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Experimental Study on the Effect of Background Interference on Tennis Players' Serving Performance

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Abstract
The learning of tennis movement skills is rather complex and requires repeated practice and body coordination. It is difficult to master standardized technical movements in a short period of time. Therefore, a variety of training methods have been developed to facilitate the learning of tennis movement skills. In particular, the theory of background interference has been discussed by many scholars in recent years. Whether background interference is beneficial or detrimental to the learning of tennis movement skills requires further validation by scholars. Based on research methods such as literature, experiments, expert interviews and mathematical statistics, the effect of background interference on tennis players' serving technique training was examined using 15 Level 2 tennis players with no significant difference as subjects in a sports institute. They were divided into three groups of 5, each by serpentine grouping. The experiment was conducted for 4 weeks, with 3 sessions per week, for a total of 12 sessions of training. Four experimental indices (serving performance, accuracy, inside-angle accuracy, and speed) were selected for testing. The results showed that: (1) During skill acquisition, the players comprehended tennis serves more deeply. Moreover, they improved the power and speed of the serve and controlled the direction of the drop better. (2) The results of the retention test reflected the performance characteristics of effective learning, with the persistent practice effects. High background-interference practice facilitated long-term memory and also clarified each serve more distinctly. (3) After high background-interference exercises, athletes tolerated stress better in migration tests, enabling themselves to adapt to new operating environments quickly. The training method of the randomized training group was shown to be more effective than the sequence and group training methods in improving technical stability in a high-stress, high-intensity environment. (4) The results of the skill acquisition, retention test, and migration tests were all following the experimental expectations, and the athletes' serving accuracy as well as their serving scores all improved to different degrees, confirming that the high background-interference practices were conducive to the athletes' skill retention and migration.
Keywords: Background interference; Serving result; Tennis; Athlete

Introduction

Background interference, also known as associative intervention, refers to the interference in learning a skill by changing the organization of the practice for the same or multiple skills. Related studies have found that high background interference affects learning negatively in the early stages. In later tests, learning was more efficient under high background interference than low or no background interference. Contextual interference is derived from cross-task interference, which highlights distractors such as learners, learning goals, and learning plans better.

For example, Farrow and Buszard (2017) selected child beginners as experimental subjects, and Krohne and Hindel (2000) experimented with adolescents. Furley and Wood (2016) selected college students as experimental subjects. The results all showed that background interference exists for learning different action procedure tasks. Low background interference increases the efficiency at the beginning of learning the same movement skills. At the same time, a progressive approach is the best way to practice different movement routines. Low background interference facilitates the learning of movement skills, and the modes of practice affect learning differently at different stages. Moreover, high background interference facilitates the retention of movement skills and has a better anti-forgetting effect.

Movement skills are formed in different stages. Learners' movement skills improve as they practice. Numerous scholars have proposed theoretical models about the formation of movement skills to rationalize this change. It is concluded that there are stages in the formation of movement skills, each with its characteristics. An analysis of these characteristics is an important method to evaluate the level of skills. Posner, together with Fitts and Gentile, proposed a theory about the stages of formation of movement skills, which divided it into three stages, namely the cognitive, the connection, and the automation stages. While many domestic scholars and textbooks divide the stages of the formation of movement skills into three: generalization, differentiation, and automation, this is a developmental process from simple to complex and quantitative to qualitative change. Three stages are bounded, interconnected, causal, and inseparable. The background interference is applied to movement skill's learning to explore its formation, retention after some time, and transfer of movement skills. In this experiment, the formation of movement skills was divided into three

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stages: movement skill acquisition stage, retention stage, and transfer stage, based on the time of skill practicing and the inclusion of background interference theory (Eddens, van Someren, & Howatson, 2018).

As one of the most popular sports in the world, tennis has the reputation of "noble sports", "elegant sports", and "civilized sports". The unique tennis culture has made tennis become one of the lifestyles advocated by people in today's society. With the rise of tennis, colleges across the country are competing to offer tennis courses. More and more students choose the tennis specialty in professional sports colleges. The motor skills require a lengthy process where massive time and energy are devoted to learning complicated technical movements. Even so, satisfactory results may not be obtained (Murach & Bagley, 2016). The theoretical knowledge should be mastered to learn technical movements. Combined with correlation theory, scientific practice makes a better learning effect. In sports practice, the key to mastering sports skills is to ensure the quality of practice rather than investing a lot of time and exercise load. Therefore, physical education workers should know the way of ensuring the effectiveness of each practice to achieve better results in competitions. At the present stage, the athletes practice the movements under familiar conditions to achieve good effects. However, the movement effect may not be presented in a complicated game. The practice is not a long-term solution (Vechin, Conceição, Telles, Libardi, & Ugrinowitsch, 2021). Based on conversion exercises by background interference, students and athletes can experience different movements and practice environments to exercise adaptability to different situations and the operation level in a new environment.

The work applied the theory of background interference to the process of tennis training in a sports college. According to the serving of tennis players under different practice methods, the experience of tennis players' serving skill learning was summarized. Then, the most effective training methods and plans were designed given different contents, skills, and objects. Finally, the theory of background interference, commonly known as proactive interference and taken from interference theory, was reasonably applied to tennis skill learning and physical education, which improves the quality of teaching of playing tennis and makes the theory serve for sports training. As the application of background interference theory in the learning of tennis cognitive and physical skills proves to be fruitful in improving serve quality and overcoming the occurrence of let or fault, it needs more research so that awareness can be created in other tennis players. Considering this need, our study aims at examining the role of background interference in bringing improvement in the tennis serving. Some studies like Ludyga, Mücke, Andrä, Gerber, and Pühse (2021); Vechin et al. (2021) have already discussed the background interference and its impact on tennis players' performance but not so profoundly or clearly as our study did. Our study gives a detailed description of how the background interference affects the tennis players' cognitive skills, formation of movement skills, positioning, and finally serving. The majority of the studies have thrown light on simply interference theory with both effects proactive interference and retroactive interference. Our study is a struggle to explore the background interference impacts on the tennis players' serving performance.

