Original Article

Effect of a 6-week Plyometric Training Program on Lower Limb Power in Young Tennis Players

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ABSTRACT

Tennis is considered to be an explosive sport and the performance requires developed motor skills. Therefore, Plyometrics is widely known to contribute to improvements in jumping ability in Tennis. The objective of the present study was to explore the effect of a plyometric training program of 6 weeks (2 sessions per week the first two weeks and 3 sessions per week the last 4 weeks) on the performance of jumping in young Tunisian tennis players, aged 16 years. Twenty-four (24) Tunisian tennis players (16 years old), voluntarily participated in this study and were randomly assigned to two different groups: an experimental group (EG, n = 12) and a control group (CG, n = 12). The results indicate a significant improvement in the height of the Countermovement Jump test vertical trigger and squat jump in the experimental group respectively of 12% and 13%.

Keywords: Plyometric training, countermovement jump, squat jump, young tennis player

INTRODUCTION

Tennis is a complex sport with more than 20 different types of strikes excluding the type of executions, intensities and tactical aims. The shots are interconnected with specific movements that greatly influence the execution of the shots. Tennis is considered to be an explosive and very dynamic sport (Fernández-Fernández et al., 2014; Fatouros et al.,2000). It's also an intermittent sport alternating periods (short and intense) of effort with periods of lower intensity such as running at low speeds (Tricoli et al., 2005). Tennis performance (including shots and various movements) requires both properly developed motor skills and optimal motor skills on the part of the athlete. Tennis performance comes down to the interaction of a large number of technical, tactical, physical and psychological determinants and tennis players must be explosive (Kawakami et al., 2002): they are called upon to react to the action of the opponent very quickly by sprinting towards the hitting point, which requires fixing solid supports on the ground and then quickly getting out of these supports to get moving.

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These short and intense movements call on qualities of muscular power which is a major determinant of performance in tennis, that is to say the ability of the player to reach his maximum power as quickly as possible. The explosive force lies in the fact of mobilizing a light load with the greatest possible speed of execution. However, vertical jumping is considered to be a fundamental component for success in various sporting disciplines (Sheppard et al., 2008). Depending on the specifics of the sports disciplines, an athlete's ability to jump may be affected by the direction of

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the jump. In addition, the height of the jump is often considered to be a critical factor during a match (Lahance et al., 2005). Therefore, many authors have shown the existence of a positive correlation between jumping ability and other physical abilities of athletes (Wisløff et al. 2004).

The countermovement jump (CMJ) and the squat jump (SJ) were a valid and reliable assessment tests for assessing vertical jump performance. They were classified as a slow action, as opposed to the Drop jump which uses fast action (Fernandez-Fernandez et al., 2013).

Plyometrics (PLIO) is widely known to contribute to neuromuscular adaptations to high eccentric forces and correspond to improvements in jumping ability (Tricolli et al., 2005).

This training modality has proven to be effective due to increased strength and speed of contraction (Malisoux et al. 2006) and the major mechanisms underlying the effects of PLIO are related to the specificity of muscle performance in the stretch-shortening cycle (SSC). The sequence of concentric contraction (shortening) preceded by an intense eccentric action (stretch) increases the force and speed of the action, compared to an isolated concentric contraction. The effect of SSC is due to Storage and the use of elastic energy, the stretch reflex and the tendon reflex (Bosco et al., 1982).

However, typical plyometric training in Tennis consists of standing jumps, multiple hops and jumps, leaps and drop jumps. However, jumps on the spot include jumps and landings in the same area, for example, vertical jumps, jumps over barriers executed at maximum intensities. In strength training theory, specific training to improve explosiveness is referred to as "Pliometric training" (Stojanovic et al., 2017): il has been advocated as an appropriate approach for sports that require explosiveness and also good vertical leap. Rahman et al. (2005) concluded that plyometric training improves, in the short term, the vertical leap, muscle strength and anaerobic power of athletes. In addition to its effect on explosiveness of tennis players, plyometrics can improve running economy, increase maximal strength and power, and prevent certain injuries in athletes (Canavau et Vescovi, 2004).

Therefore, many studies have concluded improvements in the height of the vertical jump following a plyometric training program (Malisoux et al., 2006; Rahman et al., 2005; Lahance et al., 2005). In opposition to these results, other previous works have observed no positive effect of plyometric training on the height of the vertical jump (Markovic, 2007; Herrero, 2006). Therefore, it should be noted that some studies have even observed decreases in the height of the vertical trigger following plyometrics (Luebbers, 2003).

The analysis of the scientific literature reveals that most of the previous works have focused on team sports and in particular football (Markovic et al. 2007) and that a very small number of works have explored the effect of plyometrics on the height of vertical relaxation in tennis players (Fernandez-Fernandez et al., 2013): they then concluded that plyometric training constitutes an interesting stimulus to improve explosive actions in young practitioners. It should be noted that every tennis game action includes the stretch-shortening cycle (Tricoli et al., 2005). Hence the importance of verifying the usefulness of this type of training at the level of this sports discipline.

