

Effect of plyometric training on sprint and change of direction speed in young basketball athletes

PEDRO PINHEIRO PAES¹, GUSTAVO AUGUSTO FERNANDES CORREIA², VINICIUS DE OLIVEIRA DAMASCENO³, EDUARDO VICTOR RAMALHO LUCENA⁴, IANA GUIMARÃES ALEXANDRE⁵, LAÍS RAMOS DA SILVA⁶, WLALDEMIR ROBERTO DOS SANTOS⁷, CARLOS GILBERTO DE FREITAS JÚNIOR⁸

^{1,2,3,4,5} Postgraduate Program in Physical Education, Federal University of Pernambuco, PE, BRAZIL.

^{1,2,3,4,5,6} Physical Education Department, Federal University of Pernambuco, PE, BRAZIL.

⁷ Physical Education Department, State University of Paraíba, PB, Brazil.

⁸ Postgraduate Program in Physical Education, Federal University of Paraíba, PB, BRAZIL

Published online: February 28, 2022

(Accepted for publication February 15, 2022)

DOI:10.7752/jpes.2022.02039

Abstract

This study approached the effect of six-week plyometric training (PT) on sprint and change-of-direction ability. Thirty-six young basketball athletes were randomly assigned to a male experimental group (MEG, n= 6, 15.83 ± 0.75 years, height = 1.83 ± 0.07 m, body mass = 70.78 ± 11.83 kg) or a male control group (MCG, n= 7, 15.43 ± 1.13 years, height = 1.74 ± 0.13 m, body mass = 72.94 ± 24.13 kg) and female experimental group (FEG, n= 11, 14.45 ± 0.69 years, height = 1.60 ± 0.07 m, body mass = 53.72 ± 9.01 kg) or female control group (FCG, n= 10, 15.30 ± 1.16 years, height = 1.63 ± 0.08 m, body mass = 59.98 ± 16.74 kg). The Illinois agility test (IAT) and the 20 m sprint (Sp20m) were used to evaluate the change-of-direction ability and the sprint, respectively. Repeated measurements ANOVA and effect size (ES) showed that in Sp20m, both MEG and MCG showed significant improvements, with greater effects on MEG (ES= 1.07) compared to MCG (ES= 0.29). Among females, both groups showed significant improvements in Sp20m, with greater effects in EG (ES= 0.96) compared to CG (ES = 0.29). In the IAT, the MEG (ES= 0.82) and the MCG (ES= 0.28) showed significant improvements. For females, the EG showed greater effects (ES= 0.55) compared to the CG (ES= 0.18), although there were no significant improvements. Therefore, the EG showed positive and greater effects compared to the CG. This way, it is recommended to apply PT to improve these physical capacities in young basketball athletes.

Keywords: Athletic performance; Adolescent; Exercise; Sports; Physical Fitness.

Introduction

Basketball is a collective sport in an intermittent context that requires high-intensity actions to perform technical gestures specific to the sport (Delextrat, Badiella, Saavedra, Matthew, Schelling, & Torres-Ronda, 2015; Stojanović, Stojiljković, Scanlan, Dalbo, Berkemans, & Milanović, 2018). The efficiency of these technical gestures depends on several factors, including the level of physical conditioning, allowing athletes to support more physical demands (Scanlan, Fox, Borges, Tucker, & Dalbo, 2018).

The sprint stands out for directly influencing sports performance. It is performed between 55 and 124 times during a basketball game, and is present in the most decisive moments, including dribbling, defensive recovery, offensive and defensive transition (Abdelkrim, Fazaa, & El Ati, 2007; Marins & Giannichi, 2003; