

Exploring the impact of drills training and grip strength on tennis serve performance: A factorial experimental design research

MARNEX WILLNER BERHIMPONG¹, EWENDI WENIK MANGOLO², FREDRIK ALFRETS
MAKADADA³, HARTONO HADJARATI⁴, GLADY SUKMA PERDANA⁵, ILHAM^{6*}

^{1,3,5}Departement of Sports Coaching, Faculty of Sports Science and Public Health, Universitas Negeri Manado, INDONESIA

²Faculty of Teacher Training and Education, Universitas Cendrawasih Papua, INDONESIA

⁴Department of Sports Coaching Education, Faculty of Sport and Health, Universitas Gorontalo, INDONESIA

⁶Health and Recreation Department, Faculty of Sports Science, Universitas Negeri Padang, INDONESIA

Published online: November 30, 2023

(Accepted for publication : November 15, 2023)

DOI:10.7752/jpes.2023.11355

Abstract

Problem statement: The influence of drills and strength training methods on tennis court serve has attracted significant attention among scholars in tennis sports science. Nevertheless, it remains unclear what specific effects these trainings have, especially on serve performance. **Purpose:** This study aimed to investigate the impact of several training models, such as the flat drills training and the drills serve twist exercise models, and grip strength, on tennis serve skills among students at the Faculty of Sports Sciences, Manado State University. **Approach:** The research employed a quasi-experimental design with a 2×2 factorial structure. The population comprised sports science students who have completed court tennis courses. The samples were selected from 127 male sports science students using purposive sampling techniques. Then, 40 students agreed to participate ($20,8 \pm 0,1$ years old). In this research, the skills of tennis courts were measured using service skill tests. Meanwhile, the grip strengths of the arm muscles were assessed using the Hand Grip Dynamometer tool (HGD). **Results:** This study showed several essential findings. First, the result indicated a significant difference between court tennis serve skills using a flat serve drills training model and a twist drill serve exercise model. Second, at the level of strong grip strength, court tennis serve skills using the flat serve drills exercise model was higher than those using the drills serve twist training model at low grip strength levels. In addition, court tennis serve skills with the drills serve twist exercise model were higher than those with the flat serve drills training model. Another interesting finding was the relationship between the flat serve drills training model and the twist serve drills training model with grip strength on court tennis serve skills. **Conclusions.** In conclusion, the findings of this study reveal several key insights regarding the impact of different training models on court tennis serve skills, particularly when considering grip strength levels. These insights provide valuable guidance for coaches and athletes seeking to enhance their court tennis serve skills. They can tailor their training programs to specific skills and grip strength profiles.

Keywords: drills training, grip strength, tennis serve performance

Introduction

To optimize sport performance, athletes should fully consider four aspects of sports training: physical preparation, technical preparation, mental/psychological preparation, and preparation of tactics and strategies (T. Bompa & Buzzichelli, 2015; Damrah et al., 2023; Dimiyati, Setiawati, et al., 2023; Ilham & Dimiyati, 2021; Sulistiyowati et al., 2022; Weinberg & Gould, 2015). In tennis, these aspects are vital because tennis is classified as a high-intensity sport, requiring acceleration, deceleration, and the ability to change direction quickly, then interspersed with low-intensity physical activity (Chapelle et al., 2017). Indeed, all players are not necessarily skilled in all aspects mentioned above. Some players might only master technical skills. Some others might only have physical readiness, mental readiness, or tactical and strategic readiness. However, to achieve optimal achievement, they must master those four basic aspects. Therefore, each aspect requires different attention and handling to achieve the desired goals.

Of these four aspects, scholars pay greater attention to physical and technical preparations. Various studies have been conducted to develop the physical conditions of tennis players, for example combining high-intensity training (HIT) and sport-specific fitness training (MT) versus sport-specific fitness training alone (DT) (Fernandez-Fernandez et al., 2017). The research shows that both training methods cover all aspects of fitness that are dominant in the agility aspect. In this case, the physical and technical aspects are inseparable. The combination of physical and technical training is necessary to acquire great playing skills. In other words, it is a special physicality to play.

Technical ability on a tennis court is another important aspect to obtain high performance (Ngatman et al.,

2022). In tennis, powerful development and accurate serve are the highest priority for tennis players (Binti Yusoff & Krasilshchikov, 2021; Reid et al., 2013). Particularly, the serve is considered as the most important stroke. In the gameplay, the serving player/team has a key role because they have a very good position to control the game (Lambrich & Muehlbauer, 2023; Rifki et al., 2022). They have better chances to get points because they are the first person to determine the direction, speed, and rotation of the ball from the beginning. Therefore, the opportunity must be maximized as much as possible.

Given this fact, preparing a good service is essential. The existing literature mentions that this serve movement is greatly influenced by biomechanical aspects, such as lower limb movement, hip rotation, torso tilt, upper limb extension, and internal rotation (Colomar et al., 2022; Lambrich & Muehlbauer, 2023). The efficiency of this movement is crucial to determine the success of a serve, impacting racket and ball speed (Colomar et al., 2022). In addition, tennis players must look at strength indicators, such as maximal isometric strength and the rate of strength development at specific joint positions. Strength training exercises and drills are recommended solutions to enhance strength and serving capabilities. However, the serve drill exercises must employ efficient and ideal motions to avoid negatively affecting consistency in skills, speed, and serve velocity. Consequently, various drill methods are implemented, using tools or manual techniques, to enhance ball gliding speed and spin (Bahtra et al., 2022; Butler et al., 2020; Den Hartigh et al., 2018; Murphy et al., 2014; Reid et al., 2013).

One of the drill methods is the flat serve. It is a foundational technique in tennis, executed by striking the ball towards the opponent with a flat trajectory (Porrmatikul et al., 2020). This technique serves as a fundamental skill preceding advanced levels of play. When the flat serve is executed with precise timing, momentum, and high speed, it results in an effective, accurate, and swift shot, often leading to a point (Sitompul, 2020). The flat serve is perceived as the most forceful, powerful, and rapid compared to other types of serves (Pavilas et al., 2015). The ball travels in a straight path. Although opponents can predict its trajectory; this type of serve is typically favored by and advantageous for taller players. The steps involved in performing this technique include gripping the racket, tossing the ball, hitting the ball, and follow-through movements. In conclusion, the flat serve is highly effective in generating power and speed in shots, characterized by a lack of spin and a straight trajectory.

