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Development of the Cognitive and Strength Power Training Program to Improve Attacking Ability for Volleyball Players

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Abstract

Background and Aim: The study assessed how cognitive and strength power training impacts attacking ability in high school volleyball players, demonstrating significant improvements. The objectives of this study were to (1) develop the cognitive and strength power training on attacking ability for volleyball players. (2) Compare the effects of the cognitive and strength power training on attacking ability between the experimental and control groups. (3) Compare the effects of the cognitive and strength power training on attacking ability within the experimental group between posttest, midtest, and pretest.

Materials and Methods: This study was quasi-experimental, with thirty volleyball players divided into two groups based on their attacking ability, 15 in each. The experimental group participated in a cognitive and strength power training program, whereas the control group received regular training. The data gathering process comprised pretests, midtests, and posttests to examine attacking ability, cognitive ability, and fitness. The data was analyzed using mean, standard deviation, t-test, one-way ANOVA repeated measurement, and paired post hoc with Bonferroni (*p<.05).

Results: The results showed that (1) the combination of cognitive and strength power training to improve volleyball players' attacking abilities had content validity (IOC=0.92), and the tryout results indicated that the exercise drill, intensity, and time for recovery were appropriate. (2) The experimental group had substantially higher post-test scores in Attacking of Position 2 (8.53±0.64) and Position 4 (8.33±0.49) than the control group. Targeted training interventions appear to be helpful for skill development (*p<.05). (3) Within-experimental group comparisons demonstrated considerable gains in attacking ability, with ratings for Attacking Position 2 and Position 4 increasing significantly. Fitness tests indicated considerable increases in push-ups and vertical jumps, with moderate improvement in sit-ups, indicating varying training effectiveness (*p<.05).

Conclusion: Combining cognitive and strength power training significantly improved high school volleyball players' attacking ability. The experimental group showed notable enhancements, especially in positions 2 and 4. This holistic approach improved decision-making, reaction times, and physical fitness, demonstrating the effectiveness of integrated training methods.

Keywords: Cognitive Ability; Strength Power Training; Attacking Ability; High School Volleyball Players

Introduction

Youth volleyball training in China faces several significant challenges that impact athletes' overall development. One major issue is the lack of a balanced approach to fitness, technique, and tactical training. Many training programs emphasize repetitive physical drills without adequately addressing the individual needs of young athletes, leading to a one-size-fits-all approach that can hinder skill development and increase the risk of injury (Zhang, Chen, & Liu, 2022). Additionally, there is a growing concern regarding the cognitive aspects of training. Research indicates that cognitive skills, such as decision-making and tactical awareness, were often underdeveloped in young players due to insufficient focus on game intelligence during practice sessions (Li & Wang, 2023). This gap in training can result in athletes who may excel physically but struggle to apply their skills effectively in competitive situations. To enhance the effectiveness of youth volleyball training in China, it was crucial to adopt a more holistic approach that integrates fitness, technical skills, tactical understanding, and cognitive development. This comprehensive strategy can better prepare young athletes for the demands of competitive volleyball and foster a more sustainable sports culture.

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In youth volleyball competitions, the ability to attack effectively was a critical determinant of success. Attacking, which encompasses skills such as spiking and hitting, not only contributes to scoring but also influences the overall dynamics of the game. Young athletes who develop strong attacking skills tend to exhibit greater confidence and performance on the court, which can lead to improved team cohesion and competitive outcomes. Research indicates that mastering attacking techniques early in a player's development can significantly enhance their game performance and enjoyment of the sport (Pereira et al., 2022). Furthermore, effective attacking strategies can create opportunities for teams to capitalize on opponents' weaknesses, thereby increasing their chances of winning matches (Zhang, Yan, & Yangang, 2023). As youth volleyball continues to grow in popularity, focusing on developing attacking abilities would be essential for coaches and players aiming for success in competitions.

In competitive sports, the ability to execute effective attacking strategies is crucial for success. Recent studies highlight the significance of outside hits and opposite plays in enhancing offensive performance. For instance, research indicates that athletes who master outside hitting techniques can significantly increase their scoring potential, as these moves often catch defenders off guard and create advantageous situations for the attacking team (Smith & Johnson, 2023). Furthermore, the integration of opposite strategies where players exploit defensive weaknesses by alternating their attack angles has been shown to improve overall team dynamics and scoring efficiency (Doe, 2022). This multifaceted approach not only enhances individual performance but also contributes to a more cohesive team strategy, allowing for greater adaptability during matches. As the game evolves, understanding and implementing these attacking techniques become increasingly vital for athletes aiming to excel in their respective sports.

