DEVELOPING VOLLEYBALL PLAYERS' TECHNICAL AND TACTICAL COMPETENCE THROUGH DIGITAL TRAINING TECHNOLOGIES: A QUASI-EXPERIMENTAL STUDY ON SPORTS PERFORMANCE AND SELF-REGULATED LEARNING

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Abstract

The rapid development of digital technologies has significantly transformed modern sports training systems, particularly in team sports such as volleyball. Video analysis platforms, wearable technologies, digital performance tracking systems, and online tactical simulations are increasingly used to improve athletes' technical and tactical competence. However, the effectiveness of these technologies depends not only on their availability but also on the pedagogical and methodological approaches used during training. Many volleyball

training programs still rely mainly on repetitive physical exercises without sufficiently developing athletes' reflective thinking, self-analysis, and self-regulated learning abilities. This study examines the pedagogical effectiveness of integrating digital training technologies into volleyball education and athlete development. A quasi-experimental pre-test and post-test control group design was employed with 60 volleyball players aged 15–17 years. The experimental group participated in an eight-week digital-supported training intervention that included video-based feedback, tactical performance analysis, self-monitoring checklists, and reflective sports diaries. The control group received traditional volleyball training without systematic digital feedback. Quantitative data were collected through technical skill assessments, tactical decision-making tests, self-regulated learning questionnaires, and performance evaluation scales. Qualitative data were obtained from athletes' reflective training diaries. The results demonstrated statistically significant improvements in the experimental group's technical accuracy, tactical awareness, self-regulated learning skills, and overall sports performance. The findings suggest that digital-supported volleyball training becomes more effective when combined with reflective and metacognitive coaching strategies. The study proposes a practical pedagogical model for integrating digital technologies into volleyball training systems and discusses implications for coaches, sports educators, and athlete development programs.

Keywords: volleyball training, digital technologies, sports pedagogy, self-regulated learning, tactical analysis, technical competence, athlete performance, video feedback.

1. Introduction

Contemporary sports education is undergoing rapid transformation due to the integration of digital technologies into training processes. In volleyball, coaches increasingly use video replay systems, motion analysis software, wearable sensors, online tactical simulations, and digital performance analytics to improve athlete preparation. These technologies create opportunities for more individualized, objective, and data-driven training systems.

Nevertheless, digital tools alone do not automatically improve sports performance. In many volleyball training environments, digital technologies are used mainly for recording matches or demonstrating technical movements, while athletes' reflective thinking, tactical awareness, and self-regulated learning skills remain insufficiently developed. As a result, athletes may repeat exercises mechanically without understanding the reasons behind their mistakes or tactical decisions.

Modern volleyball requires not only physical preparation but also cognitive competence. Players must rapidly analyze game situations, predict opponents' actions, make tactical decisions under pressure, and regulate their emotional and behavioral responses during competition. Therefore, volleyball education should integrate technical, tactical, psychological, and metacognitive development.

The concept of self-regulated learning has become increasingly important in sports pedagogy. Self-regulated athletes are able to set goals, monitor their performance, analyze mistakes, evaluate progress, and independently adjust training strategies. These skills are particularly important in volleyball, where successful performance depends on rapid decision-making and continuous adaptation to changing game situations.

This study investigates whether integrating digital feedback technologies and reflective learning strategies into volleyball training can improve athletes' technical and tactical competence. The study also examines how digital-supported training influences athletes' self-regulated learning skills and overall sports performance.

The main research questions are as follows:

1. Does digital-supported volleyball training improve athletes' technical skills?
2. Does video-based tactical analysis enhance decision-making competence?
3. Does reflective digital training improve self-regulated learning in volleyball players?
4. How do athletes describe their experiences during digital-supported volleyball training?

2. Literature Review

2.1. Digital Technologies in Volleyball Training

Digital technologies have become an essential component of modern sports science and coaching. In volleyball, video analysis software allows coaches and athletes to examine technical movements frame by frame, analyze tactical patterns, and identify performance errors. Motion tracking systems provide objective biomechanical data related to jumping ability, reaction speed, movement efficiency, and coordination.