The second drills method is called the flip side, or the twist serve, also known as the American twist. This serve model represents a specialized service technique involving slices, causing the ball to react differently upon touching the opponent's court surface due to the ball's spin with a slice. The grips commonly employed for this type of serve are the continental and eastern backhand. When executed correctly, the twist serve directs the ball toward the opponent in a distinct trajectory upon landing. Typically considered an advanced serve, the twist serve is employed to enhance the quality of serves and introduces an additional technique to the server's repertoire (Vacek et al., 2023). Tennis service drills are intricately linked to skill development, emphasizing continuous and systematic training programs and variations. Such approaches aim to refine precise and swift service skills (Hernández-Davo et al., 2014; Lertwonghattakul et al., 2023).

In line with the requisite technical skills, physical aspects play a crucial role in executing tennis service techniques. If physical needs are studied in serving, bio-motor capabilities are needed, a combination of strength and speed (Balyi, Istvan; Way, Richard; Higgs, 2013; T. Bompa & Buzzichelli, 2015; T. O. Bompa & Carrera, 1999; Nugroho et al., 2021; Sridadi et al., 2021). Many training methods are applied by trainers to improve serve techniques. Unfortunately, they generally still do not pay attention to the right way to be fast and produce a good service. According to our personal observation, general tennis coaches place training for tennis serve development only as a complement to the program. It means that student-athletes are only given the task to perform themselves without supervision and is usually given at the end of the training session. This training is not given priority to both techniques and even movement mechanics. This training is often ignored and given a very small portion of training. Moreover, in every court tennis match, players are still doubtful about choosing a serve. In fact, it should be used as a powerful weapon to have the opportunity to get points. According to (Murphy et al., 2014), doubts arise due to ignorance of identifying an individual's external abilities that can affect serve technique in court tennis. Individual external factors in serving court tennis include supportive environmental factors (climate at the time), physical factors (flexure of the torso flexibility of the hips, and ability of the hand muscles) and mental factors (concentration). Ideally, the trainer performs skills in several parts of the technique to focus on the ability (Davids et al., 2001). To answer these doubts, special attention needs to be given through a specific training process with systematic, planned and programmed applications.

Beside physical and technical preparation, grip strength has a significant effect on tennis service performance outcomes (Chaphekar et al., 2021; Mangolo & Makadada, 2020; Pereira et al., 2011). Whether high or low, grip strength is an internal factor for players, representing a physical aspect that significantly influences service outcomes, ultimately determining match scores. While grip size and racket positioning affect tennis gameplay, possessing strong grip strength can significantly enhance performance, particularly in terms of shot speed and power, including the strength and speed of serves (Chaphekar et al., 2021; Mavvidis et al., 2014; Rossi et al., 2009). Thus, the success of the serve is determined by suitable exercises provided by the trainer and the involvement of the individual's external abilities. An external factor that is directly related to the technique of

serving the tennis court is the individual's ability to grip. This factor is directly related to the hand holding the racket at the time of serve. For this reason, an answer is needed to address the aforementioned problems by investigating the effect of drill's serve training models and grip ability on serve skills in court tennis games. This research is an important consideration when designing training for beginner tennis players to practice serve techniques.

Methods

Research design

This research was conducted using an experimental method. In particular, it used a 2x2 factorial design involving control variables (Borowiak & Reyes, 2007; Brunner & Denker, 1994; Montgomery, 2013).

Participants

The samples in this study were taken from a population of 139 male sports science students who had completed the court tennis course. From the existing population, 12 students were eliminated due to the inability to meet the criteria required to select the research sample. The participant criteria were that 1) students' accommodation should be far from the place of experiment, 2) the students were still actively practicing athletic sports at the Student Training Education Center, and 3) students had unsupportive health to be used as research subjects. Following that, the total population was 127 students. They were then given a test of the grip ability of the arm muscles. Then, they were randomly selected to be used as a sample, in which 40 sports science students agreed to take part.

Procedure

To begin with, research permission was obtained from the in-charged stakeholders. In addition, approvals of the research participants were obtained through a research agreement sheet. During the study, the samples were classified by the degree of strength: high and low. Participants were given a pre-test after which each group was given drills serve flat and drills serve twist exercises. Then, the participants were ranked based on the test results on grip ability, from the largest score to the smallest score. After compiling the ranking, they were grouped using a percentage technique where 27% for the upper limit represented the high grip ability test score and 27% for the lower limit represented the low grip ability test score.

They were used as an experimental group. 20 people were put in the upper limit group, while the other 20 people were grouped in the lower limit. Next, 20 people of the upper limit and lower limit were tracked to occupy each group of cells. Hence, the number of samples in the four cell groups was 10 people each. Meanwhile, students who were not put in the 27% upper limit and lower limit groups were still allowed to take part in treatment. These samples were given experiments to improve serve skills on the court tennis game and still take the final test of serve skills. However, the data was not analyzed further as the sample group netted in the sample. Hence, the sample that followed this experimental study amounted to 40 people of the male sex.

The exercise program was carried out for 8 weeks with a minimum of 3 exercises per week (75 minutes per session). Each session consisted of warm-ups, core exercises, and cool-downs. After the completion of the post-test, a training program is carried out to be used as hypothesis testing data. The detailed illustration can be seen in Table 1.

Table 1. The 2x2 Factorial Design

Grip Strength (B)	Drills Training (A)	
	Serve Flat (A1)	Serve Twist (A2)
Gripability Strong (B1)	A1B1	A2B1
Gripability Weak (B2)	A1B2	A2B2
Total	A1	A2

Information:

- A1B1 = A group of students who have strong grip skills and are given drills serve flat exercises.
- A2B1 = A group of students who have strong grip skills are given drills serve twist exercises.
- A1B2 = A group of students who have weak grip skills and are given drills serve flat exercises.
- A2B2 = A group of students who had weak grip skills and were given drills serve twists practice.
- A1 = Group of students given drills serve flat.
- A2 = Group of students given drills serve flat.