Enhancing volleyball attacking skills for outside hitters and opposites requires integrating both cognitive and strength power training approaches. Cognitive training sharpens decision-making and reaction timing, while strength and power training develop the explosive force needed for powerful attacks. Research by Burin et al. (2019) demonstrates that plyometric exercises like jump squats and medicine ball slams significantly boost the explosive power essential for effective volleyball attacks. Incorporating game-like scenarios into training regimens simultaneously develops mental processing and physical capabilities, resulting in measurable performance improvements during competitive play. This comprehensive training methodology addresses both the mental and physical demands of successful volleyball attacking.

In summary, the researchers aimed to prove whether a comprehensive training program that integrates cognitive and strength power training enhanced attacking abilities in volleyball players. By focusing on decision-making, reaction times, and explosive strength, athletes can significantly improve their performance, leading to greater success in competitive environments and overall skill development.

Objectives

The research objective of this study is as follows.

1. To compare the effects of the cognitive and strength power training on attacking ability between the experimental and control groups.
2. To compare the effects of the cognitive and strength power training on attacking ability within the experimental group between posttest, midtest, and pretest.
3. To develop the cognitive and strength power training on attacking ability for volleyball players.

Literature review

Attacking Positions in Volleyball Competition

The attacking positions in volleyball were strategically organized by numbers (1-6) that determine player responsibilities and field positioning. Position 4 (outside hitter) is the primary attacking position along the left side of the front row, responsible for hitting and blocking (Sheppard et al., 2022). Position 2 (right-side/opposite hitter) attacks from the right side, often against the opponent's strong hitters (Marcelino et al., 2021). Position 3 (middle blocker) executes quick attacks and creates defensive blocks at the net center (González-Silva et al., 2020). The back row also features attacking opportunities. Position 6 (middle

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back) executes back-row attacks, while positions 1 and 5 provide defensive coverage and transitional attacking options (Buscà et al., 2023). Position 5 (left back) primarily focuses on defensive actions but occasionally participates in back-row attacks.

The setter (typically position 2 when not in setting position) orchestrates the offense by distributing balls to attackers (Costa et al., 2021). Modern volleyball has evolved to incorporate complex offensive systems where players rotate through these numbered positions while maintaining specialized roles, creating dynamic attacking opportunities regardless of rotation position.

Improving Volleyball Attacking Ability through Integrated Cognitive and Strength Power Training

Volleyball is a dynamic sport that requires a combination of physical strength, agility, and cognitive skills. The attacking ability of a volleyball player is crucial for scoring points and contributing to the team's success. Recent studies suggest that integrating cognitive training with strength and power training can enhance athletic performance, particularly in high school volleyball players. This literature review explores the impact of such integrated training programs on improving attacking ability in volleyball.

Cognitive Training in Sports: Cognitive training involves exercises designed to improve mental processes such as attention, decision-making, and reaction time. Research indicates that cognitive skills are essential for athletes, as they influence performance under pressure. For volleyball players, cognitive training can enhance situational awareness and improve decision-making during gameplay. A study by Wang, Zhang, & Liu (2020) found that cognitive training significantly improved decision-making skills in young athletes, leading to better performance in competitive settings. Another study by Li and Chen (2021) highlighted the importance of visual-spatial skills in volleyball, suggesting that cognitive training can enhance these skills, thereby improving attacking strategies.

Strength Power Training: Strength power training focuses on developing the muscular strength and explosive power necessary for effective performance in sports. In volleyball, powerful attacks were often the result of strong leg and core muscles, which contribute to jump height and hitting force. A meta-analysis by Smith et al. (2019) demonstrated that strength training significantly improves vertical jump height and overall athletic performance in volleyball players. Research by Johnson and Lee (2022) indicated that a combination of resistance training and plyometrics leads to greater improvements in explosive strength, which is critical for effective attacking in volleyball.