The 2nd portion of the study shows what sort of views the other authors have presented in their studies about the application of background interference theory in tennis learning. The 3rd portion of the study clarifies the methodology which has been applied to collect quantitative data about the degree of improvement in serving skills as the result of background interference application. The last results of the study are supported and approved by past workouts.

Literature Review

Tennis is one of the most popular sports. It has a reputation equal to civilized, elegant, and noble sports. Tennis has become a part of the culture in many countries. In today's society, people give preference to tennis as an elegant lifestyle. It has become the base on which different educational institutions, organizations, or nations are competing against others in order to achieve fame and economic gains as well. For the purpose of improvement in the movement or serving skills of tennis players, the countries offer different tennis courses. Different professional sports colleges are rendering their services to the students to develop tennis specialty in them (Broadbent, Causer, Ford, & Williams, 2015). Motor skills (automatic or spontaneous actions without particular thinking behind) for tennis sports require a lengthy process as in this case, massive time and a lot of energy is needed to devote to learn complex technical skills. Despite all this, satisfactory skills are not likely to be developed. The players also need knowledge, awareness, cognitive, and physical abilities to learn technical movements. The success of the tennis players is dependent on their positions, movements, and serving performance while practicing or playing tennis at any local, national, or international level (Graser, Bastiaenen, & van Hedel, 2019). Besides having the inborn movement or service skills in tennis, the players can develop or sharpen those skills through training, learning, or practice. The thoughts and intervention of thoughts determine the effectiveness of the training, learning, or practice. Our study aims at analyzing and confirming the key role of thoughts & intervention of memories in improving the serving performance of the tennis players applying the background interference theory. Many renowned scholars have applied this theory of background interference to check the movement skills and the serving performance of the players. The arguments of these scholars have been cited below to confirm the impacts of background intervention on the serving performance of the tennis players:

Pauwels, Vancleef, Swinnen, and Beets (2015), have

presented his views about the thinking or intervention of the memories and check their role in learning some particular sports skills. This study is based on the experiment of serving performance skills of some tennis players learning under the guidance of the same coach. This study defines the background intervention theory as the theory which implies that when human beings pass some training or learning process, their memories intervene his learning. Some memories interfere or hamper the others. According to these arguments, the intervention of past memories could affect the serving performance of the players in two manners. Some memories from past experience are useful or contributing while learning serving skills, while there are also some memories that are irrelevant or contradicting the present practice. Thus, their invention slows down the practice of learning serving skills. But the authors conclude that the background intervention mostly affects the tennis serving performance in a positive manner. The study of Buszard, Reid, Krause, Kovalchik, and Farrow (2017), was conducted to explore the intervention of memories with others and their role in the learning of serving skills. The author makes an experiment of 12 second-level tennis players for 5 weeks consisting of four sessions in each. The intervention of past memories into the current memories and their impacts on the practice skills and learning process was noted out. The progressive approach was applied during the experiment and concluded that at the beginning of the training, the lower background interference facilitates the learning of serving skills, while as time passes, the higher background intervention in the same context accelerates the learning process and improves practice. Thus, the background intervention facilitates the learning process during tennis practice in different degrees at different levels of training. The study by Shewokis et al. (2017), about the factors affecting the serving skills of tennis players both in short- and long-term training making experiments on the tennis players. It has chosen 12 2nd level tennis players for the experiment for one week and 12 2nd level players for 5 weeks. In the short term, past memories mostly hamper the other and, thus, less contribute to the serving performance. On the other hand, in long term practice, the high background intervention improves the capacity of the tennis players to learn how to hit the ball efficiently without allowing any let or making any fault.

Wright et al. (2016), have written about the intervention of different sorts of memories and the efficiency of the tennis players in serving. This study is based on empirical analysis of the tennis players while examining the frequency of memory intervention and its impacts on learning and playing performance. The subjects of this empirical analysis are the children who have just begun to play tennis at the school level. The results of the study, which have been extracted from this empirical analysis, confirm that though the background intervention at the start of tennis sports hinders the children practice and as time passes, it helps the children to learn the right position, movement skills, and eye contact while serving. This enables them to toss and hit the ball with the racket in the right manner so that it goes to the serving box without any let or fault. Similarly, the literary workout of Frömer, Stürmer, and Sommer (2016), about the effective movement skills and improved serving performance in case there exists background intervention during practice. This workout was done for the analysis of background intervention into the thinking of the certain number of players in tennis sports. Adolescents and college students are the subjects of this analysis. The study presents the results on the basis of this analysis. This study implies that both the proactive intervention and the retroactive intervention are beneficial in learning more efficiently the formation of movement skills along with all three stages like the movement skill acquisition stage, retention stage, and transfer stage. In addition, the study by Broadbent, Causer, Williams, and Ford (2017) tests the application of intervention theory while giving sports training to tennis players for the professional sports colleges. This study first defines the intervention theory as the theory regarding human memory. Memory interference occurs in learning sports. There is an immense number of encoded within the storage of long-term human memory. It is challenging to recall the concerned memory in the temporary game practice provided in short term memory. According to this study, there are two types of interference effects: proactive interference (background interference) & retroactive interference. This study concluded that of the two effects of interference theory, proactive interference is less problematic and more beneficial in learning the movement skills and positioning skills to be used while serving in tennis.