Research Instruments

The instrument used to measure grip strength was the Hand Grip Dynamometer. This tool had a validity value of 0.99 with special criteria and a reliability value of 0.99 with high criteria. The test was carried out by repeating the experiment 3 times and the best value was taken. This test was also used to classify strong and weak grip capabilities.

The serve skill test used in this research is with 10 attempts. The validity value is 0.98 while the reliability value is 0.98.

Data Analysis Techniques

This research initially performed statistical hypothesis testing, using a two-path 2 x 2 variance analysis technique (ANOVA) at a confidence level of $\alpha = 0.05$. It was then followed by the normality test. The data obtained from the results of court tennis serve skills were analyzed using the Lilifors test. Finally, homogeneity tests using the Barlett test were employed to figure out the effect between the training model and the grip ability of the court's serve tennis skills. This calculation was followed again by the Tukey Test.

The statistical hypotheses to be tested in this study were as follows:

$$\begin{aligned} \text{first} \quad H_0 &: \mu_{A1} = \mu_{A2} \\ H_1 &: \mu_{A1} > \mu_{A2} \\ \\ \text{Second} \quad H_0 &: \mu_{A1B1} = \mu_{A2B1} \\ H_1 &: \mu_{A1B1} > \mu_{A2B1} \\ \\ \text{Third} \quad H_0 &: \mu_{A1B2} = \mu_{A2B2} \\ H_1 &: \mu_{A1B2} < \mu_{A2B2} \\ \\ \text{Fourth} \quad H_0 &: \text{Int } A \times B = 0 \\ H_1 &: \text{Int } A \times B \neq 0 \end{aligned}$$

Information:

- H_0 = Zero hypothesis.
- H_1 = Alternative Hypotheses.
- μ_{A1} = Average results of serve skills with training model treatment drills serve flat.
- μ_{A2} = Average results of serve skills with drills training model treatment Serve Twist.
- μ_{A1B1} = Average results of serve skills, student group of abilities Strong grip with drills serve-flat training model treatment.
- μ_{A2B1} = Average results of serve skills, student group of abilities Strong grip with drills serve-twist drills model treatment.
- μ_{A1B2} = Average results of serve skills, student group of abilities Weak grip with drills serves, flat training model treatment.
- μ_{A2B2} = Average results of serve skills, student group of abilities Weak grip with drills serve-twist training model treatment.
- A = Drillss serve training model.
- B = Gripability.

Result

Data description

The data in this research was presented based on research variables, including Dependent variables (Y) Court tennis serve skills, and two independent variables. Each consisted of two categories, namely, the Drills serve training model (X1) and grip strength (X2). A brief overview of the research data is provided in Table 2.

Table 2. Summary of student tennis serve skills score data.

Training Methods \ Grip Strength	Exercise Drills Serve Flat	Exercise Drills Serve Twist	Number of Rows
Strong Grip Strength	$N = 10$ $\sum X = 96.9$ $\sum X^2 = 940.45$ $S = 0.4067$	$n = 10$ $\sum X = 44.1$ $\sum X^2 = 195.25$ $s = 0.2923$	$n = 20$ $\sum X = 141$ $\sum X^2 = 1135.7$ $s = 0.6990$
Weak Grip Strength	$N = 10$ $\sum X = 59.8$ $\sum X^2 = 361.04$ $S = 0.9439$	$n = 10$ $\sum X = 89$ $\sum X^2 = 796.9$ $s = 0.7208$	$n = 20$ $\sum X = 148.8$ $\sum X^2 = 1157.94$ $s = 1.66468$
Number of Columns	$N = 20$ $\sum X = 156.7$ $\sum X^2 = 1301.5$ $S = 0.6753$	$n = 20$ $\sum X = 133.1$ $\sum X^2 = 992.15$ $s = 1.0131$	$n = 40$ $\sum X = 289.8$ $\sum X^2 = 2293.64$ $s = 2.36373$

Test experimental prerequisites

Normality test

Normality testing was carried out by calculating the skill score of each court tennis serve. It was carried out on (1) overall data of students using the drills serve flat exercise model, (2) the entire student group using the drills serve twist exercise model, (3) the entire student group that had strong grip strength, (4) the entire student group that had weak grip strength, and (5) data of each group (cell) for students small groups and large groups with strong and weak grip strength (data groups A1B1, A1 B2, A2 B 1, and A2 B2).

Table 3. Summary of overall data normality test results.

Group	N	Lh	Lt	Conclusion
1	10	0.1902	0.80178	Usual
2	10	0.1000	0.80178	Usual
3	10	0.1467	0.80178	Usual
4	10	0.2000	0.80178	Usual

Information:

1. Sample group with the drills serve flat training model for students who has strong grip strength
2. Sample group with the drills serve flat training model for students who has weak grip strength
3. Sample group with the drills serve twist exercise model for students who has strong grip strength
4. Sample group with the drills serve twist exercise model for students who has weak grip strength

Lh = Value Lilifors observation (the result of the calculation)

Lt = Lilifors Price Table

Table 3 indicates the results of the overall normality test where the largest Lh price of the entire treatment group was smaller than the Lt price. Thus, it can be concluded that the sample comes from a normally distributed population.

Homogeneity test

The homogeneity test in this research examined court tennis serve skills in each treatment group. The test was carried out using the Bartlett Test at a significance level of $\alpha=0.05$.

A summary of the results of the homogeneity test calculation in each group is seen in Table 4.

Table 4. Summary of the calculation results of the Bartlett test $\alpha = 0.05$

Participant	dk	1/dk	Si	Si ²	dk (Si ²)	log (Si ²)	dk log Si ²
A ₁ B ₁	9	0.1111	0.406749	0.1654	1.489	-0.781	-7.03213
A ₂ B ₁	9	0.1111	0.292309	0.0854	0.769	-1.068	-9.61485
A ₁ B ₂	9	0.1111	0.617882	0.3818	3.436	-0.418	-3.7637
A ₂ B ₂	9	0.1111	0.720802	0.5196	4.676	-0.284	-2.55931
Sum	36	0.4444	2.0377	1.1522	10.37	-2.552	-22.97

The results above emphasize that the data of court tennis serve skill scores of students from each group were obtained from a homogeneous population. Thus, the research data are qualified to run a hypothesis testing through parametric statistics.