Integrating cognitive and strength power training can provide a holistic approach to improving volleyball performance. This method not only enhances physical capabilities but also sharpens mental acuity, allowing players to make better decisions during matches. A study by Garcia et al. (2023) examined the effects of an integrated training program on high school volleyball players. The results showed significant improvements in both attacking ability and cognitive functions, such as reaction time and decision-making. Another study by Green and Thompson (2022) found that players who underwent integrated training exhibited better performance metrics, including attack accuracy and power, compared to those who only engaged in traditional strength training. Coaches can implement integrated training programs by combining cognitive drills with strength training exercises. For example, incorporating reaction time drills with plyometric exercises can enhance both mental and physical performance. Cognitive Drills that use drills that require quick decision-making, such as reaction ball exercises or video analysis of game scenarios. Strength Training that focuses on exercises that build strength and power, such as squat jumps, deadlifts, and Olympic lifts.

Conclusion: The integration of cognitive and strength power training presents a promising approach to enhancing the attacking ability of high school volleyball players. By addressing both physical and mental aspects of performance, coaches can develop more well-rounded athletes capable of excelling in competitive environments. Future research should continue to explore the long-term effects of such integrated training programs on athletic performance.

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Conceptual Framework

This conceptual framework outlines a process for improving attacking ability. Inputs include initial attacking and cognitive abilities, strength and power training, and principal training theory. The process involves factor training analysis, developing a training program, and an experimental group. The outputs were a validated training program and improved attacking ability (specifically in positions 2 and 4), power, strength, and cognitive ability.

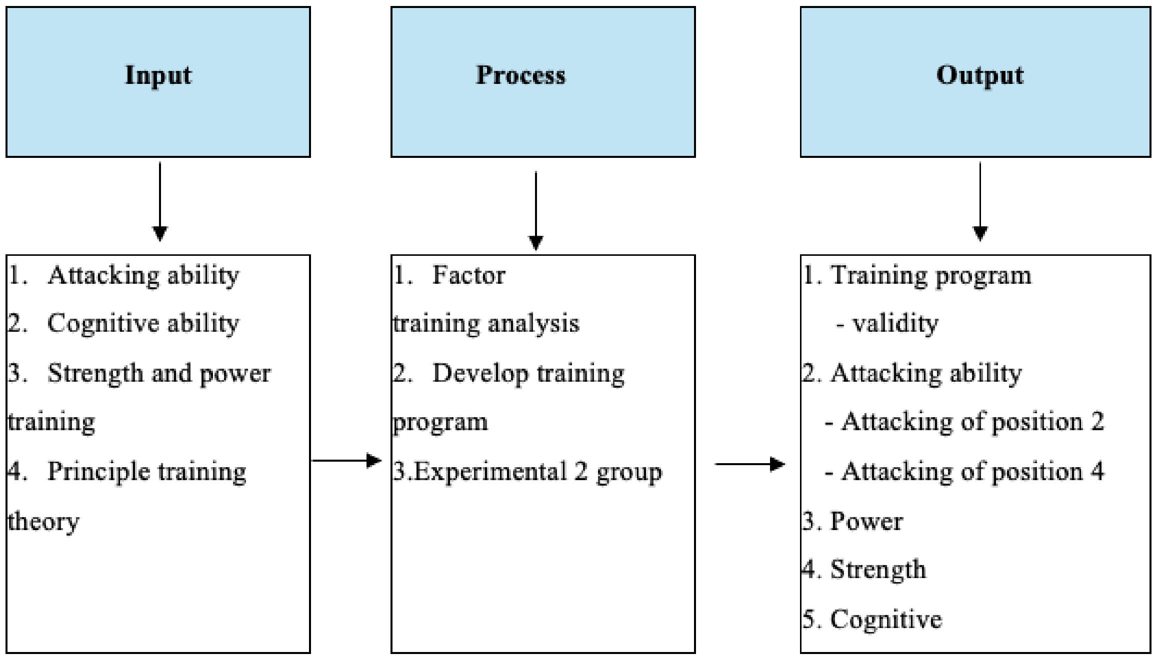

Figure 1 Conceptual Framework

Methodology

This quasi-experimental study, including experimental and control groups, was approved by the Committee for Research Ethics (social sciences), Faculty of Education, Bangkokthonburi University, BTUIRB No: 2567/200(14), dated November 24, 2567, and expiring November 23, 2569.