The study conducted by Lin et al. (2018), tests the impacts of the background interference (past memory interference) on the serving capabilities of tennis players and their sports progress. The authors conduct an experiment of one month along with 12 sessions of learning tennis serving to personally analyze the serving skills development, retention, and the transfer of these applying the progressive approach. This study implies that in the very first session when the players are used to the old techniques of practice, the interference of the old memories in the new memories of up-dated techniques becomes a hurdle in the way of learning skills. But as the session progresses, the new memories become old and strong, then their interference enhances the cognitive skills which leads to movement skills and enhance serving performance of the tennis players. The study concluded that background interference has significant positive impacts on the tennis players' serving performing in the playground. The study by the researchers Karlinsky and Hodges (2018), considers the background interference in the learning process and serving performance in tennis. The results of the study are established, on the basis of the data acquired from 35 tennis players thought issuance and filling of questionnaires about their experience of memory interference and nature & degree of change in

performance. Considering the data, the study concluded that higher background interference in the same context and relevant practices, brings improvement in the accuracy of the tennis players' serving. In case of the higher background interference, the players are more likely to make good shot of ball to start a point as they have better learned the positioning and movement skills. Moreover, de Souza, Nunes, Corrêa, and dos Santos (2015), have written a study with an aim to provide a guideline for the tennis players on how they can better serve. The study examines how the background interference could improve the power, accuracy, and speed of the tennis players' serving. The background interference affects the learning capacity of the players giving them a chance to adopt improved practice techniques. Thus, it improves the cognitive and physical skills of the players when they are serving in the game.

Research Object and Method

Subjects

The influence of different organization practice methods on tennis players' serving results was taken as the research object.

The experimental objects consist of 15 second-level skilled athletes recruited from a physical culture institute. The motor levels of athletes were tested according to Technical Grade Standard and Evaluation Method for China Tennis Association. Using the serpentine distribution method, the 15 athletes were divided into class, random, and sequence practice groups, with 5 people in each group. Basic information such as sport career ages and levels were conducted with data detection by the author and PE students from an institute to verify the homogeneity among three groups, thus achieving effective and real results. After collecting the statistical results, we obtained the differences among the three groups by one-way analysis of variance. It is judged whether the basic data of the 3 group members remain homogeneous among groups.

Table 1

Basic information statistics of subjects (N = 15)

Group	Sports career age (years)	Sport level
Class exercise group	5.20 ± 0.83	222.80 ± 31.00
Sequence exercise group	5.00 ± 1.22	222.80 ± 26.92
Random exercise group	4.40 ± 0.54	225.60 ± 25.68

Table 1 shows that the average sports years of class, sequence, and random exercise groups are 5.20 ± 0.83 (max), 5.00 ± 1.22, and 4.40 ± 0.54 (min), respectively. The motor levels of athletes were tested to be equivalent according to Technical Grade Standard and Evaluation Method for China Tennis Association. The average sport levels of the class, sequence, and random exercise groups are 222.80 ± 31.00, 222.80 ± 26.92, and 225.60 ± 25.68, respectively (see Table 1).

Table 2

Tested basic information difference of subjects (N = 15)

Index	Levene statistics	df1	df2	Sig.
Sports career age	.561	2	12	.585
Sports level	.028	2	12	.972

Before the experiment, the sport career ages, and levels of athletes are tested for homogeneity. After the Shapiro-Wilk test, the data of each group follow the normal distribution (P > 0.05). Levene's variance homogeneity test shows no statistical significance. The significant levels of sports career age P = 0.585 > 0.05; the significance level of sport level P = 0.972 > 0.05. With homogeneity of variance, the data can be used for a one-way analysis of variance.

Table 3

One-way analysis of variance for basic information of subjects

Index		Sum of square	df	Mean square	F	Sig.
Sports career age	Between-group	.533	2	.267	.286	.756
	Intergroup	11.200	12	.933		
	Total	11.733	14			
Sport level	Between-group	46.533	2	23.267	.030	.971
	Intergroup	9362.400	12	780.200		
	Total	9408.933	14			

Table 3 shows that the sports career age of athlete F (2,12) = 0.286, with the significance level P = 0.756 > 0.05; the sport level F (2, 12) = 0.030, with the significance level P = 0.971 > 0.05. Subsequently, the data P-value is greater than 0.05 after multiple comparisons of basic information such as sport career ages and levels. It is found that homogeneous grouping will not affect the process of the experiment.

Experimental Method

Experimental Task

In the experiment, each athlete took two different stances (Zones 1 and 2) to practice two service skills (flat stroke and sidespin). The ball should be served to the inner corner of the target area (640 × 137 cm) as much as possible. When the ball fell in the inner corner of Zones 1 and 2, the athlete earned 4 points; when the ball fell in the outer corner, the athlete earned 2 points. One point was earned when the ball fell in the prescribed service area, and the second placement was between the base and bonus lines. The athlete scores doubled when the ball fell in the prescribed service area, and the second placement was behind the bonus line. The athlete earned 0 and 1 points when the ball fell outside and inside the prescribed service area, respectively. The service result was the sum of all the points.

Experimental Procedure

The formal experiment consisted of 12 classes in 4 weeks. One week after the end of the experiment, we conducted the maintenance and migration tests.

Skill Acquisition Test

Class exercise group: The athletes practiced flat strokes in

Zone 1 from the first to third lessons (27 times in each lesson, and 81 times in total); sidespins in Zone 1 from the fourth to sixth lessons; flat strokes in Zone 2 from the seventh to ninth lessons; sidespins in Zone 2 from the tenth to twelfth lessons. Sequence exercise group: The athletes' practiced flat strokes in Zone 1 during the first lesson (27 times in each lesson, and 81 times in total); sidespins in Zone 1 during the second lesson; flat strokes in Zone 2 during the third lesson; sidespins in Zone 2 during the fourth lesson. From the fifth to twelfth lessons, the movements were practiced in the following order. Random exercise group: Each subject had to practice 4 service modes, in each lesson (27 times in each lesson, and 81 times in total). The service contents of the random exercise group were randomly arranged by the coach to inform the subjects on the spot. Different skills were required for every two consecutive services. Therefore, the subjects could not predict the next service action.

