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The Effect of Plyometric Training Programs (Leg Explosive Strength) on Improving Service Speed and Forehand Speed in Teenage Tennis Players (Aged 15-20 Years)

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ABSTRACT (English)

Background This study was motivated by the understanding that leg explosive power is a crucial component for generating hitting power in modern tennis. **Research Objectives** The aim of this study was to investigate the effect of an 8-week leg plyometric training program on improving serve and forehand speed in junior tennis players. **Metods** The research methodology used a quasi-experimental design with a pre-test post-test control group. Thirty junior tennis players (aged 15-20 years) were randomly divided into two groups: the Experimental Group (EG, n=15), which received regular tennis training plus plyometric training three times a week, and the Control Group (CG, n=15), which only underwent regular tennis training. Service and forehand speed (km/h) were measured using a radar gun before and after the intervention. Data analysis used the Independent T-test to compare the gain values between the two groups. **Results** The results showed a highly significant difference ($p < 0.01$). The average increase (gain) in serve speed in the Experimental Group reached 7.7 km/h, far exceeding that of the Control Group, which was only 0.7 km/h. A similar pattern was seen in forehand speed, where the EG experienced an increase of 6.3 km/h, while the CG only experienced an increase of 0.5 km/h. **Conclusion** In conclusion, the lower limb plyometric training program proved to be a highly effective intervention method for significantly improving serve and forehand speed in junior tennis players.
Keywords: Plyometrics, Tennis, Service Speed, Forehand Speed, Leg Power

ABSTRAK (Bahasa Indonesia)

Latar belakang penelitian ini adalah pemahaman bahwa kekuatan pukulan dalam tenis modern sangat bergantung pada daya ledak tungkai. Tujuan penelitian Penelitian ini bertujuan untuk menginvestigasi dampak dari program latihan plyometric tungkai yang dilakukan selama 8 minggu. Fokusnya adalah untuk melihat peningkatan kecepatan servis dan kecepatan *forehand* pada atlet tenis remaja. Metode Penelitian ini menggunakan metode *quasi-experimental* dengan desain *pre-test post-test control group design*. Sampel penelitian terdiri dari 30 atlet tenis remaja, dengan rentang usia 15-20 tahun. dibagi secara acak menjadi dua kelompok: Kelompok Eksperimen (KE, n=15) yang menerima latihan tenis reguler ditambah latihan plyometric, dan Kelompok Kontrol (KK, n=15) yang hanya menjalankan latihan tenis reguler. Intervensi latihan plyometric spesifik diberikan kepada KE sebanyak 3 kali seminggu. Kecepatan servis dan *forehand*

(diukur dalam km/jam) diukur sebelum (pre-test) dan sesudah (post-test) periode intervensi menggunakan *radar gun*. Analisis data difokuskan pada nilai *gain* (selisih post-test dikurangi pre-test) dan menggunakan uji *Independent T-test*. Hasil Hasil penelitian menunjukkan adanya perbedaan peningkatan yang sangat signifikan antara kedua kelompok. Rata-rata *gain* kecepatan servis Kelompok Eksperimen (7.7 km/jam) secara statistik jauh lebih tinggi ($p < 0.01$) dibandingkan Kelompok Kontrol (0.7 km/jam). Pola serupa juga ditemukan pada kecepatan *forehand*, di mana *gain* KE (6.3 km/jam) juga signifikan lebih tinggi ($p < 0.01$) dibandingkan KK (0.5 km/jam). Kesimpulan Berdasarkan temuan ini, disimpulkan bahwa program latihan plyometric tungkai merupakan metode intervensi yang sangat efektif untuk meningkatkan kecepatan servis dan *forehand* bagi atlet tenis remaja.
Kata kunci: Plyometric, Tenis, Kecepatan Servis, Kecepatan Forehand, Daya Ledak Tungkai

INTRODUCTION

Tennis is a highly dynamic sport that demands a complex combination of physical fitness, technical skills, strategy, and mental toughness (Fernandez-fernandez et al., 2014). In recent decades, the modern game of tennis has shifted significantly toward a more aggressive and fast-paced style of play, often referred to as the era of “power tennis”(Trends et al., n.d.). In this context, the ability to dominate the game often depends on the power and speed of shots, particularly the serve and forehand, which have evolved into primary weapons for scoring points or initiating attacks (point-winning shots) (Crespo & Federation, 2020).

Biomechanically, the assumption that the power of a tennis shot comes solely from arm strength is incorrect. An effective shot is the result of an efficient kinetic chain, a coordinated process of energy transfer from the entire body (Murata et al., 2022). This process begins with the push-off of the feet on the court to utilize Ground Reaction Force (GRF). This energy is then transferred sequentially through the legs, hip and torso (core) rotation, shoulders, arms, and finally to the racket to generate maximum racket head speed just before impact with the ball (Shimokawa et al., 2020). Weaknesses in the foundation of this chain, especially in the legs, will significantly limit the potential power that can be generated by the upper body (Swart et al., 2022).