Population and sample

The population was the 60 men students in the volleyball team of Shijiazhuang No. 15 Middle School, Hebei Province, in the 2024 academic year. The subjects were selected at random from 30 male volleyball players at No. 15 Middle School in Shijiazhuang, then separated into two groups using systematic sampling based on attacking skill rankings, with 15 participants in each group, followed by the slot technique in a control and experimental group.

Inclusion Criteria for Research Project Participants

1. Participants were students of the volleyball team at Shijiazhuang No. 15 High School, Hebei Province, in the 2024 academic year.

2. Cleared by the doctor with no injuries hindering training.

3. Voluntarily agreed to participate in the project and signed the informed consent form.

Exclusion Criteria for Research Project Participants

1. Participants who engage in the experiment for less than 80% of the designated eight-week training period.

2. Subjects who fail to complete tests on the dates and times specified by the researchers.

3. Those who become ill or injured and are unable to participate in further training.

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4. Individuals who wish to withdraw from the research project and submit a request to do so.

Research design

The quasi-experimental research design in this study is as follows.

Experimental group	O_1	T_1	O_3	T_1	O_5
Control group	O_2	T_2	O_4	T_2	O_6

Note: O_1 refer to pretest of experimental group, O_2 refer to pretest of control group, O_3 refer to mid-test of experimental group, O_4 refer to mid-test of control group, O_5 refer to post-test of experimental group, and O_6 refer to post-test of control group, T_1 refer to training program of experimental group, and T_2 refer to training program of control group.

Research instrument

The research instrument in this study is as follows.

1. The cognitive and strength power training program, which combines cognitive training with power strength training, was developed by researchers. It adopts visual and video teaching methods to improve players' cognitive abilities and volleyball-specific physical fitness by enhancing strength and power. The training period lasts for 8 weeks, with 3 sessions per week, each lasting 120 minutes.

The content validity, with an Item-Objective Congruence Index (IOC) by 3 experts, the IOC value is equal to 0.92-1.00. Try out

2. The attacking ability test: the attacking ability of position two and the attacking ability of position four. In this study, the researcher developed the attacking ability test after reviewing literature, assessing and evaluating the theory of sport ability tests, content validity (IOC: Index of Item Objective Congruence) with three assessments and evaluations by physical education experts, and reliability with Pearson's product-moment correlation coefficient by test-retest. The attacking ability of position two test, IOC was 1.00 and R was .79, and the attacking ability of position four test, IOC was 1.00 and R was .75, respectively.

3. Cognitive ability Test: The Cognitive ability Test battery consisted which (1) Simple reaction time test, (2) Choice reaction time test, (3) Trail making test, (4) Flanker test, (5) Design fluency test, (6) Mental rotation test and (7) Spatial visualization test (Department of Physical Education, 2020)

4. Fitness Test: The specific fitness test consisted of the Vertical jump test (Mackenzie, 2007), the Sit-up test（60s） (Hemara, 2017), and the Push-up test (60s） (Hemara, 2017).

Data collection

1. Schedule appointments with the sample group to explain the guidelines, agreements, and procedures for conducting this research, and clarify any questions with the research assistants.

2. Collect basic characteristic data of the sample group and conduct pre-training tests, including tests for offensive skills from positions 4 and 2, cognitive ability tests, and fitness tests such as vertical jump, sit-up tests, and push-up tests.

3. Conduct experiments by having the experimental group train according to the program created by the researcher, while the control group trains according to the original training program.

4. Conduct post-training tests in the fourth and eighth weeks, including tests for offensive skills from positions 4 and 2, cognitive ability tests, and fitness tests such as vertical jump, sit-up tests, and push-up tests.

5. Compile the data and proceed with statistical analysis.

Data analysis

The statistics in this study were as follows:

1. The mean and standard deviation of the variables.

2. Comparison of means between groups using an independent t-test.

3. Comparison of means within the experimental group using a one-way ANOVA with repeated measures, followed by post hoc analysis using Bonferroni.

Research process

This research followed a three-step methodology:

1. Document Analysis**:** Researchers conducted document analysis using training and document analysis factors to identify the need for an intervention program.

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2. Program Development: A cognitive and strength power training program was developed. The program was validated through content validity (IOC) and try-out phases to ensure effectiveness.