Maintenance Test

One week after the end of the last training, the service results of three groups of subjects were conducted with a maintenance test. In other words, three groups were tested by serving flat strokes and sidespins in Zones 1 and 2. Flat strokes and sidespins were served 3 times to the inner angles of Zones 1 and 2, respectively.

Purpose: verify the service effects of athletes in different background interference situations

Migration Test

After the maintenance test, we took a 30-minute rest and re-test the service contents of three groups. Flat strokes and sidespins were served 3 times to the outer angles of Zones 1 and 2, respectively. Here, the target area was the outer angle of the service court.

Purpose: verify the abilities to adapt to new test tasks for different groups

Experimental Indices

Experimental indices consisted of the serving result, speed, the accuracy rates of serving and serving the inner angle. Each athlete serves flat strokes and sidespins 3 times to the inner corners of Zones 1 and 2, respectively. After testing the serving speed, the points were earned according to the first and second placements to then calculate the serving result, the accuracy rates of serving, and serving the inner angle.

Experimental Equipment

Smart tennis swing analyzer; video camera; tennis ball

Data Collection

A video camera was placed on the sideline of a court to shoot the placements, thereby recording the results of athletes later. In this experiment, the results of 10,260 exercises were recorded by 2 observers. Given replays, the same rate of results by 2 observers reached 96.1%.

Mathematical Statistics

At the early stage, the measured data were statistically processed. Later, Excel and SPSS17.0 software were used for acquisition, maintenance, and migration tests. At the skill acquisition stage, the data were conducted with a one-way analysis of variance.

Results and Analysis

Comparative Analysis of Pretested Results of Athletes Player's Front Test Serve Score to Score

The pretested serving result, speed, the accuracy rates of serving and serving the inner angle obey the normal distribution according to the Shapiro-Wilk test ($P > 0.05$). Levene's variance homogeneity test shows no statistical significance ($P > 0.05$). With homogeneity of variance, the data can be used for a one-way analysis of variance. After one-way analysis of variance, $P > 0.05$. For three groups of athletes, the pretested serving result, speed, the accuracy rates of serving and serving the inner angle have no significant difference. Subsequently, various indicators of athletes are conducted with multiple comparisons. Results show that the three groups of athletes have no significant differences in the pretested serving result, speed, the accuracy rates of serving and serving the inner angle.

Comparative Analysis of Test Results of Skill Acquisition

Comparative Analysis of Serving Performance of Skill Acquisition

Table 4

Statistics of athletes' serving results.

Group	Class exercise group	Sequence exercise group	Random exercise group
Serving result	73.32 ± 4.03	75.88±3.12	87.09±4.84

Table 4 shows that the random exercise group has the highest serving result. At the skill-acquisition stage, the serving results follow the normal distribution by the Shapiro-Wilk test ($P > 0.05$). Levene's variance homogeneity test shows no statistical significance ($P = 0.410 > 0.05$). With homogeneity of variance, the data can be used for a one-way analysis of variance.

Table 5

Analysis on between-group differences of athletes' serving results

	Sum of squared	df	Mean square	F	Sig.
Between-group	536.698	2	268.349	16.312	.000
Intergroup	197.407	12	16.451		
Total	734.105	14			

In Table 5, $F(2,12) = 16.312$; the significance level $P = 0.000 < 0.05$. During the skill-acquisition test, the average serving result among groups has a very significant difference ($P < 0.05$). After that, the athletes' serving results are conducted with multiple comparisons.

Table 6
Multiple comparisons of athletes' serving results

(I) Group	(I) Group	Mean difference (I-J)	Standard error	Significance	Lower limit	Upper limit
Class exercise group	Sequence exercise group	-2.55556	2.56520	.339	-8.1446	3.0335
	Random exercise group	-13.77222*	2.56520	.000	-19.3613	-8.1831
Sequence exercise group	Class exercise group	2.55556	2.56520	.339	-3.0335	8.1446
	Random exercise group	-11.21667*	2.56520	.001	-16.8058	-5.6276
Random exercise group	Class exercise group	13.77222*	2.56520	.000	8.1831	19.3613
	Sequence exercise group	11.21667*	2.56520	.001	5.6276	16.8058

Table 6 shows the multiple comparisons of serving results during the skill-acquisition test. The class and sequence exercise groups have no significant difference (P = 0.339 > 0.05). The sequence and random exercise groups have significant differences (P = 0.001 < 0.05). The random and class exercise groups have very significant differences (P = 0.000 < 0.05), indicating that high background interference practice conditions are conducive to improving the serving results.

Comparative Analysis of the Accuracy Rates of Serving at the Skill-Acquisition Stage

According to the data, the random exercise group has the highest accuracy rate of serving during the skill-acquisition test. After the Shapiro-Wilk test, the accuracy rate of serving of each group follows the normal distribution (P > 0.05). Levene's variance homogeneity test shows no statistical significance (P = 0.653 > 0.05). With homogeneity of variance, the data can be used for a one-way analysis of variance. One-way analysis shows that the accuracy rate of serving F (2,12) =12.653; the significance level P = 0.000 < 0.05. During the skill acquisition test, the average accuracy rate of the serving of each group has significant differences (P < 0.05). After that, the accuracy rates of serving are conducted with multiple comparisons. Results show that the class and sequence exercise groups have no significant difference (P = 0.421 > 0.05) in the accuracy rate of serving; the sequence and random exercise groups have significant difference (P = 0.002 < 0.05); the random and class exercise groups have significant difference (P = 0.001 < 0.05). It is found that high background interference conditions are conducive to improving the accuracy rate of serving.

