STUDY ON PHYSICAL TRAINING IN TENNIS PERFORMANCE

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Abstract. *The purpose of the research is to determine and explain the effects of a combined workout training consisting in tennis specific sprints combined with a plyometric training. Our objectives were to analyze the effects of this type of combined training on the variable performance movements in tennis. This training has been performed for 10 weeks, three times/week with a total of 30 sessions. Forty-eight male adolescent tennis players, aged between 14 and 16 years old, participated in this study. They were divided into two groups, a control group of 23 subjects and an experimental group of 25 subjects. The participants had to have a minimum experience of 2 years of participating in competitions at a national level. The physical tests that have been used to measure their performances were: added steps, the Spider test, Illinois agility test and T-test. The statistical program used for analyzing the data was the program named SPSS version 24. To verify the obtained results, several statistical tests have been used, such as T-Test for independent samples, Pearson correlation and paired t-test. Following statistical analysis of data, it was concluded that the two groups differ significantly in terms of tennis movements performance, after the application of the training program (the results of the experiment group are better than those of the control group at the end of the intervention).*

Keywords*: combined tennis training, sprint specific, Plyometric training.*

Introduction

Tennis is characterized as a sport that involves high intensity efforts, such as accelerations, decelerations, repetitive strokes, and changes of directions, over irregular periods, on an average of 90 minutes (Kramer et al., 2015). As per some authors, tennis is a high-intensity effort sport that involves also stages of lower-intensity activity, that occur between points, and which involves active recovery and passive periods (Fernandez-Fernandez et al., 2009).

A tennis match can last up to about 5 hours. Furthermore, in order to achieve success, tennis players need a combination of fitness qualities like agility, speed, power, and general good aerobic fitness so that, high performance can be achieved (Fernandez-Fernandez et al., 2015).

Reaction time in tennis is also a critical factor, as players need to have a quick reaction to the actions performed by their opponent. Reaction time and initial acceleration, together with well-developed agility, have a strong impact on the overall performance of the athlete (Fernandez-Fernandez et al., 2009). These are essential when the tennis player is involved in fast gameplay. Initial acceleration can also be associated with the first 10 m of a sprint (Kovacs et al., 2008), while agility is seen as the capacity of easiness in changing directions, and quickness in starting and stopping (Sheppard & Young, 2006). On the other hand, speed is the ability to gain high velocity and it is also a manifestation of strength. When speaking about strength, we point out explosive force and rate force development used for a specific

movement or technique (Cronin & Hansen, 2005). On average, a sprint distance performed during a point is between 4 to 7 m, and an average of 4 to 7 changes of direction (Fernandez-Fernandez et al., 2009). Based on these statistics and facts, tennis players need to have remarkable dynamism in multidirectional movements during matches and explosive, short movements over the court (Elliott, 2006).

One reason why maximal speed cannot be achieved during a point is that tennis players are moving from side to side nearly every time. This fact can be seen as a limiting factor (Weber et al., 2007). The effort during a tennis match, which consists of strokes, changes of direction, is requiring a high rate of power development, remembering the time period that is spent on the court producing power, like in sprinting and changing direction (<100 ms.) (Brughelli et al., 2008). Regarding the strength training, there were not many studies that have been done having as samples male players of different levels, that have been evaluated on the particular training programs such as plyometric and basic strength training. It has been shown that there are improvements in the fitness qualities when training is also concentrated on speed. Authors showed that there were improvements in the neuromuscular qualities (Buchheit et al., 2010). As to the repeated sprint, it has been shown to have a bigger impact on the shuttle sprint performance (Fernandez-Fernandez et al., 2012). Plyometric training is suggested to be a specific training in various sports because it has significant positive effects on agility, strength, jumping ability and also on sport-specific performance, subsequently after the implementation of Plyometric programs (Ramirez et al., 2015).

Methodology

Scope

The purpose of this research was to determine the effects of a combined workout training consisting of tennis-specific sprints and plyometric training for speed, agility, and strength, on the performance of movements in tennis players.

Hypotheses

1. There are significant statistical differences between the experimental group and the control group, in terms of the performance of movements in tennis, at the final evaluation (after the experimental intervention).
2. There is a significant correlation between the results of the Illinois Agility test and the national ranking, in the case of the investigated junior tennis players.

Participants

Forty-eight male subjects between 14 and 16 years old participated in this research. 23 of them were part of the control group and the remaining 25 of the experimental group.