Therefore, the objective of the present study was to explore the effect of a plyometric training program of 6 weeks (2 sessions per week the first two weeks and 3 sessions per week the last 4 weeks) on the performance of vertical relaxation in young Tunisian tennis players, aged 16 years.

We hypothesized that 6-week plyometric training program will be beneficial to the performance of vertical jump in young tennis players ?

MATERIALS AND METHODS

Participants

Twenty (24) Tunisian tennis players (16 years old), voluntarily participated in this study and were randomly assigned to two different groups: an experimental group (EG, n = 12) and a control group (CG, n = 12). The participants The participants were not subjected to any particular plyometric program in addition to the usual tennis training. None of the subjects presented any medical contraindication to the practice of physical exercise. The characteristics of the subjects are presented in the table below. The participants were non-smokers, with no histories of cardiopulmonary diseases or allergies. Written informed consent for participation was obtained from each subject and their parents or guardians prior to the study after receiving verbal and written explanations on the risks and benefits of the experimental protocol. The physical characteristics of the study participants at the time of inclusion are listed in Table 1. There was no difference between groups for any of these parameters at baseline.

Procedures

This study took place during the 2020/2021 sports season. One week before the start of the manipulations, the subjects took part in two familiarization sessions. During the first orientation session, the subjects were informed of the experimental procedure, the nature and protocols of the tests and the taking of Anthropometric measurements.

The participants were then divided into 2 groups:
- An experimental group (n = 12)
- A control group (n = 12).

During the second familiarization session, the subjects were familiarized with the correct execution of exercises of the Plyometric training program.

One week later, the subjects performed two experimental sessions (test/re-test) separated by an interval of 6 weeks of training. During each experimental session, subjects performed a 20-min dynamic warm-up, which consists of a 5-min general warm-up at moderate speed, followed by 5-min dynamic stretching exercises and finally a warm-up sequence specific 10 min. A recovery time of 5 min was observed between the end of the warm-up and the start of the test. For each trial, all the subjects were verbally encouraged to perform the performance of vertical relaxation with the maximum of their capacities.

The Training Program

The plyometric training program (see Table 2 below) was inspired by the study by Spurrs et al. (2003). The program was spread over six weeks with 2 sessions per week for the first two weeks and 3 sessions per week for the last 4 weeks. The total number of sessions in our study program was sixteen training sessions.

The plyometric exercises targeted the lower limbs. A program of 2 to 4 exercises, performed at maximum intensity, with 2 to 3 sets and 6 to 15 repetitions. Rest intervals between sets were one minute recovery and between exercises 2 minutes.

A schematic representation of the experimental training program design is illustrated in Table 3.

The players in both groups completed all aspects of the training programs, with nobody experiencing any injuries related to training or testing during the experimental period. The attendance rate during the 6-week training period and for rest and exercise measurements was 98%.

Statistical Analysis

The processing of the results is carried out by the Statistica software (version 12.0, USA) and this by referring to the usual statistical rules, namely: the mean, the standard deviation, the difference is markedly significant at $p<0.05$.

Table 1: Subject characteristics of tennis players at the start of the study (T1)

	Nombre	Age (years)	Height (cm)	Weight (kg)	BMI
Experimental Group (EG)	12	16±0.4	173±5	64.4±3	21.5±0.68
Control Group (CG)	12	16±0.74	172±7	63±4,5	21.86±0.3

Data are mean±standard deviation (SD). EG: Experimental group, CG: Control group

Table 2: Subject characteristics of tennis players at the start of the study (T1) and at second test (T2)

		First test (T_1)	Second Test (T_2)	Signification (*P value*)
Weight (Kg)	Experimental Group (EG)	64.4±3	65±2.5	0.38
	Control Group (CG)	63±4,5	64±3.07	0.086
BMI	Experimental Group (EG)	21.5±0.68	21.59±1.25	0.09
	Control Group (CG)	21.86±0.3	21.81±1.18	0.57

Data are mean±standard deviation (SD). EG: Experimental group, CG: Control group; with difference signification

Table 3: Training programs experimental group (EG) and control group (CG)

Week/session	Squat jump	Split scissor jump	Double leg bound	Alternate leg bound	Single leg forward hop	Depth jump	Double leg hurdle jump	Single leg hurdle hop	Total contacts
1/1	2×10	2×10	2×10						60
1/2	2×10	2×10	2×10						60
2/1	2×10	2×10	2×10	2×10					100
2/2	2×10	2×10	2×10	2×10					100
3/1		2×12	2×12	2×12	2×10				136
3/2		2×12	2×12	2×12	2×10				136
4/1			3×10	3×10	2×12	2×6			150
4/2			3×10	3×10	2×12	2×6			150
4/3			3×10	2×15	3×10	2×8			156
5/1				2×15		2×8	2×10	2×10	136
5/2				3×15		2×10	2×10	2×10	170
5/3				3×15		2×10	2×10	2×10	170
6/1					3×10	3×10	3×10	3×10	180
6/2					2×15	3×10	3×10	3×10	180
6/3					2×15	3×10	3×10	3×10	180

Student's 't' for data analysis, we compared the means before and after training. Indeed, we tested normality through the Kolmogorov Smirnov test which showed that our distribution is normal. In addition, we compared the results before and after the training by calculating the percentage of evolution (The rate of improvement). Two-way ANOVA with repeated measures was used to determine differences between groups.