Results of testing research hypotheses

1. *The difference in students' court tennis serve skills between the use of the flat serve drills exercise model and the overall twist drills serve practice model.*

This research employed the Analysis of Variance (ANOVA) to examine the difference in students' court tennis serve skills between the use of the flat serve drills exercise model and the overall drills serve twist exercise model. The results can be seen in Table 5.

Table 5. Summary of ANOVA calculation results of student tennis serve skill scores on $\alpha = 0,05$.¹

Source of variance	Dk	jk	RJK	F _h	F _t ($\alpha = 0.05$)
A	1	13.924	13.924	47.767	4.018
B	1	1.521	1.521	5.2178	4.018
AB	1	168.1	168.1	576.67	4.018
Error (E)	36	0.2915	0.0081		
Amount	21	4.851	0.231		

Information :

dk = Degrees of freedom
 jk = Number of squares
 RJK = Average sum of squares
 F hit = Price F calculated
 F tab = Price F Table
 ** = Significance $\alpha = 0.05$
 ns = Non-Significance

As provided in Table 5, the results of the analysis of variance (ANOVA) show that the calculated F price (47.767) is greater than the F price of the table (4.01) at the level of significance $\alpha = 0.05$. This means that the null hypothesis of the study is rejected. It also proves a significant difference between court tennis serve skills that use a flat serve drills training model and court tennis serve skills that use drills serve twist practice model.

2. The Interaction between the use of the flat serve drills training model and the twist serve drills training model with grip strength on court tennis serve skills

The results of the Analysis of Variance (ANOVA) above also reveal the interaction between the use of the flat serve drills training model and the drills serve twist training model with grip strength on court tennis serve skills. Table 5 describes that the price of F count is 576.67 and the F table is 4.01 at the level of significance $\alpha = 0.05$. The calculation shows a larger F count which means that the null hypothesis is rejected. This also means that there is an interaction between the use of the flat serve drills training model and the drills serve twist training model with grip strength on court tennis serve skills.

Furthermore, to determine the meaningfulness of the interaction, another calculation was made using the Tukey Test. The results of further testing with the Tukey Test are discussed in the following sections.

3. The difference in court tennis serve skills between the use of the flat serve drills training model and the drills serve twist training model for students who have strong grip strength

The calculation of court tennis serve skill data obtained by each treatment group showed that students with strong grip abilities and flat serve drills exercise mode had an average value of 9.74 and a standard deviation of 0.4067. Meanwhile, those with the drills serve twist exercise model generated an average value of 4.48 with a standard deviation of 0.2923.

A summary of the calculation results with the Tukey Test is presented below.

Table 6. Summary of Tuckey Test calculations.²

No.	Comparison Group	Qh	Qt ($\alpha = 0.05$)	Conclusion
1	A ₁ with A ₂	105.6	2,888	Significant
2	B ₁ with B ₂	91.72	2,888	Significant
3	A ₁ B ₁ with A ₂ B ₁	43.74	2,888	Significant
4	A ₁ B ₂ with A ₂ B ₂	24.19	2,888	Significant

Information:

A₁ B₁ = Student group with the drills serve flat training model for students who have strong grip strength.
 A₁ B₂ = Student group with the drills serve flat training model for students who have weak grip strength.
 A₂ B₁ = Student group with the drills serve twist training model for students who have strong grip strength.
 A₂ B₂ = Student group with the drills serve twist training model for students who have weak grip strength.

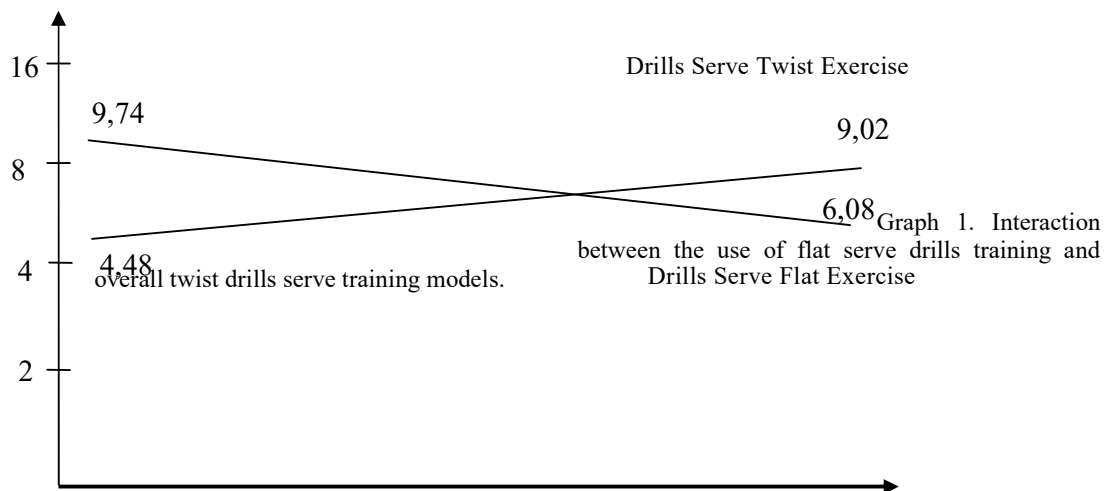
Illustrated in Table 6, the calculation results of the Tukey Test show that the calculated Q price (43.74) is greater than the table Q (2.88) at the significance level of $\alpha = 0.05$. The results of the calculation accept alternative hypotheses stating H₁: $\mu A_1 B_1 < \mu A_2 B_1$, but reject the null hypothesis which states that H₀: μ

A1 B1 $\sim$ t A2 B1. Hence it can be concluded that, in the strong grip strength, court tennis serve skills using the flat serve drills training model can be higher than serve skills using the drills serve twist exercise model.

