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ORIGINAL

EFFECT OF PLYOMETRIC TRAINING ON SPRINT PERFORMANCE

EVALUACIÓN DEL EFECTO DEL ENTRENAMIENTO PLIOMÉTRICO EN LA VELOCIDAD

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ABSTRACT

The purpose of the study was to research the effect of plyometric training on the speed of students of the Faculty of Sciences of Physical Activity and Sport, University of León, in a training period of 4 weeks, with two sessions per week in a sample of 18 subjects (23 ± 1 year), divided into two groups, Training Group, composed of 13 subjects and the Control Group, consisting of 5 subjects.

The results analyzed in a speed test of 30m sprint revealed significant differences in the Training Group after the training sessions, increasing the speed from 0-10m. and 0-30m. ($p < 0.05$). Regarding acceleration, significant changes were also obtained, with an improvement of 0-10m. ($p < 0.05$).

These results demonstrate that plyometric training can increase the speed from 0-10m. and 0-30m., reducing the time to travel that distance.

KEY WORDS: Plyometrics, Training, Speed, Muscular Strength, Muscular Power.

RESUMEN

El propósito del estudio fue investigar el efecto del entrenamiento pliométrico en la velocidad en estudiantes de la Facultad de Ciencias de la Actividad Física y del Deporte de la Universidad de León, en un periodo de entrenamiento de 4 semanas, con dos sesiones semanales, en una muestra formada por 18 sujetos (23 ± 1 año), divididos en dos grupos, el Grupo de Entrenamiento, compuesto por 13 sujetos y el Grupo Control, formado por 5 sujetos.

Los resultados analizados en un Test de velocidad de 30m. lisos revelaron diferencias significativas en el Grupo Entrenamiento después de las sesiones de entrenamiento, aumentando la velocidad de 0-10m. y de 0-30m. ($p<0,05$). En cuanto a la aceleración también se obtuvieron cambios significativos, con una mejora de 0-10m. ($p<0,05$).

Estos resultados demuestran que el entrenamiento pliométrico puede aumentar la velocidad de 0-10m. y de 0-30m., reduciendo el tiempo en recorrer dicha distancia.

PALABRAS CLAVE: Pliometría, Entrenamiento, Velocidad, Fuerza muscular, Potencia muscular.

INTRODUCTION

From a sports point of view, speed represents the ability of an individual to perform motor actions in minimum time and with maximum efficiency (Martín Acero, 2006), so its development and training is essential, since in most of the sport-physical activities, actions related with speed are needed.

In much of the literature on velocity you can see how they support the theory that the rate appears to have a strong hereditary or innate component, not to mention having other factors to be improved with training, and more with strength training, as speed itself is the rapid application of force. López, M., (1995) identifies four factors of speed: hereditary, sensory, cognitive, neural factors and muscle tendons. This idea can be completed with the contribution of different authors who dare say that speed has two main components, the nerves, which are mostly hereditary and are responsible for transmission of nerve impulses and muscular, which depend on the speed of its contractions. (Adams, K.; O'Shea, J. P.; O'Shea, K. L. and Climstein, M. 1992)

In speed training, the development of certain factors such as specific strength, technique and speed are crucial for the obtainment of performance. (Baughman et al. 1984; Hay 1994; Majdell 1991).

From the literature, we can summarize the methods and means necessary for speed training and specific force in:

a) Development of speed:

- Progressive Training. “Ins and outs”.
- Assisted Training.

b) Development of specific strength:

- Autoloads.
- Muscle training.
- Weathered training.
- Plyometrics (SJ, CMJ, DJ).
- Multijumps.

c) Development of the technique:

- Race technique (Amplitude and frequency of stride)
- Photogrammetry.

Methods and means necessary for the development of specific speed and strength. (From, Donati 1996; Heisler et al 1989;. Korchemny and Hoskisson 1993; Mero et al 1992.). In recent years, Plyometry has been introduced as a method for improving the strength and speed.

Professor Rodolfo Margaria, during the 60s, was the first to speak of the importance of the so-called stretch-shortening cycle based on plyometric training (SSC), demonstrating that a concentric contraction preceded by an eccentric one could generate higher levels of force than an isolated concentric contraction (Faccioni, 2001). Furthermore, Yuri Verkhoshansky (1973), considered to be the father of plyometrics applied to sport for many people, became interested in finding the best way to leverage the elastic energy stored in a muscle after stretching, observed by the author that the best results in triple jump athletes corresponded with less time in those who remained in contact with the ground at each of the supports. Because of this, no time to use each support is necessary to have a large eccentric strength in the muscles involved, as it will quickly switch from eccentric to concentric contraction, and thus speed up the body again in the required direction (Faccioni, 2001).