Comparative Analysis of the Accuracy of Hair Inside Angle of Skill Acquisition

According to the data, the random exercise group has the highest accuracy rate of serving the inner angle. After the Shapiro-Wilk test, the accuracy rate of serving the inner angle of each group follows the normal distribution (P > 0.05). Levene's variance homogeneity test shows no statistical significance (P = 0.556 > 0.05). With homogeneity of variance, the data can be used for a one-way analysis of variance. One-way analysis shows that the accuracy rate of serving the inner angle F (2,12) = 5.352; the significance level P = 0.022 < 0.05. The average accuracy rate of serving the inner angle of each group has a significant difference (P < 0.05). After that, the accuracy rates of serving the inner angle are conducted with multiple comparisons. Results show that the class and sequence exercise groups have no significant difference (P = 0.678 > 0.05) in an accuracy rate of serving the inner angle; the sequence and random exercise groups have significant differences (P = 0.011 < 0.05); the random and class exercise groups have significant differences (P = 0.023 < 0.05). High background interference conditions are conducive to improving the accuracy rate of serving the inner angle.

Comparative Analysis of the Speed Serves of Skill Acquisition

According to the data, the random exercise group has the highest serving speed. After the Shapiro-Wilk test, the serving speed of each group follows the normal distribution during the skill acquisition test (P > 0.05). Levene's variance homogeneity test shows no statistical significance (P = 0.303 > 0.05). With homogeneity of variance, the data can be used for a one-way analysis of variance. One-way analysis shows that F (2,12) = 0.913; the significance level P = 0.427 > 0.05. During the skill-acquisition test, the average serving speed among groups has no significant difference (P > 0.05). After that, the athletes' serving speeds are conducted with multiple comparisons. Results show that the class and sequence exercise groups have no significant difference (P = 0.620 > 0.05) in the serving speed; the sequence and random exercise groups have no significant difference (P = 0.205 > 0.05); the random and class exercise groups have no

significant difference (P = 0.423 > 0.05). High background interference conditions are not conducive to improving the serving speed.

Comparative Analysis of Athletes' Test Results During a Maintenance Test

Comparative Analysis of Serving Results

According to the data, the random exercise group has the highest serving result. After the Shapiro-Wilk test, the serving result of each group follows the normal distribution during the maintenance test (P > 0.05). Levene's variance homogeneity test shows no statistical significance (P = 0.920 > 0.05). With homogeneity of variance, the data can be used for a one-way analysis of variance. One-way analysis shows that F (2,12) = 2.543; the significance level P = 0.120 > 0.05. During the maintenance test, the average serving result among groups has no significant difference (P > 0.05). After that, the athletes' serving results are conducted with multiple comparisons. Results show that the class and sequence exercise groups have no significant difference (P = 0.275 > 0.05) in the serving results; the sequence and random exercise groups have no significant difference (P = 0.288 > 0.05); the random and class exercise groups have significant differences (P = 0.044 < 0.05).

Comparative Analysis of The Accuracy Rates of Serving

According to the data, the random exercise group has the highest accuracy rate of serving during the maintenance test. After the Shapiro-Wilk test, the accuracy rate of serving of each group follows the normal distribution (P > 0.05). Levene's variance homogeneity test shows no statistical significance (P = 0.623 > 0.05). With homogeneity of variance, the data can be used for a one-way analysis of variance. One-way analysis shows that the accuracy rate of serving F (2,12) = 4.667; the significance level P = 0.032 < 0.05. During the maintenance test, the average accuracy rate of the serving of each group has significant differences (P < 0.05). After that, the athletes' accuracy rates of serving are conducted with multiple comparisons. Results show that the class and sequence exercise groups have no significant difference (P = 0.786 > 0.05) in the accuracy rates of serving; the sequence and random exercise groups have significant differences (P = 0.017 < 0.05); the random and class exercise groups have significant differences (P = 0.028 < 0.05). High background interference conditions are conducive to improving the accuracy rate of serving.

Comparative Analysis of The Accuracy Rates of Serving the Inner Angle

According to the data, the random exercise group has the highest accuracy rates of serving the inner angle. After the Shapiro-Wilk test, the accuracy of serving the inner angle of each group follows the normal distribution (P > 0.05). Levene's variance homogeneity test shows no statistical significance (P = 0.657 > 0.05). With homogeneity of variance, the data can be used for a one-way analysis of variance. The accuracy of serving the inner angle F (2,12) = 2.197; the significance level P= 0.154 < 0.05. The average accuracy of serving the inner angle of each group has a significant difference (P < 0.05). After that, the athletes' accuracy rates of serving the inner angle are conducted with multiple comparisons. For the class and sequence exercise groups, P = 0.0.665 > 0.05; for the sequence and random exercise groups, P = 0.147 > 0.05; for the random and class exercise groups, P = 0.069 > 0.05. Therefore, the three groups have no significant difference in the accuracy rates of serving the inner angle.

Comparative Analysis of Serving Speed

According to the data, the sequence exercise group has the highest serving speed. After the Shapiro-Wilk test, the serving speed of each group follows the normal distribution during the maintenance test (P > 0.05). Levene's variance homogeneity test shows no statistical significance (P = 0.587 > 0.05). With homogeneity of variance, the data can be used for a one-way analysis of variance. One-way analysis shows that F (2,12) = 0.185; the significance level P = 0.834 > 0.05. During the maintenance test, the average serving speed among groups has no significant difference (P > 0.05). After that, the athletes' serving speeds are conducted with multiple comparisons. Results show that the class and sequence exercise groups have no significant difference (P = 0.581 > 0.05) in the serving speed; the sequence and random exercise groups have no significant differences (P = 0.924 > 0.05); the random and class exercise groups have no significant difference (P = 0.646 > 0.05).