Instruments

The physical tests that were performed before and after the training sessions were the following:

Added steps: The purpose of this test is to assess the speed of the added steps and the ability to stop and change direction. The athlete, is in a standing position at the service line, facing the net. Then he performs a run with added steps, until to the doubles line, which he will touch with his right leg. Then he continues to the other side and returns to the starting point**.**

Spider Test (Huggins et al., 2017): The purpose of this test is to measure the specific tennis speed run, with starts, stops, and changes of directions. Measuring techniques: the athlete is standing on the baseline in the exact middle of the court, holding the racket. From here the athlete initiates lateral (to the left and to the right) and oblique movements and always returns from each side to the central point of the court and continues from there. 5 points are marked on the court, that needs to be reached with the sole surface.

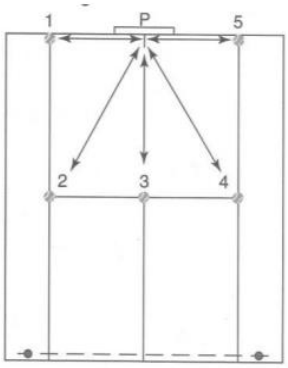

Figure 1. Spider Test

Illinois Agility Test: The length of the test is 10m and the width is 5m. Four cones are used to mark the start, end, and two return points. Another four cones were placed in the center at equal distances. Each cone in the center was spaced 3.3 m apart. The athlete was in a prone position with the chin touching the surface of the start line. On the command "start", the stopwatch is started, and the participant gets off the ground as fast as possible and runs in the course and in the direction indicated, while trying to avoid any contact with the placed cones. Then the participant runs to the cone which is located in the middle at the starting line following the zigzag course forward and then returns, sprints to the last cone on the opposite side, and finishes. When crossing the finish line, the time has stopped and recorded. Subjects performed one trial.

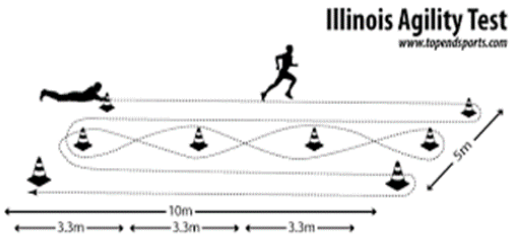

Figure 2. Illinois Agility Test (Wood, 2008a)

T- Test: This test has required the athlete to touch a series of cones, arranged in a "T" shape while moving with added steps as fast as possible during the test. Three cones are placed 5 m apart in a straight line (A, B, C) and a fourth cone (D) is placed 10 m away from the middle cone (B) so that the four cones form a "T". The athlete stood next to cone (D), at the base of the "T". At the command "Start", the stopwatch is started, and the athlete commenced with the test. The athlete ran towards the middle cone (B), then moved with added steps towards the left cone "A" which he reached, returned, and continued to the opposite side, reaches the cone "C", returned to the middle cone (B), then moved to the base of the T (D) and touched it. The stopwatch will be stopped, and the time recorded when the athlete reached the cone at the base of the T.

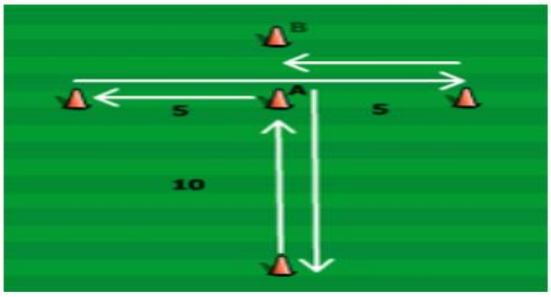

Figure 3. T-Test (Wood, 2008b)

Procedure

During the training period of the experimental group, the control group trained just specifically, meaning that they only played tennis, without performing any other physical training.

Their activity was consisting of 90 minutes of tennis, five times per week, without any other physical activity. On the other hand, the experimental group, besides the 90 minutes of tennis play, were performing the Pliospecific (this is the name proposed for this physical training, that is build out of Plyometric training and specific speed training), 3 times per week.

The subjects had an experience of at least 4 (± 1) years of play and participated for at least two years in national tournaments located in northern Portugal. The best-ranked tennis players were also participating at an international level. All participants have previously taken part in similar experiences over time, in various individual or collective sports, in which they performed activities such as jumping, running, or running with changes of direction. All participants were healthy at the start of the experiment and there were no injuries during this period. Before participating in this study, the procedures were explained to both athletes and coaches. The inclusion criteria for the athletes were to participate at a minimum 85% of the training sessions and to have an experience of minimum two years in at least national tournaments. Because of the organizational limitations, the randomization of the groups was not possible. Subjects did not perform any strength-related training programs in the last 3 weeks before starting the research. They performed just some familiarization plyometric exercises. These Portuguese tennis players were usually specifically trained for a

minimum of 12 h/ week that was concentrated on the tactical and technical parts of the tennis training. The purposed training was done additionally, after the tennis-specific training with a length between 60 and 90 minutes, 3 times per week, Monday, Wednesday, and Friday between 12:00- 13:30.