The speed in muscular contraction will have a very important role in this type of training, achieving an increase in strength, and particularly the explosive force. One can say that speed and strength are two qualities that are directly related to a large amount of movement and sports activities, in this regard Vittori (1990) found that the rate would be a "derived capacity" of the force, whereas the force

as "pure quality" is what determines the speed gained by the bodies when in movement.
The following basic considerations for this type of training are listed. To do this we will focus on Alain Piron (quoted by Cometti, 1997), which sets out three principles in plyometric training:

a) The position (relative to the degree of bending of the involved joint).

b) The movement of the levers.

c) The nature of muscular tensions.

To get variety in training it is necessary to modify one of these three principles (Cometti, 1997).

Regarding progression in plyometric training exercises, Verkhoshansky (1966) proposes three stages:

a) Perform general strength exercises and varied multi-hop exercises.

b) Plyometric work combined with strength resistance training.

c) Drop – Jump training.

Regarding the frequency of training there is no consensus, as authors like Poole and Maneval (1987) proposed two weeks of training and others like Diallo et all (2001) propose three week sessions, but always taking into account the level of preparation and strength of the athlete, and never working two consecutive plyometrics sessions.

For all this it is important to pay close attention to the technical execution of the exercises, since even small technical deviations can cause serious injury. Because of this, we should only be too careful about the type of footwear and the ground on which it is performed to avoid injury and increase safety, remembering to perform an adequate warm-up.

Once the theoretical and practical approach to the object of study has been made, and to finish off this section, I will say that the objective proposed in this study focuses on assessing the effect of plyometric training organized in 8 sessions during 4 weeks on the ability to yield velocity and acceleration in students with a sedentary life, following the procedure proposed by Kotzamanidis C. (2003) in a 30m walking distance., and under specific conditions described in the following sections.

MATERIAL AND METHOD

Sample

A total sample of 18 students took part (23 ± 1 year), students of the Faculty of Physical Activity and Sports, University of León, divided into two groups, Training Group (hereafter TG), composed of 13 students, who conducted 8 sessions of plyometric training and the control group (hereafter CG) consisting of 5 students, and did not perform any training. Everyone took part for the study on a voluntary basis, and were informed at all times of the experimental method to follow.

Because all students show a sedentary life, and none of them have previous experience in the training of speed and / or plyometrics, the selection of the sample to form two groups was performed randomly.

Procedure

The procedure followed was similar to that used by Kotzmanidis C. (2003).

First thing was the evaluation of the velocity in students performing at two training sessions in the same week, 9 subjects each day, and in the same order that they presented themselves they underwent an evaluation test performed after speed explanation and demonstration. All tests were conducted in a closed room sports area of the faculty itself with a stable temperature.

The assessment consists of a test speed in a 30 m sprint. with a rolling start ten meters before where the first barrier of photocells is placed, and a second barrier positioned at 30m, taking as values for the race the times at 10 and 30 m. (Kotzamanidis, C. 2003).

All students performed a standard warm-up of continuous race of 10 minutes followed by 5 sub-maximal runs and 10 jumps. Afterwards they had to perform two runs of 30 m. (choosing the best record in the two for further analysis), with an active rest of 3 minutes between the two runs (walking through the pavilion), being the participants at all times encouraged to run as quickly as possible. (Kotzamanidis, C., 2003).

In the test the following variables have been estimated:. Acceleration from 0-10m, 0-10m speed, speed of 10-30m. and speed of 0-30m.

As instruments for measure two pairs of DSD Laser System photoelectric cells and SportSpeed 2.2 software were used.

The training period lasted for 4 weeks, with two sessions per week, making a total of 8 sessions.

These sessions are based on Diallo O. et all (2001) but have had to be adapted to the sample, because the load included by this author in the training was minimal for the students, eventually establishing training sessions with 10 minutes of continuous running as a warm up without actually ever exceeding the 140-150ppm. In the main part of the session they made various racing series with vertical and horizontal dodging 10 obstacles placed at a certain height with each obstacle separate from the next by 1m., and an active rest of 2 minutes between each series (walking through the pavilion).

- Obstacle Height Progression: Session 1, 2 and 3. Height of 30 cm, Session 4.5 and 6 Height of 50 cm, Session 7 and 8: height of 70cm.

- Progression in number of series: Session 1 and 2: 6 series, Session 3 and 4: 8 series, Session 5, 6,7 and 8: 10 series.