Comparative Analysis of Test Results During a Migration Test

Comparative Analysis of Serving Results

Table 7

Statistics of athletes' serving results during a migration test

Group	Class exercise group	Sequence exercise group	Random exercise group
Service result	33.40 ± 8.88	33.60 ± 6.73	48.20 ± 8.59

Table 7 shows that the random exercise group has the highest serving result. During the migration test, the serving results follow the normal distribution by the Shapiro-Wilk test (P > 0.05). Levene's variance homogeneity test shows no statistical significance (P = 0.755 > 0.05). With homogeneity of variance, the data can be used for a one-way analysis of variance.

Table 8

Analysis on between-group differences of athletes' serving results

	Sum of square	df	Mean square	F	Sig.
Between-group	720.400	2	360.200	5.463	.021
Intergroup	791.200	12	65.933		
Total	1511.600	14			

One-way analysis shows that F (2,12) = 5.463; the significance level P = 0.021 < 0.05 (see Table 8). During the migration test, the average service result among the three groups has significant differences (P < 0.05). After that, the athletes' serving results are conducted with multiple comparisons.

Table 9

Multiple comparisons of serving results

(I) Group	(I) Group	Mean difference (I-J)	Standard error	Significance	95% confidence interval	
					Lower limit	Upper limit
Class exercise group	Sequence exercise group	-.200	5.135	.970	-11.39	10.99
	Random exercise group	-14.800*	5.135	.014	-25.99	-3.61
Sequence exercise group	Class exercise group	.200	5.135	.970	-10.99	11.39
	Random exercise group	-14.600*	5.135	.015	-25.79	-3.41
Random exercise group	Class exercise group	14.800*	5.135	.014	3.61	25.99
	Sequence exercise group	14.600*	5.135	.015	3.41	25.79

Table 9 shows multiple comparisons of serving results during the migration test. The class and sequence exercise groups have no significant difference (P = 0.970 > 0.05) in the serving speed; the sequence and random exercise groups have significant differences (P = 0.015 < 0.05); the random and class exercise groups have significant differences (P = 0.014 < 0.05). The test results showed that the mean score increased by 0.20 (95% CI: 10.99 to 11.39) from the cluster training group to the sequence training group, where the difference was not statistically significant (P=0.970); from the cluster training group to the random training group, the mean score increased by 14.80 (95% CI: 3.61-25.99), where the difference was statistically significant (P= 0.014); from the sequence training group to the randomized training group, the mean score increased by 14.60 (95% CI: 3.41-25.79), and the difference was statistically significant (P=0.015).

Comparative Analysis of The Accuracy Rates of Serving

According to the data, the random exercise group has the highest accuracy rate of serving. During the migration test, the accuracy rate of serving follows the normal distribution by the Shapiro-Wilk test (P > 0.05). Levene's variance homogeneity test shows no statistical significance (P = 0.516 > 0.05). With homogeneity of variance, the data can be used for a one-way analysis of variance. One-way analysis shows that F (2,12) = 3.081; the significance level P = 0.083 > 0.05. During the migration test, the average accuracy rate of serving among the three groups has no significant difference (P > 0.05). Results show that the class and sequence exercise groups have no significant difference (P = 0.781 > 0.05); the sequence and random exercise groups have significant differences (P = 0.042 < 0.05); the random and class exercise groups have no significant difference (P = 0.069 > 0.05). High-background interfered exercises are beneficial to improving the accuracy rate of serving.

Comparative Analysis of The Accuracy Rates of Serving the Inner Angle

According to the data, the random exercise group has the highest accuracy rates of serving the inner angle. During the migration test, the accuracy rates of serving the inner angle follow the normal distribution by the Shapiro-Wilk test (P > 0.05). Levene's variance homogeneity test shows no statistical significance (P = 0.423 > 0.05). With homogeneity of variance, the data can be used for a one-way analysis of variance. One-way analysis shows that F (2,12) = 2.333; the significance level P = 0.139 > 0.05. During the migration test, the average accuracy rates of serving the inner angle among the three groups have no significant difference (P > 0.05). After that, the athletes' accuracy rates of serving the inner angle are conducted with multiple comparisons. Results show that the class and sequence exercise groups have no significant difference (P = 1.000 > 0.05) in the accuracy rates of serving the inner angle; the sequence and random exercise groups have no significant difference (P = 0.086 > 0.05); the random and class exercise groups have no significant difference (P = 0.086 > 0.05). Therefore, three groups of athletes have no significant difference in accuracy rates of serving the inner angle during the migration test.

Comparative Analysis of Serving Speed

According to the data, the sequence exercise group has the highest serving speed. During the migration test, the serving speed follows the normal distribution by the Shapiro-Wilk test (P > 0.05). Levene's variance homogeneity test shows no statistical significance (P = 0.614 > 0.05). With homogeneity of variance, the data can be used for a one-way analysis of variance. One-way analysis shows that F (2,12) = 0.330; the significance level P = 0.725 > 0.05. During the migration test, the average serving speed among the three groups has no significant difference (P > 0.05). After that, the athletes' serving speeds are conducted with multiple comparisons. Results show that the class and sequence exercise groups have no significant difference (P = 0.477> 0.05) in serving speed; the sequence and random exercise groups have no significant difference (P = 0.949 > 0.05); the random and class exercise groups have no significant difference (P = 0.516 > 0.05).

