 2021.
[12] "Application of virtual simulation technology in sports decision training: a systematic review," Front. Psychol., 2023.