4. The difference in court tennis serve skills between the use of the flat serve drills training model and the drills serve twist exercise model for students who have a weak grip strength

The calculation of student tennis serve skill data obtained by each treatment group showed that students with weak grip strength and the flat serve drills exercise model had an average value of 6.08 and a standard deviation of 0.6179. Meanwhile, if they use the drills serve twist exercise model, the average value was 9.02 with a standard deviation of 0.7303. Based on the Tukey Test shown in Table 6, the calculated Q price is 24.19 and the table Q price is 2.88 at the significance level of $\alpha = 0.05$. The results of the calculation show that the calculated Q price is greater than table Q. This means that the alternative research hypothesis stating $H_1: \mu A_2 B_1 > \mu A_2 B_2$ is accepted. Meanwhile, the null hypothesis which states that $H_0: \mu A_2 B_1 = \mu A_2 B_2$ is rejected. Thus, it can be concluded that in the low grip strength, court tennis serve skills using the drills serve twist exercise model are higher than those with flat serve drills training models.

The form of interaction shown by the difference in court tennis serve skills between these two training models and two grip strengths are described in Graph 1:



Discussion

Based on the data analysis above, this research indicates a different average score of court tennis serve skills using the two training models. The average score of students using the drills serve flat exercise model was 7.94, greater than students using the drills serve twist exercise model method by 7.3. Meanwhile, the Tuckey test showed that the first hypothesis test with the acquisition of F count was 47.767. This value is greater than the F table, which is 4.018 at $\alpha = 0.05$.

Overall, this research argues that the score of court tennis serve skills using the flat serve drills exercise model is better than that obtained using the drills serve twist exercise model. This also confirms a significant difference between the court tennis serve skill scores of students who use the flat serve drills practice model and the drills serve twist practice model. In other words, the use of different forms of practice will result in different court tennis serve skill scores.

This difference is mainly caused by the varied applications of the drills serve flat training model. Further, more specific simulations in the training model emphasize the form of the flat serve technique. Usually, this type of flat serve is first taught to beginners to learn to serve compared to other serve techniques. This is because this type of flat serve is performed or hit with a flat or total forward-facing racket surface. Its development can be done with maximum power. Considering the description and mechanics of movement in this serve for beginners and more skilled levels, this serve technique is easy to implement. The application of the drills serve flat training model is easy to do and helps players quickly improve. This is also because since beginners this type of serve has been done so that physiologically the movement mechanics or patterns have been formed and are easy to implement. Therefore, this flat serve drills training model can be quickly developed to produce maximum serve techniques.

As for the drills twist exercise model, it is a simulation of the serve twist movement which emphasizes several movements. Basically, this serve movement technique can be maximized when given to advanced players because movement mechanics require concentration, tenacity in mastering movements, and a high level of body flexibility. This is in line with previous research arguing that the service technique with the twist technique is an advanced serve technique, which is commonly used by professional players (Giles et al., 2019). Thus, to get

maximum serve skill results, the drills twist training model requires time. In addition, the training maturity process is quite long and should be supported by adequate body ability and flexibility (Vacek et al., 2023). Although both training models indeed have advantages and disadvantages, overall, the application of the drills serve flat training model is better than the drills twist training model.

At the level of strong grip strength, the average score of court tennis serve skills with the flat serve drills exercise model was 9.74, greater than students who used the drills serve twist exercise model method of 4.48. The results of this calculation show that at the level of strong grip strength, the average score of students' court tennis serve skills using the flat serve drills exercise model is higher than those using the drills serve twist exercise model. Furthermore, based on the Tuckey test, the group of students who had a strong grip strength obtained a Qhit price of 43.74, greater than Qtab 2.88 at $\alpha=0.05$. This indicates that the alternative hypothesis which states that $H1: \mu A1 B1 < \mu A2 B1$, can be tested. In other words, students with a strong grip strength level and the flat serve drills exercise model are better than those with the twist drills serve exercise model.

In this context, it can be interpreted that the effectiveness of the flat serve drills training model is closely related to the level of student tennis serve skills. The form of exercise will be effective if it can develop student grip strength in the training process. Grip strength in court tennis is one of the determining factors in producing the quality of the punch results. A strong grip can produce maximum accuracy and punch strength. It is also needed to hold the racket so that when the racket hits the ball, interference movements such as a rotating racket or vibrating wrist are minimal.

The application of the drills serve flat training model is associated with strong grip strength. It emphasized specific exercise variations in the drills of the flat serve technique (Chaphekar et al., 2021). The description and mechanics of the flat serve movement is to hit the ball overhead with the ball hit on a flat or total forward racket surface. Usually, tennis players emphasize maximum speed and hitting power. To get maximum punch power and serve accuracy, strong grip strength is needed. Therefore, students who have strong grip strength are better or very suitable to apply the drills serve flat training model in order to produce maximum court tennis serve skills.

At the level of weak grip strength, the average score of court tennis serve skills using the drills serve flat exercise model was 6.08, lower than students who used the drills serve twist exercise model method 9.02. This calculation shows that at the level of weak grip strength, the average score of students' court tennis serve skills using the flat serve drills exercise model is lower than that using the drills serve twist exercise model.

In this research context, this finding is in line with the theory of coaching science. The theory argues that the effectiveness of applying an exercise model is closely related to the supporting individual characteristic factor, such as one's physical ability (T. Bompa & Buzzichelli, 2015; Ilham & Dimyati, 2021; Sukarmin et al., 2021). More specifically, it is also related to the application of the drills serve twist exercise model with the level of grip strength to produce good court tennis serve skills. In students with weak grip strength, the application of the more dominant drills serve twist exercise model is suitable. The reason is because of the description and mechanics of the serve twist movement. This serve technique hits from the back of the top of the ball with a horizontal 60-degree racket position up. At the time of hitting the ball, there are stages of hand movements, namely carving (cutting), peeling (peeling) and hatchet (whyk), which require a series of overall serve twist movements. These movements need several limbs to act, namely the movement of bending the back and waist rotation, and the very strong control by the wrist to pronate the rotation of the arm joint. To facilitate control of the wrist and hand joints, weak grip strength is needed. Therefore, to produce good court tennis serve skills in students who have weak grip strength, the application of the drills serve twist exercise model is very dominantly implemented.