After the training period a sprint test of 30m. is repeated to observe the differences after the training period, in terms of acceleration from 0-10mm, rate of 0-10mm. speed at 10-30m. and speed from 0-30m.

STATISTICAL ANALYSIS

Results are presented as mean and standard deviation. Analysis and statistical processing of the results was carried out through the computer program for Windows, SPSS 17 (Statistical Package for the Social Sciences 17). The study of the differences before and after the intra-and inter-group training were carried out through nonparametric tests due to the sample size. The pre-post comparison was performed using the Wilcoxon test, and differences between groups using the Mann-Whitney test. Establishing a significance level of $p < 0.05$.

RESULTS

For a better understanding of these results, they have been organized into three groups: Inter-group difference, differences in TG and differences in the CG.

Inter-group differences after the training period

The test results of 30 m. sprint from the students of the Faculty of Physical Activity and Sports, University of León, which are outlined in the following tables show no significant differences ($p > 0.05$) between groups (CG and TG) after 8 sessions. No significant differences were observed, but the two groups improve the test that is performed after the period of 4 weeks of training.

Despite finding no significant difference, the TG achieves better results in 0-10, 10-30 and 0-30 meters, getting the biggest differences in the first 10 m. with respect to the Pre-Test and the CG, with an average of 2.2706 seconds and a standard deviation of the mean of 0.12405 seconds, reaching a speed of 4.60 m

/ s on average in the second test. In the CG it shows that in the range of 10-30m. the time worsens 0.042 seconds over the first test, also causing the speed to slow on this stretch at 0.116 m / s relative to the mean.

In the three tables displayed below, the different results are shown (time in seconds) of CG and TG at different distances before and after the training period.

Tº 10-30	Group	Number	Mean	Standar Desv.
Pre-Test	G.E	13	2,502	,093
	G.C	5	2,498	,088
	Total	18	2,501	,089
Post-Test	G.E	13	2,446	,126
	G.C	5	2,540	,156
	Total	18	2,472	,137

Table 1. Results (seconds) of both groups in the distance of 0-10m. (Mean and Standard Deviation).

Tº 0-10m	Group	Number	Mean	Standard Desv.
Pre-Test	G.E	13	2,271	,124
	G.C	5	2,333	,064
	Total	18	2,288	,112
Post-Test	G.E	13	2,179	,151
	G.C	5	2,284	,112
	Total	18	2,208	,146

Table 2. Results (seconds) of both groups in the distance of 10-30m. (Mean and Standard Deviation).

Tº 0-30m	Group	Number	Mean	Standard Desv.
Pre- Test	G.E	13	4,772	,167
	G.C	5	4,831	,088
	Total	18	4,789	,149
Post-Test	G.E	13	4,624	,217
	G.C	5	4,824	,260
	Total	18	4,680	,240

Table 3. Results (seconds) of both groups in the distance of 0-30m. (Mean and Standard Deviation).

Training Group differences after the training period

	Test	Mean	Standard Dev.
Speed 0-10m	Pre-Test	4,416	,246
	Post-Tet	4,609*	,311
Speed 10-30m	Pre-Test	8,005	,293
	Post-Test	8,198*	,418
Speed 0-30m	Pre-Tes	6,293	,220
	Post-Test	6,500*	,294
Clarificati on 0-10m	Pre-Test	1,956	,221
	Post-test	2,134*	,283

Table 4. Results of speed (m / s) and acceleration (m/s2) in the TG. before and after the training period. Results of 0-10m., 10-30m. and 0-30m. (Average, Standard Deviation). * Statistically significant (p <0.05).

As shown in Table 4., The speed results before and after the training period showed significant differences (p <0.05) at distances of 0-10 m. 10-30 m. and 0-30 m., improving the results compared to the first test.

The biggest difference is in the range of 0-30 m., This being significant (p <0.05), as students arrived at this distance with an average of 4.6245 seconds, improving on average 0,15 seconds compared to the first test, therefore increasing the speed by 0.02 m/s.

In the distance of 0-10m. a second difference is found, also significant with an improvement in 0.0918 seconds on the average (Average post-workout 2.1788 seconds, with standard deviation of 0.12405). At this distance, there is another significant difference in acceleration (p <0.05), as they end up covering this distance with an average acceleration of 1.9521 m/s2, increasing acceleration over the first test on 0.1774 m/s2.