The transfer of lower-limb explosive power to tennis strokes may also depend on the direction and mechanical characteristics of the plyometric movement. Vertical plyometric movements, such as countermovement jumps, emphasize rapid extension of the ankle, knee, and hip and the generation of vertical ground-reaction forces (Pang & Li, 2026). These characteristics are particularly relevant to the serve, where forceful leg extension contributes to upward propulsion and initiates the kinetic chain toward the trunk and hitting arm. In contrast, lateral and directional plyometric movements, such as lateral bounds and multidirectional jumps, emphasize rapid force production and redirection in the frontal and transverse planes. These movement characteristics are particularly relevant to the forehand groundstroke, which requires lateral drive, lower-body stabilization, and rotational force transfer through the pelvis and trunk toward the racket. Therefore, incorporating different directions of plyometric movement may enhance the ability of the lower limbs to contribute effectively to the distinct mechanical demands of the serve and forehand.

The main source of this initial power is the explosive power of the leg muscles. Young athletes, aged 15-20 years, are in a critical phase of physical and technical development (G et al., 2016). At this stage, they have a significant window of opportunity to develop neuromuscular attributes such as explosive power (G et al., 2016). However, conventional training programs often focus more on mastering striking techniques (drills) and cardiovascular endurance (playing points), while specific interventions to increase explosive power are often neglected (Santos et al., 2021). This creates a gap between the demands of the modern game and the training methods applied (Brink et al., 2018).

To bridge this gap, plyometric training is proposed as a highly relevant intervention method (Ramírez et al., 2022). Plyometric training is a training method specifically designed to increase muscle explosive power through the exploitation of the stretch-shortening cycle (SSC) (Wang & Zhang, 2016). Unlike pure strength training (heavy weight lifting), plyometrics not only increases maximum strength but also trains the nervous system and muscles to generate that strength in the shortest possible time (Booth & Orr, 2023). This ability (known as Rate of Force Development - RFD) directly reflects the explosive actions required in serving (jumping) and forehand (rapid rotation from the stance) (Hayes et al., 2018).

Although theoretically the relationship between leg explosive power and striking speed is very strong, and many international studies support the effectiveness of plyometrics for athletic performance, research that specifically measures its impact in quantitative units (km/h) on serve and forehand speed in a population of young tennis players in Indonesia is still very limited (Hayes et al., 2018). Many coaches may still be hesitant to implement this program due to a lack of local empirical evidence or concerns about the risk of injury (Lloyd & Cscs, 2018).

Therefore, this study aims to fill this gap by empirically testing the effects of a structured 8-week leg plyometric training program. Specifically, this study will measure and compare the increase in serve speed and forehand speed between the group of athletes who received the plyometric intervention and the control group who did not (Rao & Rao, 2016). The hypothesis of this study is that the group that participated in the plyometric program will show a statistically significant increase in serve and forehand speed compared to the control group (Paul, 2021).

METHOD

Design

This study used a quasi-experimental design with a pre-test post-test control group design.

Participants

This study involved 30 teenage tennis players (19 boys and 11 girls) from several tennis clubs in Surabaya as samples. The age range of participants was 15 to 20 years, with an average age of 17.2 (± 1.5) years. The inclusion criteria were: being registered as an active athlete, having at least 3 years of tennis training experience, not currently suffering from a leg injury, and being willing to participate in the entire research program. Next, the sample was randomly divided into two groups, namely the Experimental Group (EG) and the Control Group (CG), each consisting of 15 athletes.

Instruments and data measurements

Service and forehand speed data were collected before (pre-test) and after (post-test) the 8-week intervention program. Measurements were taken using a radar speed gun (Bushnell brand) with an accuracy level of ± 1.0 km/h. The service speed test procedure required athletes to perform 10 “flat” serves at maximum speed to the deuce service box, where the 5 best serves were recorded and averaged as a score. For the forehand speed test, athletes hit 10 forehand cross-court balls at maximum speed from a relay pass given by the coach; the best 5 strokes that entered the court were recorded, and the average was taken as the final score.

Procedure

The research intervention was conducted over 8 weeks, during which both groups continued their regular club tennis training (an average of 4 times/week). The difference in treatment was that the Experimental Group (EG) received an additional specialized lower-body plyometric training program 3 times per week. These plyometric sessions lasted approximately 30-40 minutes and included exercises such as squat jumps, box jumps, depth jumps, and bounding, with progression in volume and intensity increased every 2 weeks. In contrast, the Control Group (CG) only participated in their regular club tennis training without any additional plyometric training.