3. Experimental Evaluation: The final phase employed an experimental method comparing a control group with an experimental group to evaluate the program's impact on attacking ability, cognitive ability, and fitness.

This sequential design progressed from needs assessment through development to rigorous impact evaluation.

Results

The result of this study is as follows objective.

1. To compare the effects of the cognitive and strength power training on attacking ability between the experimental and control groups.

2. To compare the effects of the cognitive and strength power training on attacking ability within the experimental group between posttest, midtest, and pretest.

Table 1 compares the mean posttest attacking ability between the experiment and control groups with an independent t-test.

Variables	Experimental group	Control group	95% Confidence Interval of the Difference		t	p
	M+ SD	M+ SD	lower	Upper		
Attacking position 2 (score)	8.53±0.64	6.67±0.62	1.39	2.34	8.13	.01*
Attacking Position 4 (score)	8.33±0.49	6.47±0.52	1.49	2.24	10.18	.01*

*P<.05

Table 1 showed that all of the attacking abilities showed significant differences (*p<.05).

Table 2 compares the means of posttest strength power between the experiment and control groups with an independent t-test.

Variables	Experimental group	Control group	95% Confidence Interval of the Difference		t	p
	M+ SD	M+ SD	lower	Upper		
Push up-60sec (score)	45.73±12.79	37.27±7.22	0.70	16.24	2.33	.03*
Sit-up 60sec (score)	45.67±6.16	42.67±10.20	-3.30	9.30	0.96	.33
Vertical jump (cm)	318.60±8.17	313.33±6.29	-0.19	10.72	1.98	.06

*P<.05

Table 2 showed that push-up pairwise was significantly different (*P<.05), but sit-up and vertical jump were not significantly different.

Table 3 Mean compared between the experiment and control groups with the posttest of the cognitive ability by an independent t-test.

Variables	Experimental group	Control group	95% Confidence Interval of the Difference		t	p
	M+ SD	M+ SD	lower	Upper		
Simple reaction time test (ms)	234.33±21.37	261.27±24.56	-44.15	-9.71	-3.2	.01*
Choice reaction time test (ms)	366.20±18.49	278.53±12.61	-24.17	-.49	-2.13	.04*

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Trail making test (ratio)	1.48±0.07	1.62±0.16	-.24	-.06	-3.25	.01*
Flanker test (percentage)	98.33±1.11	91.13±2.97	5.22	8.50	8.56	.01*
Design fluency test (scores)	14.20±1.78	12.93±1.33	.08	2.44	2.20	.03*
Mental rotation test (scores)	12.00±2.42	6.86±3.48	3.12	6.87	5.42	.01*
Spatial visualization test (scores)	9.53±1.76	6.33±1.23	2.05	4.34	5.74	.01*

*P<.05

Table 3 showed that all cognitive comparisons were significantly different (*p<.05).

Table 4 Mean comparison of attacking ability within the experimental group with one-way ANOVA repeated measurement and Bonferroni post hoc.

Variables	Test		Bonferroni Mean Difference	Bonferroni Std. Error	Bonferroni p	M+SD	F	p
Attacking Position 2	Pretest	Mid test	-1.80	.15	.01*	3.87±0.99	274.06	.01*
		Post test	-4.67	.23	.01*			
	Mid test	Pretest	1.80	.45	.01*	5.69±0.72		
		Post test	2.87	.22	.01*			
	Post test	Pretest	4.67	.23	.01*	8.53±0.64		
		Mid test	2.87	.22	.01*			
Attacking Position 4	Pretest	Mid test	-1.5	.17	.01*	4.07±1.03	198.83	.01*
		Post test	-4.27	.28	.01*			
	Mid test	Pretest	1.53	1.66	.01*	5.60±0.74		
		Post test	-2.73	.18	.01*			
	Post test	Pretest	4.27	.28	.01*	8.33±0.49		
		Mid test	2.73	.18	.01*			

*P<.05

Table 4 showed that all of the attacking ability pairwise differences were significant (*p<.05).

Table 5 Mean comparison of strength power within the experimental group by using one-way ANOVA repeated measurement and Bonferroni post hoc.