As for the distance of 10-30 m., The difference between both tests is significant ($p < 0.05$), but it is the one in which less difference can be seen, improving 0.05562 seconds on the average of the first Test (2.50162 seconds). In this range, an increase in the speed of 0.1366 m / s relative to the mean of the test (8,005 m / s) is the main difference compared with the first test.

Differences in the Control Group after the period of 4 weeks

	Test	Mean	Standard Dev.
Speed 0-10m	Pre-Test	4,289	,118
	Post-Tet	4,386	,209
Speed 10-30m	Pre-Test	8,014	,286
	Post-Test	7,898	,466
Speed 0-30	Pre-Tes	6,212	,115
	Post-Test	6,233	,322
Acceleration 0-10	Pre-Test	1,841	,102
	Post-Test	1,927	,182

Table 5. Speed results in the CG. before and after the period of 4 weeks. Results of 0-10m., 10-30m. and 0-30m. (Average, Standard Deviation). * Statistically significant ($p < 0.05$).

With the results obtained in the CG after 4 weeks, no significant differences were observed in the time variable nor in speed as $p > 0.05$ at distances of 0-10, 10-30 and 0-30 meters. As well as not finding any significant differences, it can be seen how records even worsen, both in time and in the speed of 10-30 m., reaching 0.042 seconds increase in the result compared to the average obtained in the first Test (4,831 seconds), making the speed in this stretch decrease by 0.1163 m/s relative to the mean of the Test (8,014 m/s).

Regarding the results obtained from 0-10m., an improvement occurs without being significant, reducing the average time of the first Test (2.284 seconds) in 0.048 seconds, so you can say that the speed increased 0.097 m/s relative to the mean of the first Test (4.28 m/s).

Just like an improvement in the time and speed in 0-10 m occurs, acceleration for this section is observed to vary without it being significant, increasing the speed in 0.0086 m/s2, after getting an average after the period of 4 weeks of 1,927 m/s2.

DISCUSSION

To evaluate the changes induced by the plyometric training in speed the program followed by Kotzamanidis. C. (2003) was chosen, with the 30m. sprint test.

The results obtained before and after the training period in the 30m sprint test indicate that significant improvements in the TG exists after the period of 4 weeks, which may be due to the effect of increasing the plyometric Explosive Strength and Potency of the students, agreeing with the study by Kotzamanidis C. (2003). With this data we can suggest that 8 training sessions can get benefits, which can be observed in investigations of other authors such as Fletcher et all (2004), which use the same periodization training with 8 sessions divided in 4 weeks, getting benefits in Explosive Strength and Potency of the lower body, thus improving acceleration and speed because of this type of training. Furthermore, it is observed in various literature studies that have a similar duration than this study that they also get improvements in speed as in the case of H. Makaruk et all (2010) with a training period of six weeks, or Rimmer and Sleivent (2000) with 7 weeks of training, in which both managed to improve maximum strength and power with the consequent increase in speed.

In the TG increased speed is produced on the total distance of 30m., which is mainly due to increased speed and acceleration in the distance of 0-10m., where you can find the biggest differences being significant in this group, which is mainly as we have mentioned above due to an increase in explosive strength and power, and that the increase in these skills results in an improvement mainly in the first meters of the race, agreeing with several studies, such as Saez Saez (2008), which used a technique of plyometric jumps similar to that used in this study, with vertical jumps and horizontal scroll, concluding this author that this type of training improves the ability to sprint.

In the range of 10-30m significant improvements coinciding with Kotzmanidis C. (2003) are also found, arguing that it has been improved by the summation of increased Explosive Strength and Stretch - Shortening Cycle (SSC) of the lower body muscle groups, in addition to an improvement in maximum strength. In the same vein, we find the study by Delecluse (1997), with the same method in untrained adults, and being contrasted by Rimer and Sleiveter (2000) on trained populations, where the speed is increased by this method in distances of 10-30m., based on the assumption that plyometric training reduces the stance phase of the stride so it eventually increases speed. These views can be reinforced with the results obtained in this study, as significant changes were found in the TG, which did not happen in the CG., in which a significant increase of speed did not occur, but this decreases even in the final 20m. contributing to those previously argued about speed improving with this type of training.

On the other hand the improvement in initial acceleration (0-10m.) in the CG. may be due to students already knowing the test as it was the second time they performed the test, resulting in a learned test, noting improvements in Simple Reaction Time relative to the output signal. For this we have to pay attention when evaluating the initial speed and acceleration in the Test, as a learning process occurs.

