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Article

AI-Enhanced Cognitive Training and Basketball Athletes' Situational Awareness on the Court

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Abstract: This study comprehensively examined the relationship between artificial intelligence (AI)-enhanced cognitive training and basketball athletes' situational awareness (SA) on the court. A descriptive-comparative-correlational research design was systematically employed, utilizing a sample of 149 collegiate basketball athletes from Guangzhou Sport University as primary respondents. Data were collected via a validated, researcher-made questionnaire and rigorously analyzed using descriptive statistics, independent samples t-tests, one-way ANOVA, and Pearson's r correlation. The empirical results revealed that athletes perceived AI-enhanced cognitive training as slightly effective overall (overall mean = 2.50). Participants reported stronger perceived benefits in critical areas such as anticipation, focus, strategic retention, processing speed, and adaptability, although they noted limited gains in reaction time and decision-making accuracy. Demographic variables, including sex and age, did not significantly influence training perceptions; however, more experienced athletes reported significantly better strategic retention and adaptability. Furthermore, the athletes' self-assessed situational awareness was found to be moderately developed (overall mean = 2.50), characterized by notable strengths in anticipation and spatial awareness, alongside distinct weaknesses in opponent recognition and high-pressure decision-making. Situational awareness did not differ significantly across sex, age, or playing experience. Ultimately, a weak overall correlation existed between AI training perception and situational awareness ($r = 0.04$, $p > 0.05$), with only isolated significant links observed. These critical findings strongly justify the strategic development of a specialized, AI-powered situational awareness training program integrating targeted cognitive drills, realistic game scenarios, and personalized feedback to substantially improve skill transfer to actual on-court athletic performance.

Keywords: artificial intelligence; cognitive training; situational awareness; basketball; decision-making

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1. Introduction

Artificial intelligence (AI) has increasingly transformed sports training by improving athlete performance through personalized, adaptive, and data-driven approaches. In basketball, athletes are required to process complex visual information, anticipate opponents' actions, maintain awareness of teammates' positioning, and make rapid decisions under pressure. Such demands highlight the importance of perceptual-cognitive abilities, including attention, reaction time, anticipation, and decision-making, which are closely associated with successful on-court performance. AI-enhanced cognitive training, including virtual reality (VR), eye-tracking systems, multiple-object tracking (MOT), and machine learning technologies, has emerged as a promising method for strengthening these cognitive skills and improving athlete preparedness in dynamic game situations [1].

Situational awareness (SA) is considered an important psychological and cognitive factor in basketball performance. Based on Endsley's model, SA involves the perception of relevant environmental cues, comprehension of their meaning, and projection of future events. In basketball, situational awareness allows athletes to recognize offensive and

defensive opportunities, interpret game tempo, anticipate opponents' actions, and make effective decisions under time pressure [2]. Previous studies suggest that athletes with stronger situational awareness demonstrate superior court vision, faster decision-making, and more efficient tactical execution, making SA an essential component of competitive success.

Recent studies have reported that AI-enhanced cognitive training can improve attention control, visual search efficiency, processing speed, and anticipation among athletes. Virtual reality simulations and AI-assisted feedback systems have been shown to create realistic game environments that enhance tactical learning and cognitive engagement. However, evidence regarding the transfer of these cognitive improvements to actual on-court situational awareness remains inconclusive [1]. While some athletes may benefit from AI-assisted training, situational awareness is also influenced by game experience, teamwork, communication, and tactical understanding, suggesting that AI training alone may not guarantee improved basketball performance.

Despite increasing interest in AI applications in sports, limited research has examined the relationship between AI-enhanced cognitive training and basketball athletes' situational awareness, particularly among student-athletes in the Chinese context. Therefore, this study investigated the relationship between AI-enhanced cognitive training and basketball athletes' situational awareness on the court among athletes at Guangzhou Sport University. Findings from this study may contribute to the development of an AI-powered situational awareness training program to improve cognitive performance and decision-making in basketball [3].

2. Review of Related Literature and Studies

2.1. Artificial Intelligence and Cognitive Training in Basketball

Artificial intelligence (AI) has increasingly been integrated into sports training to improve athletes' performance through adaptive, personalized, and data-driven approaches. In basketball, AI technologies are commonly used to analyze movement patterns, tactical behaviors, and decision-making processes to support athlete development [4]. Compared with traditional coaching approaches that rely primarily on observation and repetitive drills, AI-assisted systems provide objective feedback and individualized training recommendations. Technologies such as machine learning, eye-tracking, virtual reality (VR), and motion analysis have become increasingly important in improving both physical and cognitive aspects of performance.