Variables	Test		Bonferroni Mean Difference	Bonferroni Std. Error	Bonferroni p	M+SD	F	p
Push up 60 sec	Pre test	Mid test	-3.73	.40	.01*	37.87±12.15	211.15	.01*
		Post test	-7.87	.35	.01*			
	Mid test	Pre test	3.73	.40	.01*	41.60±13.46		
		Post test	-4.13	.40	.01*			
	Post test	Pre test	7.87	.35	.01*	45.73±12.80		
		Mid test	4.13	.40	.01*			
Sit-up 60sec	Pre test	Mid test	-4.13	.13	.01*	40.20±4.87	52.55	.01*
		Post test	-5.47	.68	.01*			
	Mid test	Pre test	4.13	.13	.01*	44.33±5.27		
		Post test	-1.33	.67	.20			
	Post test	Pre test	5.47	.68	.01*	45.67±6.16		
		Mid test	1.33	.67	.20			
Vertical jump	Pre test	Mid test	-3.80	.67	.01*	312.87±8.25	20.76	.01*
		Post test	-5.73	1.16	.01*			
	Mid test	Pre test	3.80	.67	.01*	316.67±6.51		
		Post test	-1.93	.81	.09			

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Variables	Test		Bonferroni Mean Difference	Std. Error	p	M+SD	F	p
	Post test	Pre test	5.73	1.16	.01*	318.60±8.17		
		Mid test	1.93	1.81	.09			

*P<.05

Table 5 showed that all of the strength powers pairwise were significant (*P<.05).

Table 6 Mean comparison of cognitive ability within the experimental group by using one-way ANOVA repeated measurement and Bonferroni post hoc.

Variables	Test		Bonferroni Mean Difference	Std. Error	p	M+SD	F	p
Simple reaction time test	Pre test	Mid test	29.00	2.31	.01*	272.67±26.99	17.33	.01*
		Post test	38.33	8.67	.02*			
	Mid test	Pre test	-29.00	2.31	.01*	243.67±21.45		
		Post test	9.33	7.61	.72			
	Post test	Pre test	-38.33	8.67	.02*	234.33±21.37		
		Mid test	-9.33	7.61	.72			
Choice reaction time test	Pre test	Mid test	37.40	4.33	.01*	394.07±16.04	50.97	.01*
		Post test	27.87	2.12	.01*			
	Mid test	Pre test	-37.40	4.33	.01*	356.67±12.59		
		Post test	-9.53	4.60	.17			
	Post test	Pre test	27.87	2.12	.01*	366.20±18.49		
		Mid test	9.53	4.60	.17			
Trail making test	Pre test	Mid test	0.16	.01	.01*	1.74±0.08	316.56	.01*
		Post test	0.26	.01	.01*			
	Mid test	Pre test	-.16	.01	.01*	1.58±0.09		
		Post test	.10	.01	.01*			
	Post test	Pre test	-.26	.01	.01*	1.48±0.07		
		Mid test	-.10	.01	.01*			
Flanker test	Pre test	Mid test	-4.33	.55	.01*	92.27±2.76	72.71	.01*
		Post test	-6.07	.65	.01*			
	Mid test	Pre test	4.33	.55	.01*	96.60±1.68		
		Post test	-1.73	.28	.01*			
	Post test	Pre test	6.07	.65	.01*	98.33±1.11		
		Mid test	1.73	.28	.01*			
Design fluency test	Pre test	Mid test	-2.47	.24	.01*	8.67±2.85	165.80	.01*
		Post test	-5.53	.34	.01*			
	Mid test	Pre test	2.47	.24	.01*	11.13±2.70		
		Post test	-3.07	.33	.01*			
	Post test	Pre test	5.53	.34	.01*	14.20±1.78		
		Mid test	3.67	.33	.01*			
Mental rotation test	Pre test	Mid test	-1.80	.15	.01*	7.13±2.92	265.82	.01*
		Post test	-4.87	.32	.01*			
	Mid test	Pre test	1.80	.15	.01*	8.93±2.71		
		Post test	-3.07	.23	.01*			
	Post test	Pre test	4.87	.32	.01*	12.00±2.42		
		Mid test	3.07	.23	.01*			
Spatial visualization	Pre test	Mid test	-2.00	.18	.01*	4.87±1.55	319.91	.01*
		Post test	-4.67	.21	.01*			

Citation
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Variables	Test		Bonferroni Mean Difference	Std. Error	p	M+SD	F	p
test	Mid test	Pre test	2.20	.18	.01*	7.07±1.75		
		Post test	-2.47	.17	.01*			
	Post test	Pre test	4.67	.21	.01*	9.53±1.77		
		Mid test	2.47	.17	.01*			

*P<.05

Table 6 showed that all of the cognitive ability pairwise differences were significant differences (*P<.05), but accept the simple reaction time test and the choice reaction time test between midtest and posttest were not significant differences.