Data analysis

The data were analyzed using SPSS version 25. Descriptive statistics (mean, standard deviation) were used to describe the pre-test and post-test data. To test the hypothesis, the gain value (post-test - pre-test difference) was calculated for each athlete. The Independent T-test was used to compare the average gain value between the Experimental Group and the Control Group. The significance level (α) was set at $p < 0.05$.

RESULTS

Pre-test and post-test data from both groups were collected and analyzed. The initial homogeneity test showed that both groups were relatively equal in the pre-test, both in terms of service speed (p=0.812) and forehand speed (p=0.890).

After the 8-week program, the Experimental Group (EG) showed a clear improvement in both variables measured, while the Control Group (CG) showed very minimal changes. A detailed comparison is presented in Table 1 below. This section reports the findings from the preliminary or partial stages of the study that need to be communicated promptly. The data analysis is presented in accordance with the research objectives established in the article. Relevant findings may also be illustrated through tables and figures to provide a clearer representation of the data.

Table 1. Comparison of Pre-test, Post-test, and Gain Score Average Values for Service Speed and Forehand between the Experimental Group (EG) and Control Group (CG)

Variables	Variables	N	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	P-VALUE
Service Speed (km/h)	EG	15	140.5 ± 8.2	148.2 ± 7.9	< 0.001*
	CG	15	141.1 ± 7.9	141.8 ± 8.0	
Forehand Speed (km/h)	EG	15	115.2 ± 6.4	121.5 ± 6.1	< 0.001*
	CG	15	114.9 ± 6.8	115.4 ± 6.7	

Showing a statistically significant difference ($p < 0.05$).

Based on the data in Table 1, the results of the Independent T-test analysis of the gain score (improvement) show a very significant difference between the two groups. In terms of service speed, a very significant difference ($p < 0.001$) was found between the Experimental Group (EG), which experienced an average increase of 7.7 km/h, compared to the Control Group (CG), which only experienced an increase of 0.7 km/h. A very significant difference ($p < 0.001$) was also seen in forehand speed, where the EG showed an average increase of 6.3 km/h, while the CG only experienced an average increase of 0.5 km/h.Article text. Article text article text article text article text article text article text article text article text article text article text (Figure 1).

DISCUSSION

The results of this study clearly show that an 8-week plyometric leg training program has a significant positive effect on improving the serve speed and forehand speed of junior tennis players. This finding is consistent with the basic principles of tennis biomechanics. Increased leg explosive power, which is the main target of plyometric training, directly contributes to an increase in Ground Reaction Force (GRF) (Eng & Sundar, 2021). Athletes in the Experimental Group (EG) became more capable of "pressing" the court more strongly and quickly (Baloncesto, 2023). Through the kinetic chain, this greater leg power is efficiently transferred to the hips, torso, and finally to the arms, resulting in higher racket head speed at impact (Shimokawa et al., 2020).

An increase in service speed of 7.7 km/h and forehand speed of 6.3 km/h represents a substantial improvement in tennis performance (Cross, 2020).

The serve and forehand are shots that rely heavily on the transfer of energy from bottom to top. An increase in KE of nearly 8 km/h on the serve and more than 6 km/h on the forehand is a substantial improvement in the context of tennis performance (Cross, 2020). This improvement not only impacts the power of the shot but can also provide a significant tactical advantage in a match (Available, 2015).

Meanwhile, the Control Group (CG), which only underwent regular tennis training, did not show any significant improvement (Canós et al., 2022). This indicates that conventional tennis training (technical drills, sparring) may be sufficient to maintain explosive power levels, but not enough to significantly improve them over an 8-week period (Ćorilić et al., 2025). This confirms that to improve specific physical components such as explosive power, specific training interventions such as plyometrics are required.Discussion is the action of interpreting the results. The relationships and extrapolations that could be derived from the results are clearly expressed. The two central elements of the discussion are the following: to indicate what the findings mean and how they relate to what was known until then (Performance, 2020).

These findings support previous research linking lower body strength to serve speed. However, this study provides direct and measurable evidence (in km/h) of the effectiveness of plyometric interventions in a population of adolescent athletes.

There are several limitations to this study. The sample size of 30 athletes is relatively small and only includes athletes from one region. In addition, this study did not strictly control for variations in athletes' technical strokes, which may have changed slightly as their physical strength increased.

CONCLUSION

Based on the results of data analysis and discussion, it can be concluded that the leg plyometric training program given 3 times a week for 8 weeks is effective and significant in increasing serve speed and forehand speed in teenage tennis players aged 15-20 years. The effectiveness of this program is proven by the significant difference in the effects between the group that received plyometric training and the group that did not.

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CONFLICT OF INTEREST

There is no conflict of interest in this study.

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