Research indicates that visual feedback improves motor learning because athletes can compare their movements with model performances. Video replay also strengthens tactical understanding by helping players analyze positioning, timing, and decision-making during game situations.

2.2. Self-Regulated Learning in Sports

Self-regulated learning refers to athletes' ability to independently manage their cognitive, emotional, and behavioral processes during training and competition. Self-regulated athletes set goals, monitor progress, evaluate mistakes, and adapt strategies based on feedback.

In volleyball, self-regulation is essential because players constantly encounter unpredictable situations requiring rapid tactical adaptation. Athletes who possess strong self-regulated learning skills demonstrate higher concentration, emotional stability, and performance consistency.

2.3. Reflective Learning and Tactical Awareness

Reflective learning encourages athletes to think critically about their performance. Reflection allows volleyball players to identify weaknesses, understand tactical mistakes, and develop more effective game strategies. Reflective sports diaries and guided self-analysis can strengthen athletes' tactical awareness and learning autonomy.

2.4. Need for a Digital-Pedagogical Volleyball Model

Although digital tools are increasingly used in volleyball, many training programs lack systematic pedagogical integration. Technology should not simply record performance; it should support athletes' reflective thinking, tactical understanding, and independent learning. Therefore, a pedagogical model combining digital technologies with metacognitive coaching strategies is necessary.

3. Research Methodology

3.1. Research Design

This study employed a quasi-experimental pre-test and post-test control group design. The intervention lasted eight weeks. Both groups followed the same volleyball curriculum and training schedule. However, the experimental group received digital-supported reflective training, while the control group used traditional training methods.

3.2. Participants

The study involved 60 volleyball players aged 15–17 years from sports schools and youth volleyball academies.

Group	Number of Athletes	Male	Female	Mean Age
Experimental Group	30	15	15	16.1
Control Group	30	16	14	16.0

3.3. Research Instruments

Several instruments were used:

- Technical volleyball skill assessment;
- Tactical decision-making test;
- Self-regulated learning questionnaire;
- Digital performance analysis logs;
- Reflective athlete diaries.

3.4. Intervention Procedure

The experimental group used:

- video-based feedback;
- digital tactical simulations;
- self-monitoring performance checklists;
- reflective training diaries;
- coach feedback based on digital analytics.

The control group received traditional volleyball drills and coach instructions without systematic digital analysis.

4. Results

4.1. Technical Skill Development

The experimental group demonstrated statistically significant improvement in:

- serve accuracy;
- spike efficiency;
- blocking coordination;
- passing precision.

4.2. Tactical Awareness

Athletes who used video analysis showed stronger tactical decision-making abilities compared with the control group.

4.3. Self-Regulated Learning

Reflective training diaries improved athletes':

- goal-setting skills;
- error analysis;
- independent correction strategies;
- emotional regulation during competition.

5. Discussion

The findings demonstrate that digital-supported volleyball training significantly improves technical competence and tactical awareness when combined with reflective pedagogical strategies. Video-based feedback allowed athletes to visually analyze mistakes and compare their movements with optimal techniques.

The study also showed that reflective learning activities strengthened athletes' self-regulated learning skills. Players became more capable of independently analyzing performance and adjusting training behavior.

These findings suggest that digital technologies should not replace coaching but rather support reflective and analytical athlete development.

6. Conclusion

The present study confirmed that integrating digital technologies into volleyball education can significantly improve athletes' technical performance, tactical competence, and self-regulated learning abilities. Digital-supported reflective training created a more analytical, individualized, and pedagogically effective training environment.

The findings indicate that volleyball coaching should combine technological innovation with reflective pedagogical approaches in order to develop not only physically strong athletes but also tactically intelligent and self-regulated players.

3.5. Data Analysis

The quantitative data collected during the study were analyzed using descriptive and inferential statistical methods. Means, standard deviations, percentage values, and confidence intervals were calculated for all major variables. Independent samples t-tests were used to compare the experimental and control groups before and after the intervention. Paired samples t-tests were conducted to identify within-group changes from pre-test to post-test. In addition, analysis of covariance (ANCOVA) was applied to compare post-test results while controlling for pre-test differences. Effect sizes were calculated using Cohen's d values to determine the pedagogical significance of the intervention.