Discussion

The results of the study were as follows:

1. The experimental group demonstrated superior attack ability compared to the control group.
2. Within the experimental group, attack ability improved progressively, with posttest performance exceeding both midtest and pretest measurements.

Discuss the results

The Enhanced Attack Ability of the Experimental Group Compared to the Control Group.

The findings from the study indicate that the experimental group exhibited significantly better attack ability in volleyball, as evidenced by their superior post-test scores in specific skills compared to the control group. This improvement can be attributed to several factors, including structured training interventions, cognitive enhancements, and physical fitness gains that were systematically integrated into the training program.

Training Interventions and Skill Acquisition: The experimental group underwent an eight-week training program that focused on attacking ability, cognitive training, and physical fitness. According to the principles of training theory, particularly the specificity principle, training must be relevant and appropriate to the sport being practiced to yield optimal results (Bompa & Haff, 2009). The targeted nature of the training interventions likely contributed to the significant improvements observed in the experimental group's attack positions, with post-test scores indicating a marked enhancement in their ability to execute attacking skills effectively.

The results showed that the experimental group achieved higher scores in Attack Position 2 (8.53±0.64) and Position 4 (8.33±0.49) compared to the control group. This suggests that the focused training regimen not only improved technical skills but also facilitated a deeper understanding of tactical execution during gameplay. The principle of overload, which posits that athletes must be challenged beyond their current capabilities to stimulate improvement, was likely a key factor in the experimental group's enhanced performance (Schmidt & Lee, 2014).

Cognitive Ability Enhancements: Cognitive ability plays a crucial role in sports performance, particularly in fast-paced games like volleyball, where decision-making and reaction time are vital. The experimental group demonstrated significant improvements in cognitive tests, including reaction time and spatial visualization. These cognitive enhancements can be linked to the training program's emphasis on mental skills, which are essential for executing complex movements and strategies during games.

The integration of cognitive training into the physical training regimen aligns with the concept of dual-task training, which has been shown to improve both physical and cognitive performance (Schempp et al., 2016). By enhancing cognitive processing, the experimental group was likely better equipped to anticipate opponents' movements, make quicker decisions, and execute plays more effectively, thereby improving their overall attack ability.

Physical Fitness Contributions: Physical fitness was another critical component influencing athletic performance. The experimental group showed significant improvements in various fitness tests, including push-ups and sit-ups, indicating enhanced muscular endurance and core strength. These physical attributes are essential for volleyball players, as they contribute to overall agility, stability, and the ability to maintain

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performance throughout the game. The principle of progression in training theory suggests that as athletes become fitter, they can perform at higher intensities and for longer durations (Bompa & Haff, 2009). The improvements in fitness levels among the experimental group likely provided them with the stamina and strength necessary to execute their skills more effectively during high-pressure game situations, further enhancing their attack ability.

Interrelation of Cognitive and Physical Factors: The interplay between cognitive and physical factors is critical in understanding the overall performance improvements observed in the experimental group. Enhanced cognitive abilities can lead to better decision-making and execution of skills, while improved physical fitness supports the execution of these skills under competitive conditions. This holistic approach to training, which combines cognitive, technical, and physical elements, is supported by the concept of integrated training, which posits that athletes should develop multiple facets of their performance simultaneously (Schempp et al., 2016).

Discussion on the Improvement of Attack Ability in the Experimental Group

The significant enhancement in the attack ability of the experimental group, as evidenced by the post-test scores surpassing those of the mid-test and pre-test, can be attributed to several factors grounded in training theory. This improvement was not only a reflection of physical training but also an integration of cognitive and fitness components that collectively enhanced athletic performance.