Factorial design in research gives the possibility for researchers to assess the interaction between the two independent variables, namely the different influence of one of the two variables at a different level from the other variable (Chaeroni et al., 2023; Yendrizal et al., 2023). If an interaction happens, it means that both the flat serve drill model and the twist serve drill model along with different grip strengths influence students' serving skills.

The results of the average score examination indicate that the form of exercise with the drills serve flat training model is more effective for the group of students with a strong grip strength, which is 9.74 compared to 4.48. This is also supported by the calculation of ANOVA that obtains the price of F hit $47.767 > F_{tab} 4.01$ at $\alpha = 0.05$. This means that the null hypothesis is rejected, while the alternative hypothesis is accepted, which states an interaction between the use of the exercise model form and grip strength against court tennis serve skills. These results also do not find any interaction between the use of this form of exercise and grip strength on court tennis serve skills. Thus, it can be concluded that the use of the flat serve drills training model and the twist serve drills training model has effectiveness when adjusted to the grip strength possessed by students.

The form of interaction shown by the results of this calculation provides a clear reason that indeed the diversity of student characteristics will cause different training methods. In this case, a form of exercise should consider the internal aspects of students, including the skills of student court tennis serves who follow the existing form of exercise. Therefore, the form of exercise and grip strength will influence each other and interact positively in the training process, especially in the achievement of results or scores of court tennis serve skills. Further research is suggested to examine whether or not performing training with adequate frequency and training programs requires a biomechanical analysis system that analyzes the technique well (Fernandez-Fernandez et al., 2017; Reid et al., 2013; Wallace & Knudson, 2020).

It is important to note that this research has several limitations. For instance, the population and sample are only limited to male students of the Faculty of Sports Sciences who pass the field tennis course. In addition, the participants have limited skills so that the results of this study may not necessarily be generalized to other populations in different places. Students who are given treatment as samples do not live in one place (dormitory) so it is not controlled, especially regarding the possibility of students who carry out physical activities similar to the treatment or experiments given by the research team. Students who participate in the research population do not all have facilities, like rackets. During the research, the participants borrowed from the other students so that the implementation of training and the results of serve skills have not been maximized (Fernandez et al., 2009; Torres-Luque et al., 2015). This factor is very important to note because using other people's tools makes them not accustomed to using the tool. Besides, there is a feeling of fear of using them. Thus, it will affect the lack of maximum results of the serving ability (Dimyati, Ilham, et al., 2023; Ilham & Dimyati, 2021; Ketels et al., 2020). Another limitation is regarding the application of the exercise model, which has very little variation (approach to only one technique in the game of tennis). Consequently, students have not maximized in following the treatment. Furthermore, technical personnel who assist in handling treatment in four sample groups are only limited to 2 people. As a result, they have not been effective in supervising students who are given treatment. In addition, other influencing factors are uncontrolled environmental variations and individual characteristics of the population and samples, such as the form of environmental temperature, weight and height. Therefore, it is assumed that the results of this study have not been maximized. Finally, the time for treatment or experiment is carried out in the afternoon starting from 15.00 WITA (Central Indonesia Time) until it is completed (according to the schedule and training program). This schedule is conducted after students finish all academic activities at the faculty. There is a possibility that they have not met expectations because they are still in a state of fatigue and have to complete other tasks as students to prepare for lectures the next day.

Conclusion

In conclusion, this research has generated several key findings. First, there is a significant difference in influence ($p < 0.05$). The drills serve flat exercise model has a more effective influence than the serve twist exercise model on court tennis serve skills. After that, the student group with strong grip strength and given the drills serve flat exercise model are better than the student group given the drills serve twist exercise model. This research also reports the group of students who have low grip strength. For this group, court tennis serve skills are higher when given the drills serve twist exercise model. This is so when compared to the student group given the drills serve flat exercise model. Finally, the research records an interaction between the drills serve training model and grip strength on court tennis serve skills.

The implications of the study's findings are significant for both coaches and athletes in tennis. The recognition of the substantial impact of different training models on court tennis serve skills emphasizes the need for a nuanced approach to serve skill development. Coaches can use this information to design customized training regimens that consider individual player profiles, maximizing the effectiveness of their training sessions. This study focuses on the influence of drills training and grip strength levels on tennis serve skills. It highlights the importance of both skill-specific and physical conditioning in the training process. Coaches can now address grip strength as a critical component of serve proficiency. Meanwhile, athletes can tailor their training methods and routines to complement their tennis skill development. In summary, the research underscores the value of personalized training programs that take into account both the selected training model and an athlete's specific grip strength level. By doing so, coaches and athletes can work collaboratively to enhance court tennis serve skills in a more effective and efficient manner, ultimately raising the overall standard of play in the sport.

References

- Bahtra, R., Putra, A. N., Tohidin, D., Rifki, M. S., & Dinata, W. W. (2022). The Development of the Endurance Training Model Based on Technique Drill. *International Journal of Human Movement and Sports Sciences*, 10(4), 654–659. <https://doi.org/10.13189/saj.2022.100404>
- Balyi, Istvan; Way, Richard; Higgs, C. (Ed.). (2013). *Long-Term Athlete Development* (1st ed.). Human Kinetics.
- Binti Yusoff, S. S., & Krasilshchikov, O. (2021). Match and game performance variables in elite and junior men singles tennis players. *Sport Mont*, 19, 189–193. <https://doi.org/10.26773/smj.210932>
- Bompa, T., & Buzzichelli, C. (2015). *Periodization training for sports*, 3e. Human kinetics.
- Bompa, T. O., & Carrera, M. C. (1999). *Periodization Training For Sports* (1st ed.). Human Kinetics. <http://books.google.com/books?id=RUowTe6UvbcC&pgis=1>
- Borowiak, D. S., & Reyes, J. P. D. L. (2007). Selection of the best in 2×2 factorial designs. *Communication in Statistics*, 9(21), 2493–2500. <https://doi.org/http://dx.doi.org/10.1080/03610929208830926>
- Brunner, E., & Denker, M. (1994). Rank statistics under dependent observations and applications to factorial designs. *Journal of Statistical Planning and Inference*, 42(3), 353–378. [https://doi.org/10.1016/0378-3758\(94\)00002-6](https://doi.org/10.1016/0378-3758(94)00002-6)