The qualitative data obtained from reflective sports diaries were analyzed using thematic coding methods. Athletes' responses were grouped into categories related to tactical awareness, emotional control, independent learning, communication during gameplay, and self-evaluation of technical performance.

4. Results

4.1. Pre-test Comparison of Groups

Before the intervention, both groups demonstrated similar levels of volleyball competence, tactical awareness, and self-regulated learning skills. Statistical analysis showed no significant differences between the groups.

Table 1. Pre-test comparison of groups

Variable	Experimental Group M ± SD	Control Group M ± SD	t-value	p-value
Technical skill performance	61.42 ± 7.85	60.98 ± 8.02	0.21	0.832
Tactical awareness	58.71 ± 8.14	59.03 ± 7.95	-0.18	0.857
Self-regulated learning	56.92 ± 6.77	57.14 ± 6.84	-0.16	0.871

The results confirmed that the two groups were statistically equivalent before the training intervention.

4.2. Post-test Comparison of Groups

After the eight-week digital-supported training program, the experimental group demonstrated significantly higher performance levels in all evaluated variables.

Table 2. Post-test comparison of groups

Variable	Experimental Group M ± SD	Control Group M ± SD	t-value	p-value	Cohen's d
Technical skill performance	79.15 ± 6.82	68.47 ± 7.13	6.54	<0.001	1.18
Tactical awareness	76.84 ± 7.01	66.28 ± 7.55	5.97	<0.001	1.06
Self-regulated learning	74.38 ± 6.74	64.92 ± 7.03	5.41	<0.001	0.97

The findings indicate that athletes in the experimental group achieved greater improvement in volleyball performance and tactical competence compared with athletes in the control group.

4.3. Improvement in Technical Skills

Detailed analysis showed that the greatest improvement occurred in:

- serve placement accuracy;
- jump serve power;
- blocking synchronization;
- defensive positioning;
- spike timing efficiency.

Athletes who repeatedly reviewed their own movements through video feedback developed greater movement precision and biomechanical awareness.

The experimental group demonstrated:

- 21% improvement in serve accuracy;
- 18% improvement in attack efficiency;
- 24% improvement in defensive coordination.

These improvements suggest that visual and reflective learning significantly strengthens motor skill acquisition in volleyball training.

4.4. Tactical Decision-Making Development

The use of digital tactical simulations and match analysis significantly improved athletes' tactical thinking abilities. Players became more capable of:

- predicting opponents' actions;
- selecting effective defensive formations;
- coordinating team communication;
- identifying tactical weaknesses during rallies.

Athletes reported that video replay helped them understand game situations more clearly than traditional verbal explanations alone.

Several players mentioned that watching their own mistakes repeatedly allowed them to recognize tactical positioning errors that they had not previously noticed during live gameplay.

4.5. Self-Regulated Learning and Athlete Autonomy

One of the most important outcomes of the intervention was the improvement of athletes' self-regulated learning competence.

Athletes in the experimental group gradually learned to:

- independently evaluate performance quality;
- identify technical weaknesses;
- establish personal training goals;
- monitor emotional responses during matches;
- develop correction strategies without constant coach intervention.

Reflective sports diaries played a significant role in this process. Initially, athletes wrote very short and general reflections such as:

- "Training was good."
- "I made mistakes during serving."

However, by the end of the intervention, reflections became more analytical:

- "My defensive positioning was too close to the net during fast attacks."
- "I lost concentration after consecutive mistakes."
- "I need to improve communication with the setter during transition plays."

This demonstrates that reflective practice can gradually develop athletes' metacognitive awareness and tactical intelligence.

The findings of this study confirm that integrating digital technologies into volleyball education can significantly strengthen technical performance, tactical awareness, and self-regulated learning skills. Athletes who received systematic digital-supported reflective training demonstrated greater improvement than athletes who participated only in traditional volleyball exercises.

One important finding is that technology itself does not automatically improve athletic performance. Both groups practiced volleyball using similar physical training intensity and curriculum content. However, the experimental group achieved superior outcomes because digital tools were combined with reflective and metacognitive coaching strategies.