RESULTS

The analysis of the anthropometric measurements carried out on our subjects before and after plyometric training period, showed no significant change for either the experimental group or the control group (Table 2).

However, the results presented in Table 4, we find that the values obtained during the two tests generated a highly significant difference (p=0.002) for the performance of CMJ in the experimental group, whose mean values are of the order of 33.5 ± 5 cm during the first test and 37.5 ± 2.5 cm during the second test, then we noticed a non-significant difference for the control group with mean values of the order of 33.7 ± 4.2 cm during of the first test and 34.1 ± 3.2 cm during the second test (Table 4).

In the squat jump, the performance of our tennis players revealed a significant improvement (p<0.01) only in the experimental group (from 32.2 ± 4 to 36.5 ± 3.8) with a rate of 13%. However, for the control group no significant difference is observed with a percentage of 1.74%.

This finding confirms our initial hypothesis which states that plyometric training involves an evolution of the explosive strength of the lower limbs.

Table 4: Comparison between the Experimental group (EG) and Control Group (CG) before (first test: T1) and after 6-week period (Second test : T2). Values are also shown

		First test (T_1)	Second Test (T_2)	Signification (*P value*)
CMJ (cm)	*Experimental Group*	33.5±5	37.5±2.5	0.001
	Control Group	33.7±4.2	34.1±3.2	0.200
SJ (cm)	*Experimental Group*	32.2±4	36.5±3.8	0.002
	Control Group	32.3±5.1	3±2.4	0.200

Data are mean±standard deviation (SD) of Countermouvement jump (CMJ) and Squat Jump (SJ)

DISCUSSION AND CONCLUSION

Plyometrics can increase the ability to produce more powerful movement over a very short period of time. It acts mainly on the stretching-shortening cycle which occurs in almost all body movements, mainly during sports practice. It is undeniable in all disciplines where explosive force is important such as Tennis since it intervenes during Service, Smash,…

The objective of this study was to explore the effect of a 6-week plyometric training program (2 sessions the first two weeks and 3 sessions the last 4 sessions) on lower limb relaxation performance in young Tunisian tennis players.

The analysis of the anthropometric performances carried out on our subjects before and after the plyometric training did not show any significant evolution as well for the experimental group as for the control group. Our results align with those of Diallo et al., (2001), who indicate that all anthropometric characteristics were similar in the experimental group and the control group.

The results of the present study indicate a significant improvement in the height of the Countermovement Jump test vertical trigger and squat jump in the experimental group respectively of 12% and 13% which aligns with numerous studies that have explored the effect of different plyometric training programs on vertical relaxation and muscle power of the lower limbs in athletes from different sports disciplines (Markovic et al., 2007; Malisoux et al., 2006; Lahance et al., 2005). However, Markovic et al., 2007 showed that a program similar to ours but of longer duration, improved the performance of CMJ jumps by 7%.

This is also confirmed by the work of Kotzamanidis et al. (2006) and Herrero et al. (2006) that the improvement of muscular strength and vertical jump height are linked to continuous plyometric training.

The present study also allowed us to deduce that the training program based on plyometric exercises based on jumps, induces a better post-training performance in Tennis with young practitioners.

Our results corroborate with those advanced by Fernandez-Fernandez et al. (2014) who showed that a plyometric training program improves the explosive actions of tennis players and it seems to be a good stimulus to improve the physical qualities of tennis players.

Therefore, Rahman et al. (2005) indicated that short-term plyometric training is able to improve vertical jumping ability, muscle strength and anaerobic power. However, it is important to point out that the gains obtained during the CMJ following a training based on the drop jump could be explained by an improvement in the strength of the extensors of the hip of the explosiveness (Wissloff et al., 2004) because the plyometrics leads to performance improvements especially in activities requiring explosive muscle contractions (Malisoux et al., 2006).

On the other hand, plyometric training would then appear as a way to increase coordination between arms and legs and to improve the strength of the lower limbs: It is recognized that following training of this kind, the improvement in muscle power is due to several factors such as pre-activation and co-activation of muscles as well as than to the synchronization of the activation of the agonist and antagonist muscles (Sheppard et al., 2008).

Thus, the results obtained confirm the hypothesis that plyometric training could have significant improvements in the development of explosive strength of the lower limbs in young tennis players, just as a period of six weeks is sufficient to have an effect on the performance of young tennis players.

In addition, it is important to specify that during a plyometric training program, coaches must know the best volume and intensity of the jumps, in order to adapt the exercises to the level of the physical capacities of the players to avoid injury and overtraining.

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