Training Program

The training program was performed 3 times per week for a total of 10 weeks. The control group was just preparing specifically, while the experimental group, was performing an extra 60 to 90 minutes with Pliospecific physical training, 3 times per week, that involved a combined training (CT) consisting in a plyometric training (PT) and specific repeated sprint training (RST). This involved PLIOSPECIFIC training with the implementation of plyometric exercises (for speed, agility, and strength) combined with specific tennis fitness training (running with repeated sprints, changes of direction, and lateral running). The number of repetitions of the plyometric training was determined according to previous studies organized with young athletes. The warm-up consisted of plyometric rope jumps, medicine ball throw, or specific tennis warm-up. The main part was consisting of the plyometric ladder exercises or box exercises (20´ to 30') and different sprint-specific exercises from the baseline (20').

Results

The data has been analyzed using SPSS 24 version.

The variables used were operationalized as follows: the type of Pliospecific program or combined training which consists of Pliometric training and specific speed training, a program covered by the experimental group. The specific tennis training was the type of program that the control group went through. The difference between the control group and the experimental one was that the latter also performed the training called Pliospecific, in addition to the specific tennis training. The subjects in the control group did not follow any other physical effort during the experiment.

The tests used to determine the variable "tennis movement performance" were the following: added steps, Spider Test, Illinois Agility test, T-test (physical test used on the field to measure agility). This was formed by subsuming them. To build this variable, the mean of the mentioned tests, was taken into consideration.

First, the equivalence was verified.

The T-student test for independent samples was used to verify the equivalence of the two groups.

Prerequisites: Check the equivalence between the two groups, control, and experiment, in terms of tennis movement performance, before using the proposed training program.

Table 1. *Descriptive statistics of the specific tennis movements before training and the results of the Independent T-Test before training*

Group experiment/control		N	Mean	Std. Deviation	Std. Error Mean
Performance of the movements in tennis before training	Experimental	25	61.84	2.89	.57
	Control	23	62.93	3.46	.72

Table 2. *Levene's Test for Equality of Variances and independent t test (before)*

		Levene's Test		T-Test for Equality of Means						
		F	p	t	df	p	Mean Difference	Std.Error Difference	%95 Confidence Interval	
									Lower	Upper
Tennis Performance before	Equal variances assumed	1.630	.208	-1.18	46	.240	-1.09249	.91850	-2.94	.75
	Equal variances not assumed			-1.18	43.054	.244	-1.09249	.92548	-2.95	.77

As it can be seen in Table 2 the condition mentioned above has been confirmed. Although the performance results of the tennis participants in the experimental group are slightly better (M = 62.93), the two groups do not differ significantly ($p > 0.05$) regarding the performance of the movements in tennis before the application of the training program. Thus, before the start of the training program, the two groups do not differ in terms of tennis movements performance.

There are positive differences between the two groups in terms of the performance of movements in tennis at the end of the intervention programme, respectively the subjects who benefited from Pliospecific training, registered after the training, significantly better results.

Table 3. *Descriptive statistics of the specific tennis movements after training and the results of the Independent T-Test after training*

Group experiment/control		N	Mean	Std. Deviation	Std. Error Mean
Performance of the movements in tennis after training	Experimental	25	59.49	2.89	.57
	Control	23	63.18	3.46	.72

Table 4. *Levene's test for equality of variances and independent t test (after)*

		Levene's Test		T-Test for Equality of Means						
		F	p	t	df	p	Mean Difference	Std.Error Difference	%95 Confidence Interval	
									Lower	Upper
Tennis Performance after	Equal variances assumed	1.150	.287	-3.80	46	.000	-3.68	.96	-5.63	-1.73
	Equal variances not assumed			-3.77	43.23	.000	-3.68	.97	-5.64	-1.71

The first hypothesis was checked using the T-student test for independent samples. The results indicated a significant difference (p = 0.000) between the two groups in the sense that the experimental group that benefited from the combined program recorded significantly better results (M = 59.49) compared to the control group (M = 63.18). The effect size index is g = 1.16 (a very strong difference between variables).

Table 5. *Comparison between the results before and after the implementation of the Pliospecific program - Descriptive statistics*

Group experiment/control		N	Mean	Std. Deviation	Std. Error Mean
Experiment	Performance of tennis movements before training	25	61.84	2.89	0.57
	Performance of tennis movements after training	25	59.49	3.09	0.61
Control	Performance of tennis movements before training	23	62.93	3.46	0.72
	Performance of tennis movements after training	23	63.18	3.61	0.75

Table 6. *Paired sample T-test results between the results before and after training, for the control and experimental group*

		Paired sample test					Paired differences		
		Mean	Std. Deviation	t	df	p	Std Error	%95 Confidence Interval	
								Lower	Upper
Experimental	Results before and after training	2.34	.92	12.62	24	.000	.18	1.96	2.72
Control	Results before and after training	0.24	.30	-3.80	22	.001	.06	-.37	-.11

The main statistical indicators were calculated for both the experimental and control group, before and after training (pre- and post- experiment). The results are shown in Tables 5 and 6. There are 25 subjects for the experimental group and 23 in the control group.