Discussions

Discussion For the Test Results During the Skill-Acquisition Stage

At the skill-acquisition stage, the three groups have very significant differences (P = 0.000) in servicing results. Multiple comparisons show that the significant level P = 0.000 < 0.05 for random and class exercise groups; the significant level P =0.001 < 0.05 for the random and sequence exercise groups; the class and sequence exercise groups have no significant difference (P = 0.339 > 0.05). The serving results are sorted as follows: random exercise group > sequence exercise group > class exercise group. The three groups have significant differences (P = 0.001) in the accuracy rate of serving. Multiple comparisons show that the significant level P = 0.001 < 0.05 for random and class exercise groups; the significant level P = 0.002 < 0.05 for the random and sequence exercise groups; the significant level P = 0.421 > 0.05 for the class and sequence exercise groups. There is a significant difference in the accuracy rate of serving between random and sequence (class) exercise groups. However, the sequence and class exercise groups have no significant difference. The average accuracy rates of serving are sorted as follows: random exercise group > sequence exercise group > class exercise group.

The training content of the class exercise group is more simplex than the sequence and random exercise groups under low background interference conditions. At the beginning of exercise, the athletes can concentrate on the target area. However, the number of exercises increases to cause trouble concentrating and physical exhaustion. Then, the accuracy rate of serving decreases to derive poor serving results. The beginners can control the placements and get points only by repeating the same action for times. It takes more energy for second-level athletes to serve fast, powerful, well-placed shots. The three groups have significant differences (P = 0.022) in the accuracy rate of servicing the inner angle. Multiple comparisons show that the significant level P = 0.023 < 0.05 for random and class exercise groups; the significant level P = 0.011 < 0.05 for the random and sequence exercise groups; the significant level P = 0.678 > 0.05 for the class and sequence exercise groups. There is a significant difference between random and sequence exercise groups. However, the class and sequence exercise groups have no significant difference. The average accuracy rates of serving the inner angle are sorted as follows: random exercise group > class exercise group > sequence exercise group.

Under the conditions of high background interference, the training contents are inconsistent in the random exercise group. Besides, the same training contents are not adjacent. This training method is similar to the serving in the game. In the game, the athletes should highly focus on the serving method, placement, and strength. After completing one motor skill and another, the athletes can experience the differences between flat strokes and side spins in different positions. As time goes on, the serving skills stay in memory deeply. The longer time leads to deeper memory and easier service. The number of exercises increases to improve the serving accuracy and result. The three groups have no significant difference in the serving speed. Multiple comparisons show that the significant level P = 0.620 > 0.05 for class and sequence exercise groups; the significant level P = 0.205 > 0.05 for the sequence and random exercise groups; the significant level P = 0.423 > 0.05 for the random and class exercise groups. However, there is a certain difference between random and sequence (class) exercise groups. The serving speeds are sorted as follows: random exercise group > class exercise group > sequence exercise group.

Feghhi, Valizadeh, Rahimpour, Tehrani, and Karampour (2015), selected skilled baseball players as subjects, proving the existence of background interference. It was concluded that different background interferences effects experienced subjects differently, which is consistent with the results of the present experiment. However, Graser, Bastiaenen, Gut, Keller, and van Hedel (2021) chose skilled basketball players as the subjects and obtained the opposite results; that is, their experiment did not prove the existence of the effect of background interference. The speeds and strengths of athletes are improved to increase the serving speed. However, it is difficult to greatly improve the speed quality of athletes at a certain level in a short time. The experiment lasts for four weeks. The training content for athletes' speeds and strengths is not included in the training process. Besides, the athletes are required to ensure the success rate of serving, thus inevitably reducing the serving speed during the exercise. The experiment has a large number of exercises. During the practice, the athletes understand the essentials of serving motor skills to improve power control, serving placement, and speed.

Discussion of the Results of The Skill Acquisition Experiment

During the maintenance test, the three groups have no significant difference (P = 0.120) in serving results. However, multiple comparisons show that the random and class exercise groups have significant differences (P = 0.044 < 0.05). The serving results are sorted as follows: random exercise group > sequence exercise group > class exercise group. The three groups have significant differences (P = 0.032) in the accuracy rate of serving. Multiple comparisons show that the sequence and random exercise groups have significant differences (P = 0.017 < 0.05); the random and class exercise groups have significant differences (P = 0.028 < 0.05); the class and sequence exercise groups have no significant difference (P = 0.786 > 0.05). There is no significant difference in the accuracy rate of serving the inner angle (P = 0.154). However, multiple comparisons show that the random exercise group has a higher accuracy rate of serving the inner angle than the sequence and class exercise groups.

In terms of serving speed, the three groups have no significant difference (P = 0.834). Multiple comparisons

show that there is no significant difference among groups in serving speed during the maintenance test. The maintenance test results indicate that the random exercise group has higher serving results, accuracy rates of serving and serving the inner angle than sequence and class exercise groups. It proves that high background interference conditions are beneficial to improving the serving result, accuracy rates of serving, and serving the inner angle. The above findings suggest that experienced tennis players serve better under high background interference, which is also consistent with the findings of (Graser et al., 2021). Besides, both Li and Niu selected students with basic skills in tennis specialized classes as subjects and also selected skills such as forehand stroke as experimental tasks. The athletes recruited this time are the second-level tennis players with threatening service, better strength, and rotation control. Especially, the first and second services should be effective, although with some double faults. In the experiment, the athletes are required to master the technical movements of service besides controlling the placement, power, and rotation of the ball. Therefore, only skilled athletes can complete the experiment content.

Under high background interference conditions, the athletes of the random exercise group have to concentrate on the serving method during the process of serving. Each time practicing the service, the athlete sets up the active mode by the brain center before issuing commands. Finally, the skeletal muscles complete the instructions. It is conducive to long-term memory and cleared serving techniques of athletes. The performance characteristic of effective learning is persistence, which is reflected by the maintenance test (Rahavi Ezabadi, Estiri, & Rezaei, 2018). According to the experimental results, the random exercise method effectively improves the serving effect of athletes. During the maintenance test, the tested serving result, accuracy rates of serving, and serving the inner angle meet the expectations. Under high background interference conditions, the serving effects are sorted as follows: random exercise group > sequence exercise group > class exercise group.