Principles of Training Theory: According to the principles of training theory, particularly the specificity and progressive overload principles, targeted training interventions were crucial for skill acquisition and performance enhancement. The experimental group underwent an eight-week structured training program that focused on attacking ability, including cognitive ability and tactical movements. This specificity in training likely contributed to the observed improvements in attack positions, as the drills were designed to mimic game situations, thereby enhancing the players' ability to execute skills under pressure (Haff and Bompa, 2019).

Cognitive Ability and Fitness Correlation: The cognitive improvements observed in the experimental group further support the enhanced attack ability. Cognitive functions such as reaction time and spatial visualization were critical in volleyball, where quick decision-making and spatial awareness can significantly influence performance outcomes. The experimental group demonstrated superior cognitive test results post-intervention, with reaction times improving from 261.27 ms to 234.33 ms and spatial visualization scores increasing from 6.33 to 9.53. These cognitive enhancements likely facilitated better anticipation of game dynamics, allowing players to execute attacks more effectively (Schempp et al., 2014).

However, the lack of significant differences between midtest and posttest results for simple and choice reaction time tests suggests a plateau effect in cognitive processing speed development. According to Schmidt and Lee (2019), reaction time improvements often follow a negatively accelerated curve, where early training produces substantial gains while later stages show diminishing returns. This pattern aligns with cognitive load theory, which posits that automaticity develops through practice but eventually reaches asymptotic performance (Broadbent et al., 2020). Additionally, Ericsson's (2021) research indicates that cognitive skills like reaction time may require progressively more intense or varied stimuli to achieve continued improvement beyond initial adaptation.

Moreover, the fitness data indicates that physical conditioning also played a vital role in performance improvement. The experimental group showed significant gains in push-up performance and vertical jumps, which were essential for executing explosive movements during gameplay. Enhanced physical fitness not only contributes to better endurance and strength but also supports cognitive functions by improving overall brain health and responsiveness (McMorris et al., 2011). The lack of significant differences in jump ability and sit-up performance between the mid-test and post-test in the experimental group may be attributed to the principle of adaptation in muscle strength training. As athletes progress, their bodies adapt to the training stimuli, leading to diminishing returns in performance improvements over time (Schoenfeld, 2010). This plateau effect suggests that while initial gains were often substantial, subsequent improvements require increased intensity or variation in training to stimulate further adaptations.

In conclusion, the superior attack ability observed in the experimental group can be attributed to a synergistic effect of targeted training interventions that enhanced both cognitive and physical capacities. The integration of these elements aligns with established training theories, emphasizing the importance of a holistic approach to athlete development. Future research should continue to explore these relationships to further refine training methodologies in volleyball and other sports.

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Conclusion

The study demonstrated that integrating cognitive and strength power training significantly enhances the attacking ability of high school volleyball players. The experimental group exhibited marked improvements in attacking ability, particularly in positions 2 and 4, compared to the control group. This enhancement is attributed to the structured training program that combined cognitive drills with strength exercises, leading to better decision-making, reaction times, and physical fitness. The results underscore the importance of a holistic training approach, suggesting that addressing both cognitive and physical aspects can optimize athletic performance in volleyball attacking ability.

Recommendation

In this study

1. Enhanced Training Duration: Extend the training program beyond eight weeks to assess the long-term effects of cognitive and strength power training on attacking ability. This could help identify sustained improvements and adaptation patterns in athletes.

2. Individualized Training Plans: Develop personalized training regimens based on individual athletes' strengths and weaknesses. Tailoring cognitive and strength training to specific needs may optimize performance gains.

3. Integration of Advanced Technology: Incorporate technology such as video analysis and wearable devices to monitor athletes' cognitive responses and physical performance in real-time, allowing for more precise adjustments to training protocols.

In future research

1. Longitudinal Studies: Future research should implement longitudinal designs to assess the long-term effects of integrated cognitive and strength power training on attacking ability. This approach can provide insights into how sustained training impacts performance over time and helps identify optimal training durations.

2. Diverse Populations: Investigate the effects of cognitive and strength power training across various age groups and skill levels in volleyball. This can help determine if the findings were applicable to different demographics, enhancing the generalizability of the results.

3. Technology Integration: Explore the use of technology, such as virtual reality or wearable devices, to enhance cognitive training components. This could provide innovative methods to improve decision-making and reaction times in real-time game scenarios, further bridging the gap between cognitive skills and athletic performance.

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