- Butler, B. N., Aicher, T. J., & Wieber, B. (2020). Junior College or the NCAA: The Case of a U.S. Women's Tennis Team with No U.S. Players. *Journal of Global Sport Management*, 5(1), 83–101. <https://doi.org/10.1080/24704067.2019.1670089>
- Chaeroni, A., Fitriadi, Surur, M., & Gusril. (2023). Badminton: An Attempt to Improve Playing Skills by Utilizing Training Media. *International Journal of Human Movement and Sports Sciences*, 11(3), 621–626. <https://doi.org/10.13189/saj.2023.110315>
- Chapelle, L., Clarys, P., Meulemans, S., & Aerenhouts, D. (2017). Physiological responses, hitting accuracy and step count of a tennis drill in function of court surface: A randomised cross-over design. *International Journal of Performance Analysis in Sport*, 17(4), 622–629. <https://doi.org/10.1080/24748668.2017.1378985>
- Chaphekar, A., Somarajan, S., Patel, B., Patel, V., & Bhalara, M. (2021). Comparison of Hand Grip Strength in Different Wrist Positions in Right and Left Handed Tennis Players. August, 8–11. <https://doi.org/10.21275/SR201222120203>
- Colomar, J., Corbi, F., Brich, Q., & Baiget, E. (2022). Determinant Physical Factors of Tennis Serve Velocity: A Brief Review. *International Journal of Sports Physiology and Performance*, 17(8), 1159–1169. <https://doi.org/10.1123/ijspp.2022-0091>
- Damrah, Muthahari, Z., Pitnawati, Mario, D. T., Astuti, Y., Zulbahri, & Ilham. (2023). Court Tennis Referee Decision Making: How does Mastery of Game Rules, Stress Management, and Concentration Affect it? *International Journal of Human Movement and Sports Sciences*, 11(5), 1020–1027. <https://doi.org/10.13189/saj.2023.110510>
- Davids, K., Kingsbury, D., Bennett, S., & Handford, C. (2001). Information-movement coupling: Implications for the organization of research and practice during acquisition of self-paced extrinsic timing skills. *Journal of Sports Sciences*, 19(2), 117–127. <https://doi.org/10.1080/026404101300036316>
- Den Hartigh, R. J. R., Hill, Y., & Van Geert, P. L. C. (2018). The development of talent in sports: A dynamic network approach. *Complexity*, 2018. <https://doi.org/10.1155/2018/9280154>
- Dimiyati, Ilham, Komaini, A., Pranoto, N. W., Ndayisenga, J., Rahayu, A. S., & Lumintuarso, R. (2023). Constructing the Validity and Reliability of the General Self-Efficacy Questionnaire (GSE-Climb) for Climbing Athletes in the Speed World Record Category. *International Journal of Human Movement and Sports Sciences*, 11(6), 1201–1218. <https://doi.org/10.13189/saj.2023.110604>
- Fernandez-Fernandez, J., Sanz, D., Sarabia, J. M., & Moya, M. (2017). The effects of sport-specific drills training or high-intensity interval training in young tennis players. *International Journal of Sports Physiology and Performance*, 12(1), 90–98. <https://doi.org/10.1123/ijspp.2015-0684>
- Fernandez, J., Sanz, D., & Mendez, A. (2009). A review of the activity profile and physiological demands of tennis match play. *Strength and Conditioning Journal*, 31(4), 15–26.
- Giles, B., Peeling, P., Dawson, B., & Reid, M. (2019). How do professional tennis players move? The perceptions of coaches and strength and conditioning experts. *Journal of Sports Sciences*, 37(7), 726–734. <https://doi.org/10.1080/02640414.2018.1523034>
- Hernández-Davo, H., Urbán, T., Sarabia, J. M., Juan-Recio, C., & Javier Moreno, F. (2014). Variable training: effects on velocity and accuracy in the tennis serve. *Journal of Sports Sciences*, 32(14), 1383–1388. <https://doi.org/10.1080/02640414.2014.891290>
- Ilham, I., & Dimiyati, D. (2021). The Effect of Visualization, Relaxation, and Self-efficacy on the Performance of Men Speed World Record Athletes Category. *International Journal of Human Movement and Sports Sciences*, 9(1), 48–55. <https://doi.org/10.13189/saj.2021.090107>
- Ketels, M., Rasmussen, C. L., Korshøj, M., Gupta, N., De Bacquer, D., Holtermann, A., & Clays, E. (2020). The Relation between Domain-Specific Physical Behaviour and Cardiorespiratory Fitness: A Cross-Sectional Compositional Data Analysis on the Physical Activity Health Paradox Using Accelerometer-Assessed Data. *International Journal of Environmental Research and Public Health*, 17(21). <https://doi.org/10.3390/ijerph17217929>
- Lambrich, J., & Muehlbauer, T. (2023). Biomechanical analyses of different serve and groundstroke techniques in tennis: A systematic scoping review. *PLoS ONE*, 18(8 August), 1–17. <https://doi.org/10.1371/journal.pone.0290320>
- Lertwonghattakul, T., Sriramatr, S., & Rachnavy, P. (2023). Analysis of Kinetic Chain Mechanism Affecting Energy Flow in Kick Topspin Tennis Serve in Elite and Amateur Tennis Players. *Annals of Applied Sport Science*, 11(2). <https://doi.org/10.52547/aassjournal.1133>
- Mangolo, E. W., & Makadada, F. A. (2020). The Relationship between Hand Grip Strength and the Accuracy of Field Tennis Services in Eighth Semester Male Students in Department of Training Faculty of Sports Science UNIMA. *Budapest International Research and Critics in Linguistics and Education (BirLE) Journal*, 3(2), 1220–1239. <https://doi.org/10.33258/birle.v3i2.1055>
- Mavvidis, A., Manousaridou, Grivas, N., Evagelidis, T., & Laios, A. (2014). The effectiveness of serve in tennis depending on the placement of palm across the racket grip inwards or outwards. *Journal of Physical Education and Sport*, 14(4), 576–580. <https://doi.org/10.7752/jpes.2014.04089>