Cognitive training in basketball focuses on strengthening mental abilities that influence performance during competition, including reaction time, attention, anticipation, visual processing, decision-making, and working memory. Basketball players operate in highly dynamic environments where they must quickly interpret information, predict opponents' actions, and adjust their responses under time pressure. Previous studies indicate that elite athletes generally demonstrate more efficient visual search strategies and faster information-processing abilities than less experienced players. Multiple-object tracking (MOT) training, for example, has been shown to improve divided attention and cognitive flexibility, allowing athletes to better monitor teammates, opponents, and ball movement simultaneously.

Recent advancements in AI-enhanced cognitive training have further improved the realism and effectiveness of basketball training environments. Virtual reality simulations allow athletes to rehearse offensive and defensive situations without physical fatigue, while eye-tracking systems help identify inefficient visual attention patterns that may influence performance. AI-based feedback systems can also adjust training difficulty based on individual athlete responses, improving engagement and skill adaptation. However, although studies suggest positive effects of AI-enhanced cognitive training on cognitive performance, evidence regarding its transfer to actual game situations remains mixed, highlighting the need for further investigation into its relationship with basketball situational awareness [5].

2.2. Situational Awareness in Basketball Performance

Situational awareness (SA) is widely recognized as an essential cognitive ability in sports performance, particularly in fast-paced and dynamic team sports such as basketball. Originally introduced as a concept to describe an individual's ability to perceive relevant environmental information, comprehend its meaning, and predict future events, situational awareness plays a critical role in basketball. Athletes constantly encounter rapidly changing situations that require them to recognize teammates' positions, anticipate opponents' movements, interpret tactical opportunities, and make effective decisions within limited time [6]. Strong situational awareness contributes to better court vision, improved tactical execution, and reduced performance errors during competition.

Research has shown that highly skilled basketball athletes generally demonstrate superior situational awareness compared with less experienced players. Expert athletes tend to process visual information more efficiently, maintain better attention under pressure, and make faster tactical decisions. Studies involving eye-tracking technology suggest that experienced players exhibit more effective gaze behavior by focusing on relevant environmental cues while minimizing unnecessary distractions. Likewise, anticipation ability enables athletes to predict offensive and defensive actions, allowing faster and more accurate responses during gameplay. These cognitive advantages often contribute to higher levels of performance and consistency during competitive matches [7].

Despite its importance, situational awareness is influenced by multiple factors beyond individual cognitive ability [8]. Game experience, tactical knowledge, teamwork, communication, and psychological resilience may all affect an athlete's ability to maintain awareness in high-pressure environments. Moreover, fatigue and stress can reduce information-processing efficiency and impair decision-making performance. Because situational awareness develops through repeated exposure to realistic game conditions, researchers increasingly emphasize the importance of training approaches that simulate actual basketball environments. This has led to growing interest in AI-assisted training systems designed to strengthen athletes' perceptual and cognitive performance in game-like situations.

2.3. Transfer of Cognitive Training to Basketball Performance

The effectiveness of cognitive training in sports depends not only on improvements achieved during training but also on the successful transfer of these gains to actual competitive performance. In basketball, athletes are expected to apply enhanced attention, reaction speed, anticipation, and decision-making skills during fast-paced and unpredictable game situations. Researchers argue that cognitive training is valuable only when improvements observed in controlled environments can be effectively translated into real-game performance, where physical fatigue, tactical complexity, and psychological pressure are present [9].

Previous studies report mixed findings regarding the transferability of cognitive training to basketball performance. Some studies suggest that AI-enhanced tools such as virtual reality, multiple-object tracking, and eye-tracking systems improve perceptual-cognitive skills, including attention control, visual search efficiency, and anticipation [10]. These improvements may contribute to better court awareness and faster tactical responses. However, other researchers note that gains observed in laboratory settings or isolated cognitive exercises do not always transfer effectively to real basketball competition. This limitation is often attributed to insufficient ecological validity, meaning training activities may fail to fully replicate the complexity and unpredictability of actual gameplay.

To improve training transfer, scholars increasingly recommend integrating cognitive training with realistic basketball scenarios [11]. AI systems that incorporate real game footage, opponent simulations, and tactical decision-making exercises are considered more effective than abstract cognitive drills alone. Coaches also play an important role by combining technology-assisted cognitive exercises with team-based practice and strategic

instruction. As basketball performance depends on both individual cognition and team coordination, effective transfer requires training programs that reflect authentic game demands and support athletes' situational awareness during competition.