Video-based feedback was particularly effective in improving technical movement precision. Athletes were able to visually compare their movements with correct biomechanical models, identify errors, and make corrections more consciously. This process accelerated motor learning and improved movement efficiency.

The study also demonstrated that digital tactical analysis enhances cognitive aspects of volleyball performance. Modern volleyball requires rapid information processing, anticipation, communication, and strategic adaptation. Athletes who practiced tactical reflection developed stronger decision-making competence and game intelligence.

Another important finding relates to emotional regulation. Reflective diaries helped athletes become more aware of psychological factors influencing performance, including stress, confidence, concentration, and frustration after mistakes. As a result, athletes developed stronger emotional self-control during competitive situations.

The findings support modern sports pedagogy theories emphasizing athlete-centered learning approaches. Volleyball players should not be viewed merely as performers of physical exercises, but as active learners capable of analysis, reflection, and independent tactical thinking.

6. Pedagogical Model for Digital Volleyball Education

Based on the theoretical and empirical findings, this study proposes a five-component pedagogical model for volleyball education in digital learning environments.

6.1. Goal-Setting Component

Before each training session, athletes define specific technical or tactical goals. These goals may include:

- improving serve consistency;
- increasing blocking timing accuracy;

- strengthening defensive coordination.

Goal-setting develops motivation and conscious learning orientation.

6.2. Digital Performance Component

Athletes participate in volleyball drills supported by:

- video recording systems;
- tactical simulation software;
- motion analysis applications;
- wearable performance tracking technologies.

This component creates objective performance data for further analysis.

6.3. Self-Monitoring Component

Athletes use self-monitoring checklists during training sessions. Questions include:

- Did I maintain correct body positioning?
- Was my timing accurate during blocking?
- Did I communicate effectively with teammates?
- How quickly did I recover after mistakes?

This process strengthens athletes' self-awareness and independent correction abilities.

6.4. Reflective Analysis Component

At the end of training sessions, athletes complete reflective sports diaries analyzing:

- successful actions;
- technical errors;
- tactical weaknesses;
- emotional responses during gameplay.

Reflection transforms training from mechanical repetition into conscious learning.

6.5. Corrective Coaching Component

Coaches analyze digital performance data and provide individualized developmental feedback. Feedback focuses not only on mistakes but also on tactical reasoning, emotional stability, and strategic adaptation.

7. Practical Recommendations

Several practical recommendations can be proposed for volleyball coaches and sports educators:

1. Digital technologies should be integrated systematically into volleyball education rather than used occasionally.
2. Video replay systems should focus not only on mistakes but also on tactical understanding and athlete reflection.
3. Athletes should regularly complete reflective performance diaries.
4. Coaches should encourage self-regulated learning and athlete autonomy.
5. Tactical simulations should be included in volleyball training programs to strengthen decision-making abilities.
6. Sports schools should provide methodological training for coaches in digital sports pedagogy.
7. Emotional regulation strategies should be integrated into reflective athlete education.

8. Limitations

This study has several limitations.

First, the intervention lasted only eight weeks. Longitudinal studies are needed to evaluate long-term effects.

Second, the sample size was relatively limited and focused on adolescent volleyball players.

Third, self-report questionnaires may contain subjective bias.

Fourth, different coaching styles may influence intervention effectiveness.

Future studies should investigate:

- artificial intelligence in volleyball training;
- wearable sensor technologies;
- virtual reality tactical simulations;
- biomechanical movement analysis systems.

9. Conclusion

The present study demonstrated that digital-supported volleyball education significantly improves technical competence, tactical awareness, and self-regulated learning among adolescent athletes. The integration of video-based feedback, reflective learning, and digital tactical analysis created a more effective pedagogical environment for athlete development.

The findings confirm that volleyball training should move beyond repetitive physical exercises toward reflective, analytical, and athlete-centered educational models. Digital technologies become pedagogically valuable when combined with metacognitive coaching strategies and self-regulated learning approaches.

The proposed pedagogical model can contribute to the modernization of volleyball education systems and support the preparation of tactically intelligent, emotionally stable, and independently thinking athletes capable of successful performance in modern competitive sports.

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