Although this procedure was only used in plyometric training, in the literature it is observed how different authors combine plyometrics with other types of training, such as is the case with Ratamess et all (2007), combining plyometric and resistance training during 10 weeks, achieving significant improvements on speed tests of 60m., mainly because this type of training provides the neuromuscular system in the transition from muscle eccentric contraction to concentric, known as Stretch - Shortening Cycle (SSC), a factor to take into account in the improvements in speed of the subjects in this research, so the time to travel the distance of 30m. is lower after the training period. Another case is Benito E. (2010) that combines plyometrics with electro stimulation, achieving a significant improvement in strength and lower body power, reaching the conclusion that it is more efficient to use electro stimulation before plyometric training, so based on this study, you could have gotten a larger increase in speed if we had added the electro stimulation.

Fletcher I. (2004) combined plyometric training with strength training for 8 weeks with a lower total volume, and still managed that subjects similar to that of this study age, increase their upper body acceleration, speed and strength in the teeing of golfers. So this type of training could be used not only with the lower body but also with the upper body and thus achieve higher performance depending on the sport.

Regarding the total volume of jumps used in this protocol, many studies use a larger volume, both in the training session and total volume of the training period, as is the case of Saez Saez (2008) with a volume of over 2000 jumps in 7 weeks of training, which also resulted in a significant improvement in the ability to sprint.

Regarding the frequency of training and total volume of jumps, we must pay great attention in Reyment et all (2007) who found no significant improvements in a 40 yard Test (36.5 m.) After the training period, which may be due to a low frequency training or racing at the same volume or even the training period had not been adequate. Markovic G. (2007) advocates the importance that a technical description of plyometric training has and is sometimes absent, as in this training period we must pay it the attention it deserves, explaining and describing in a clear and detailed protocol to continue dedicating in this study in the first and second day, exercises to become familiar with it and tests to be performed, not only to achieve maximum performance, but also to minimize the risk of injury, as many of these exercises are very specific, and depending on the characteristics of the sample they must be taken into account before starting to execute them (Fletchert I. 2004).

Continuing with the importance of Frequency and Volume of Jumps, in the study of Kotzamanidis C. (2003) the improved results of 0-10 m. are not in accordance with those obtained in this investigation, because in the corresponding study, they dont find significant difference of 0-10m., which may be due to the load and intensity of training, as there was an increase over the study conducted by the author, with a greater number of jumps per session, with the obstacles being higher.

After reviewing literature this protocol had to be modified, because after the first training session that requires 60 jumps over 15 cm., subjects, when asked and taking into account their feelings about the effort made, were satisfied with an increase in the load and intensity of training, because after training they showed no signs of fatigue and their feelings were not those of having performed a training session, so both the load and the intensity was increased for subsequent sessions. But besides all this, the results obtained by this author may be due to the performance capability of the sample as it depends on numerous factors such as age, level of training or lifestyle, having said study a larger sample in age, with a higher level of training and motor experiences, which influenced in the energy deficit and the ability to get potency.

Although the test used was 30m sprint., other authors used a Test with a greater distance, as is the case with Ratamess et all (2007) as he used a 60m sprint Test., so it can be said that this type of training also improves speed at distance, but in most of the studies reviewed it can be seen that it is in the first half of the race where the main improvements are found, as in this research.

In various other types of Test research, based primarily on jump tests, as in the case of T. Boraczynski (2008) with a Test of CMJ, to assess the effect of plyometric training on jumping getting similar results than in this study increasing the Explosive Strength and Speed Strength of subjects, these being of similar age than in this study, subjects also improve Explosive Strength and Speed Strength.

Besides improving Explosive Strength and Power, even though in this study it has not been assessed, different studies show that this type of exercise improves the dynamic balance of the subjects, as seen in the study by H. Arazi (2011) for 8 weeks of training, in adolescents, performing ground plyometrics and aquatic plyometric exercises, so it is a form of plyometrics to consider, as it is less harmful. In this study, the author found no significant difference between the two groups, getting both to improve significantly after the training period. Robinson et all (2004) follows the line of this study comparing plyometric training on ground and in water coming to similar conclusions, given that both types of exercises are valid, and produce an improvement in the Strength.

CONCLUSIONS

The results suggest that the plyometric training used in this study on students with a sedentary life, with a duration of 8 sessions organized in 4 weeks, can have positive effects, increasing the performance capability of the speed and acceleration in a distance of 30 meters, focusing on improving the Maximum Strength, Explosive Strength, Power and the stretch-shortening cycle of the muscle. These results also suggest the potential confirmation of the protocol followed by Kotzamanidis C. (2003) which was used in this study. Finally, we wish to point out that to verify both protocols of training, it should be verified in future studies with a larger sample size.

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