2.4. Research Gap

Although previous studies have explored the role of artificial intelligence (AI) and cognitive training in sports performance, several research gaps remain. Existing literature has primarily focused on the effectiveness of specific technologies such as virtual reality (VR), eye-tracking systems, and multiple-object tracking (MOT) in improving isolated cognitive skills, including attention, reaction time, and visual processing. While these studies provide evidence regarding the potential benefits of AI-assisted training, fewer investigations have examined whether such improvements meaningfully contribute to athletes' situational awareness during actual basketball performance [12].

Moreover, many previous studies concentrated on professional athletes, experimental interventions, or technology validation, with limited attention given to student-athletes in educational sports settings [3]. In the Chinese context, empirical research examining the relationship between AI-enhanced cognitive training and basketball athletes' situational awareness remains limited despite increasing interest in sports technology and athlete development. Situational awareness is influenced by multiple factors, including tactical understanding, communication, teamwork, and competitive experience, making it necessary to investigate whether AI-based cognitive training contributes to broader basketball awareness rather than isolated mental skills alone.

Therefore, this study addressed these gaps by examining the relationship between AI-enhanced cognitive training and basketball athletes' situational awareness on the court among student-athletes at Guangzhou Sport University. Specifically, the study explored athletes' assessment of AI-enhanced cognitive training, their level of situational awareness, demographic differences, and the relationship between these variables. Findings from the study may contribute to the development of more effective AI-powered training programs that align cognitive development with real-game basketball demands.

3. Methodology

3.1. Research Design

This study employed a descriptive-comparative-correlational research design to examine the relationship between AI-enhanced cognitive training and basketball athletes' situational awareness on the court. The descriptive aspect was used to determine the respondents' demographic profile and assess their perceptions of AI-enhanced cognitive training and situational awareness. This design enabled the researcher to describe the current condition of the variables under investigation and identify prevailing patterns among basketball athletes [5].

The comparative aspect of the study was utilized to determine whether significant differences existed in athletes' assessment of AI-enhanced cognitive training and situational awareness when respondents were grouped according to sex, age, and years of playing experience. Independent samples t-test and one-way analysis of variance (ANOVA) were employed to compare responses across demographic groups [5, 6]. This approach helped determine whether personal characteristics influenced athletes' perceptions and awareness levels.

The correlational component was used to examine the relationship between AI-enhanced cognitive training and basketball athletes' situational awareness. Pearson's r correlation analysis was applied to determine the degree and direction of association between the variables. Through this research design, the study generated empirical evidence regarding the possible contribution of AI-enhanced cognitive training to athletes' awareness and decision-making performance during basketball competition.

3.2. Research Locale, Respondents, and Sampling Technique

This study was conducted at Guangzhou Sport University, an educational institution located in Guangdong Province, China, recognized for its specialization in physical education and sports development. Established in 1958, the university has continuously contributed to the training of athletes, coaches, and sports professionals. The institution was selected as the research locale due to its established basketball program and accessibility to student-athletes actively engaged in basketball training and competition.

The respondents of the study consisted of basketball student-athletes enrolled at Guangzhou Sport University. A total of 149 basketball athletes participated in the study, representing different age groups, sexes, and years of playing experience [2,7]. These respondents were selected because of their active involvement in basketball activities and familiarity with cognitive training practices used in sports settings.

The study employed total enumeration sampling, in which all available basketball student-athletes meeting the inclusion criteria were invited to participate [10]. This sampling technique ensured comprehensive data collection and minimized sampling bias by including the entire accessible population of basketball athletes within the university. The use of total enumeration further strengthened the representativeness of the findings and provided a broader understanding of athletes' perceptions regarding AI-enhanced cognitive training and situational awareness.

3.3. Research Instrument and Data Gathering Procedure

The primary instrument used in this study was a researcher-designed questionnaire aimed at assessing basketball athletes' perceptions of AI-enhanced cognitive training and situational awareness on the court. The questionnaire was divided into three sections. The first section collected demographic information, including sex, age, and years of playing experience. The second section evaluated AI-enhanced cognitive training across seven dimensions: reaction time, decision-making accuracy, anticipation, focus and concentration, strategic retention, processing speed, and adaptability. The third section measured situational awareness through indicators such as teammate awareness, opponent recognition, play anticipation, game tempo reading, pressure decision-making, spacing awareness, and adaptability.