The results of the variable *Performance of tennis movements* were taken into account and the results were compared before and after the proposed training. The results indicated a significant difference (p = 0.000) between the two measurements in the sense that in the experimental group that benefited from the Pliospecific program they recorded before the training an average of results (M = 61.84) significantly higher compared to the average post-workout results (M = 59.49). The effect size index is d = 0.78 (a strong impact of the intervention programme on the performance of tennis movements).

The same trend cannot be observed in the control group which records significantly better results at the beginning of the program (M = 62.93) and they decrease (M = 63.18) after the training program.

There is (also) a significant correlation between the results of the Illinois Agility test and the national ranking, in the case of the investigated junior tennis players.

The results were taken into account for the total sample, after intervention. Verification of the second hypothesis was performed using the Pearson correlation, after which the following significant values could be observed (p = 0.001): average positive correlation (r = 0.451) between the results of the Illinois test and the place in the national ranking, in the sense that the higher the test results, the higher the place in the ranking. This means that there is a positive significant association between the results; the statistical analysis of the results shows that high performance (high place in the ranking) is linked with very good results for the agility test.

Table 7. *Correlations between ranking and Illinois Agility test after training*

Correlations

		Ranking 14-16 years	Illynoise Agility Test after Trainning
Ranking 14-16 years	Pearson Correlation	1	.451**
	p		.001
	N	48	48
Illynoise Agility Test after Trainning	Pearson Correlation	.451**	1
	p	.001	
	N	48	48

**. Correlation is sig. at 0.01 level (2-tailed)

The effect size index is r^2 = 20, emphasizing a moderate to weak relation between variables.

Discussion

This study compares the efficiency of a combined physical fitness program to just tennis training sessions, on the fitness qualities of the U16 Tennis players. One of the studies has shown that after a combined tennis training with explosive strength, of young U16 tennis

players, the linear sprint and the jumping ability have been improved (Fernandez-Fernandez et al., 2014). Also, other studies on different sports such as football (Christou et al., 2006), or handball (Cherif et al., 2012), that were done following a single training program (for example repeated sprint training alone) have shown growth in neuromuscular performance.

No researchers analyzed the effects of the combination of these two programs for U16 Portuguese players, and they're effect on the performance of the movements in tennis. If this training is followed there is a big chance for improvements. This program is also based on velocity, agility and strength. A recent study, where U16 female athletes were involved, show, a correlation between the maturation and tennis performance in U16 girls, with R square of 13% (Kramer et al., 2017).

As shown in previous studies (Fernandez-Fernandez et al., 2015) tennis training alone cannot generate significant improvements in physical fitness.

Speed in tennis involves the ability to move as quick and easy as possible in different directions during play, having the initial acceleration as a key to performance because most of the tennis movements are not longer than maximum 3-4 m so there is actually no opportunity to reach the maximum speed (Murphy et al., 2014). As already mentioned in the last years, more studies (Fischietti et al., 2018) have been concentrated on the development of speed performance in young athletes using different types of training methods, and it was pointed out that plyometric training is useful regarding methods of speed improvements.

Conclusion

Following the research, the following conclusions could be drawn. Although the performance results of the tennis participants in the experimental group are slightly better, the two groups do not differ significantly in terms of the performance of movements in tennis before the application of the training program. Thus, before the start of the training program, the two groups were equivalent in terms of the performance of tennis movements, and so they can be compared.

The use of a combined program called Pliospecific, consisting of a plyometric training (AP) and a tennis-specific training (Pliospecific or combined training) improve the performance of tennis movements. We conclude that this type of training program is very important in achieving performance.

After comparing the two groups after training, regarding the performance of the movements in tennis, the experiment group recorded significantly better results compared to the control group.

Following the correlation between the Illinois Agility Test and the national ranking, in terms of total sample results (after training), it was concluded that there is a positive significant association between these results. The statistical analysis show that high performance is linked with great results for the agility test.

After using the proposed program, called Pliospecific, consisting of Pliometric training and tennis-specific training, it was concluded that the performance of movements in tennis has been improved. There was a significant difference between the two measurements meaning that in the experimental group that benefited from the PLIOSPECIFIC program, athletes recorded a significantly higher average of results (meaning a weaker performance)

before training, compared to the average of post-training results. The same trend cannot be observed in the control group which had significantly better results at the beginning of the program. In conclusion, the control group (in the case of the current study) did not progress after the completion of the experiment.

Authors' Contributions

All authors have contributed equally to this study and should be considered as main authors.

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