- Montgomery, D. C. (2013). Design and Analysis of Experiments. In L. Ratts, L. Buonocore, A. Melhorn, C. Ruel, H. Nolan, & M. Eide (Eds.), *Design* (8th ed., Vol. 2). John Wiley & Sons, Inc. http://catalogue.uab.cat/record=b1764873~S1*cat
- Murphy, A. P., Duffield, R., Kellett, A., & Reid, M. (2014). A descriptive analysis of internal and external loads for elite-level tennis drills. *International Journal of Sports Physiology and Performance*, 9(5), 863–870. <https://doi.org/10.1123/ijsp.2013-0452>
- Ngatman, Alim, A., & Yuliarto, H. (2022). Developing a learning model on basic techniques forehand and backhand volley based on integrated training approach for junior tennis players aged 8-12 years. *Journal of Physical Education and Sport*, 22(11), 2642–2648. <https://doi.org/10.7752/jpes.2022.11335>
- Nugroho, A., Tomoliyus, T., Sumaryanto, S., & Ilham, I. (2021). Effects of Service Quality, Social Environment and Financial on Motivation, Satisfaction, and Performance for Athletes at Training Center PON XX in DIY. *International Journal of Human Movement and Sports Sciences*, 9(5), 1067–1079. <https://doi.org/10.13189/saj.2021.090529>
- Pavilas, C., Suwanthada, S., & Chaiwatcharaporn, C. (2015). The tennis strike simulation machine identified and confirmed power spot location on tennis racket during flat first serve. *Journal of Exercise Physiology Online*, 18(3), 14–26.
- Pereira, H. M., Menacho, M. de O., Takahashi, R. H., & Cardoso, J. R. (2011). Handgrip strength evaluation on tennis players using different recommendations. *Revista Brasileira de Medicina Do Esporte*, 17(3), 184–188. <https://doi.org/10.1590/S1517-86922011000300007>
- Porramatikul, M., Anekjumnongporn, T., Meeopartmongkon, T., Lorpipatana, B., Chaiwatcharaporn, C., & Yimlamai, T. (2020). Button damper reduces the impact force during tennis flat serve. *Journal of Physical Education and Sport*, 20(3), 1561–1568. <https://doi.org/10.7752/jpes.2020.03214>
- Reid, M., Whiteside, D., Gilbin, G., & Elliott, B. (2013). Effect of a common task constraint on the body, racket, and ball kinematics of the elite junior tennis serve. *Sports Biomechanics*, 12(1), 15–22. <https://doi.org/10.1080/14763141.2012.724702>
- Rifki, M. S., Ariston, A., Sepriadi, S., Jannah, K., Syafruddin, S., Zarwan, Z., Dinata, W. W., Komaini, A., & Bahtra, R. (2022). Development of the floating serve technique in volleyball. *Gazzetta Medica Italiana Archivio per Le Scienze Mediche*, 181(11), 841–846. <https://doi.org/10.23736/S0393-3660.22.04805-7>
- Rossi, J., Foissac, M. J., Vigouroux, L., & Berton, E. (2009). The effect of tennis racket grip size on grip force during a simulated tennis match play. *Computer Methods in Biomechanics and Biomedical Engineering*, 12(sup1), 219–220. <https://doi.org/10.1080/10255840903093953>
- Sitompul, S. R. (2020). Development of tennis serve learning models based on multiple training. *International Journal of Human Movement and Sports Sciences*, 8(6), 11–15. <https://doi.org/10.13189/saj.2020.080702>
- Sridadi, Tomoliyus, Septiasari, E. A., Parijan, Yuliarto, H., & Ilham. (2021). Effect of technical training using a ball on the dribbling speed for football players aged 10-12 years. *International Journal of Human Movement and Sports Sciences*, 9(4), 824–831. <https://doi.org/10.13189/saj.2021.090429>
- Sukarmin, Y., Ilham, I., Marpaung, H. I., Famelia, R., Komaini, A., & Pradipta, G. D. (2021). Knowledge, Competence of Indonesian Climbing Sports Athletes in the Prevention and Management of Injuries. *International Journal of Human Movement and Sports Sciences*, 9(6), 1262–1271. <https://doi.org/10.13189/saj.2021.090621>
- Sulistiyowati, E. M., Suherman, W. S., Sukanti, E. R., Ilham, Sriwahyuniati, F., Budiarti, R., & Pranoto, N. W. (2022). Development of Early Childhood Skills by Guiding Tests in Sports Rhythmic Gymnastics. *International Journal of Human Movement and Sports Sciences*, 10(2), 253–263. <https://doi.org/10.13189/saj.2022.100216>
- Torres-Luque, G., Ramirez, A., Cabello-Manrique, D., Nikolaidis, P. T., & Alvero-Cruz, J. R. (2015). Match analysis of elite players during paddle tennis competition. *International Journal of Performance Analysis in Sport*, 15(3), 1135–1144. <https://doi.org/10.1080/24748668.2015.11868857>
- Vacek, J., Vagner, M., Cleather, D. J., & Stastny, P. (2023). A Systematic Review of Spatial Differences of the Ball Impact within the Serve Type at Professional and Junior Tennis Players. *Applied Sciences*, 13(6), 3586. <https://doi.org/10.3390/app13063586>
- Wallace, B., & Knudson, D. (2020). The effect of course format on student learning in introductory biomechanics courses that utilise low-tech active learning exercises. *Sports Biomechanics*. <https://doi.org/10.1080/14763141.2020.1830163>
- Weinberg, R. S., & Gould, D. (2015). Foundations of Sport and Exercise Psychology. In M. Schrag, A. S. Ewing, C. A. Gentis, & A. Cole (Eds.), *Human Kinetics* (6th ed.). Human Kinetics. <https://doi.org/10.1123/jsep.20.3.336>
- Yendrizal, Kiram, Y., Yenes, R., Komaini, A., Ihsan, N., & Mario, D. T. (2023). Effect of weight training and motor skills on muscle strength: A factorial experimental design. *Journal of Physical Education and Sport*, 23(6), 1416–1424. <https://doi.org/10.7752/jpes.2023.06173>