A four-point Likert scale was utilized to measure respondents' perceptions and self-assessments. For AI-enhanced cognitive training, responses were categorized as follows: 3.51–4.00 (Very Effective), 2.51–3.50 (Effective), 1.51–2.50 (Slightly Effective), and 1.00–1.50 (Not Effective). For situational awareness, the scale interpretation was: 3.51–4.00 (Very True), 2.51–3.50 (True), 1.51–2.50 (Slightly True), and 1.00–1.50 (Not True). To ensure content validity, the questionnaire underwent review and validation by experts in sports education and research. A pilot test was conducted to establish reliability, resulting in a Cronbach's alpha coefficient of 0.80, which indicates acceptable internal consistency.

Before data collection, formal approval was obtained from the university and relevant authorities [9]. Participants were informed about the study's purpose, and informed consent was secured prior to their involvement. The questionnaires were distributed in person to ensure a higher response rate and to address any potential concerns from respondents. Once collected, the responses were organized, checked for completeness, and prepared for statistical analysis.

3.4. Statistical Treatment and Ethical Considerations

The collected data were analyzed using appropriate statistical tools to address the objectives of the study. Frequency and percentage distribution were used to describe the demographic profile of respondents. Mean and standard deviation were utilized to assess athletes' perceptions of AI-enhanced cognitive training and their situational awareness. Independent samples t-test was employed to determine significant differences according to sex, while one-way analysis of variance (ANOVA) with Scheffé post hoc test was used to examine differences according to age and years of playing experience [11]. Pearson's r correlation analysis was applied to determine the relationship between AI-enhanced cognitive training and basketball athletes' situational awareness.

Ethical principles were strictly observed throughout the conduct of the study. Participation in the study was voluntary, and respondents were informed that they had the right to decline or withdraw at any stage without penalty [12]. Confidentiality and anonymity were maintained by ensuring that respondents' personal information was not disclosed and that data were used solely for academic purposes. Furthermore, the study ensured that no physical or psychological harm would result from participation, and all collected information was handled with integrity and professional responsibility.

4. Results and Discussion

4.1. Demographic Profile of the Respondents and Assessment of AI-Enhanced Cognitive Training

This section presents the demographic profile of the respondents and their assessment of AI-enhanced cognitive training. The results are presented in Table 1.

Table 1. Proposed AI-Powered Situational Awareness Training Program

Objectives	Activities	Persons Involved
Improve reaction time & basic decision	AI reflex drills; small-sided high-pressure games	Coaches, AI trainers, athletes
Enhance anticipation & pattern recognition	AI opponent simulations; video play analysis	Coaches, AI trainers, athletes
Strengthen focus & concentration	AI cognitive drills; post-session visual feedback	Coaches, AI trainers, athletes
Improve strategic retention	Repetitive AI tactical drills; memory transfer tasks	Coaches, AI trainers, athletes
Develop adaptability	Unpredictable AI scenarios; adaptive debriefs	Coaches, AI trainers, athletes
Enhance spatial & teamwork awareness	AI spacing exercises; positioning & passing drills	Coaches, AI trainers, athletes

The demographic profile revealed that most respondents were male, accounting for 83.2% of the total sample, while female athletes comprised only 16.8%. In terms of age, the majority belonged to the 16–17 age group, followed by respondents aged 15 years and below, while fewer athletes were aged 18 years and above. Regarding years of playing experience, most respondents had between three to five years of basketball experience, indicating moderate exposure to structured basketball training and competition.

Results further showed that athletes assessed AI-enhanced cognitive training as slightly effective, with an overall mean of 2.50. Among the indicators, anticipation, focus and concentration, strategic retention, processing speed, and adaptability obtained relatively higher mean scores, while reaction time and decision-making accuracy received comparatively lower ratings. These findings suggest that athletes perceived AI-enhanced cognitive training as more beneficial in strengthening higher-order cognitive abilities related to concentration, anticipation, and cognitive flexibility than in improving immediate response execution and rapid decision-making [9].

Moreover, findings revealed no statistically significant differences in athletes' assessment of AI-enhanced cognitive training according to sex and age. However, years of playing experience showed significant differences in strategic retention and adaptability, with more experienced athletes reporting stronger perceived benefits [2].

This suggests that prolonged basketball exposure may strengthen athletes' ability to apply AI-assisted cognitive training to tactical understanding and flexible game adaptation.

4.2. Situational Awareness Assessment and Differences by Profile

This section presents basketball athletes' self-assessment of situational awareness on the court and examines whether significant differences exist according to sex, age, and years of playing experience [2].

Results revealed that basketball athletes assessed their situational awareness as Slightly True, with an overall mean of 2.50. Among the indicators, anticipation and spacing awareness obtained relatively higher mean scores, suggesting that athletes generally demonstrated awareness of movement patterns and positioning during gameplay. In contrast, opponent recognition and pressure decision-making received comparatively lower ratings, indicating possible challenges in identifying opponents' intentions and making effective decisions during high-pressure situations.