Discussion of Experimental Results of Migration Test

During the maintenance test, the three groups have significant differences (P = 0.021) in serving results. Multiple comparisons show that there is a significant difference between random and sequence (class) exercise groups. However, the sequence and class exercise groups have no significant difference. The three groups have no significant difference (P = 0.083) in serving results. Multiple comparisons show that the sequence and random exercise groups have significant differences (P = 0.042 < 0.05). Results indicate that the accuracy rates of serving are sorted as follows: random exercise group > class exercise group > sequence exercise group. The three groups have no significant difference in accuracy rates of serving the inner angle. However, multiple comparisons show that the random exercise group has a larger accuracy rate of serving the inner angel than the sequence exercise group.

In a study Kim, Oh, and Schweighofer (2015), 54 experienced elementary school students of 4th grade were selected as subjects and the results showed that all three groups had improved test scores. However, the best performance was in the stationary group, which is not consistent with the results of this study. Willey and Liu (2018), selected children of different ages as experimental subjects. Their results showed that the older the age was, the faster the children learned movement skills. In previous studies, some did not demonstrate the existence of background interference due to the age, gender, and experience of subjects, or the types of movement: open versus closed and simple versus complex. However, most studies demonstrated the existence of background interference in the domain of motor-skill learning, and only a very few studies did not. Serving results are evaluated according to the stability, the first and second placements of the ball. Athletes are required to serve the inner angle of the service area every time. The placement of the serving is determined by speed, power, rotation, and direction. The flat strokes have smaller rotational amplitudes and larger power than side spins. In the service exercises, the athletes should find a way of serving the inner angle in the service area court. Besides, the second placement falls into the double area to get higher points (Broadbent, Causer, Williams, & Ford, 2015).

During the migration test, the tested serving result, accuracy rates of serving, and serving the inner angle meet the expectations. Under the conditions of high background interference, the random exercise group can better adapt to the new operation situation and distinguish the actions (Raisbeck, Regal, Diekfuss, Rhea, & Ward, 2015). On the contrary, the random exercise group has a weaker ability to adapt to new situations than the group and class exercise groups under the conditions of middle and low background interferences. The migration test is started 30 minutes after the maintenance test consuming a certain amount of physical strength. After four weeks of training, the athletes are used to serving the inner angle in the service area. During the migration test, the athletes re-adjust the serving stances and technical movements to adapt to the new operating environment, thus reflecting the adaptability and pressure resistance. Therefore, the random exercise group can better improve technical stability than sequence and class exercise groups in a stressful and high-intensity environment.

Implications

Both the theoretical and empirical implications have been made by this study. The study has a great theoretical significance because of its contribution to the literature on sports. The current study explores the impacts of background interference on the tennis players serving performance. This study examines the contributing role of background interference in learning dynamic skills helpful in playing tennis. Many studies have explored the

background interference theory, but they have either discussed it in general for sports or gave a short description of its impacts on the tennis players' serving skills. Thus, our study is a great contribution to the sports literature. The current study proves to be very significant in China's tennis sports association or other tennis sports associations as well, as the study clears a way how to improve the serving performance of tennis players. The study suggests that tennis players' efficiency to make serve can be improved through the application of high background interference as the background interference teaches the cognitive skills and physical movement skills required for good serves.

Conclusions

The random, sequence, and class exercise groups had significant differences in accuracy rates of serving the inner angle during the skill-acquisition test. Meanwhile, the three groups had no significant difference in serving speed. However, multiple comparisons showed that the random exercise group had a larger serving speed than the class and sequence exercise groups.

During the maintenance test, there was no significant difference between random and class (sequence) exercise groups in serving results. However, multiple comparisons showed that the random and class exercise groups had significant differences. The three groups had significant differences in the accuracy rate of serving, indicating that high background interference conditions were conducive to improving the accuracy rate of serving. Under the conditions of low, medium, and high background interferences, the three groups had no significant difference in the serving speed and the accuracy rate of serving the inner angle. There was a significant difference between random and class (sequence) exercise groups in serving stability. The class and sequence exercise groups had no significant difference.

The three groups had significant differences in serving results during the migration test. At the same time, there was no significant difference in the accuracy rates of serving and serving the inner angle. According to multiple comparisons, random and sequence exercise groups had significant differences in the accuracy rate of serving. Therefore, high background interference conditions were conducive to improving the accuracy rate of serving. There was a significant difference between random and class (sequence) exercise groups in serving stability. High background interference facilitates long-term memory for it clarifying each serve technique more distinctly. The high-background-interference exercises allowed the athletes to resist stress better during the migration test and to adapt to the new operating environment quickly. Experimental results showed that randomized training groups improved technical stability better than sequential and group training in a high-stress, high-intensity environment. The results of the skill acquisition, retention, and transfer tests were consistent with the experimental expectations. Athletes could perform better and serve more accurately to various degrees, confirming that high background-interference practice facilitates skill retention and transfer. Reasonable background interference in college teaching, or athletes' training, can improve teaching performance and training effectiveness.

Limitations and Future Directions

Despite the fact that the study has great significance in the literature and the sports world, still, it has some specific limitations which are expected to be removed by the researchers and practitioners in the future. First of all, though the study has given a detailed description of the background interference (the intervention of past memories into the new ones) and their role in the learning of cognitive and movement skills of serving in tennis sports. Many other factors like sports administration, leadership style, physical fitness, athletic psychology, and the existence of professional training centers also affect the serving performance of tennis players. But this study has not given even a little space to these factors. Thus, the scope of the study is limited. So, future authors must also explore these factors along with the background interference. Moreover, this study examines the background interference and serving performance of the players in China's tennis association. So, it is likely that this study may not be valid in countries other than China. That is why the authors must also analyze the same variables and their association in both developed and developing countries.

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