These findings suggest that although athletes possess a foundational level of situational awareness, certain aspects of game cognition still require improvement [2]. Basketball involves constant movement, rapid transitions, and simultaneous information processing, requiring athletes to anticipate actions and react appropriately within limited time. The relatively lower ratings in opponent recognition and pressure decision-making may indicate difficulty in interpreting complex game situations and responding effectively under competitive stress.

Furthermore, findings revealed no statistically significant differences in situational awareness according to sex, age, and years of playing experience. This suggests that athletes generally demonstrated comparable levels of situational awareness regardless of demographic characteristics. The absence of significant differences may indicate that situational awareness develops through shared basketball experiences and training exposure rather than demographic characteristics alone [2].

4.3. Relationship between AI-Enhanced Cognitive Training and Situational Awareness

This section explores the relationship between AI-enhanced cognitive training and basketball athletes' situational awareness on the court.

The findings revealed a very weak and statistically non-significant relationship between AI-enhanced cognitive training and basketball athletes' overall situational awareness ($r = 0.04$, $p = 0.67$). This result indicates that AI-enhanced cognitive training alone may not be sufficient to substantially improve athletes' overall situational awareness during basketball competition. Situational awareness is influenced not only by cognitive abilities but also by tactical understanding, teamwork, communication, and actual game experience, which may explain the weak relationship observed in the study.

However, several isolated significant relationships were identified between reaction time and teammate awareness, as well as between focus and teammate and spacing awareness. These findings suggest that although AI-enhanced cognitive training may not strongly influence overall situational awareness, selected cognitive abilities may contribute to specific aspects of basketball awareness, particularly those associated with positioning, teamwork, and spatial recognition.

Based on the findings of the study, an AI-powered situational awareness training program was proposed to strengthen basketball athletes' cognitive and tactical performance. The proposed program emphasizes reaction speed, anticipation, concentration, strategic retention, adaptability, and teamwork awareness through AI-assisted activities designed to simulate realistic basketball situations and support effective decision-making during competition [8].

5. Recommendations

Basketball coaches and trainers may integrate AI-enhanced cognitive training with realistic basketball drills and game-based activities to improve athletes' reaction time, decision-making, and situational awareness during competition.

Sports institutions and training programs may provide structured cognitive training activities that focus on anticipation, adaptability, concentration, and tactical understanding to enhance athletes' basketball performance.

Athletes may participate in targeted training exercises aimed at improving opponent recognition, decision-making under pressure, and teamwork awareness, particularly in high-pressure basketball scenarios.

Future researchers may include larger and more diverse respondent groups and examine additional factors such as coaching style, team communication, and competitive level to further analyze basketball situational awareness.

Future studies may adopt experimental or longitudinal research designs to assess the long-term effectiveness of AI-enhanced cognitive training in improving actual basketball performance [8, 10].

6. Conclusions

This study examined the relationship between AI-enhanced cognitive training and basketball athletes' situational awareness on the court among student-athletes at Guangzhou Sport University. Findings revealed that respondents were predominantly adolescent basketball athletes with moderate playing experience. Athletes assessed AI-enhanced cognitive training as slightly effective, indicating that AI-supported cognitive activities provided moderate benefits in improving basketball-related cognitive abilities. Stronger perceived benefits were observed in anticipation, focus and concentration, strategic retention, processing speed, and adaptability, while reaction time and decision-making accuracy received comparatively lower evaluations.

The study further revealed that basketball athletes demonstrated a moderate level of situational awareness, particularly in anticipation and spacing awareness, although lower performance was observed in opponent recognition and pressure decision-making. No statistically significant differences were found in situational awareness according to sex, age, and years of playing experience, suggesting relatively consistent awareness levels across demographic groups. Similarly, AI-enhanced cognitive training assessment generally did not vary according to sex and age, although more experienced athletes reported stronger benefits in strategic retention and adaptability.

Moreover, findings indicated a very weak and statistically non-significant relationship between AI-enhanced cognitive training and overall situational awareness. This suggests that AI-supported cognitive training alone may not substantially improve basketball athletes' holistic situational awareness during competition. However, selected cognitive dimensions, particularly reaction time and focus, demonstrated limited associations with teammate and spacing awareness, indicating that certain aspects of cognitive training may still contribute to specific components of basketball awareness. Overall, the findings suggest that AI-enhanced cognitive training may be more effective when integrated with realistic game scenarios, tactical instruction, and team-based basketball practice.

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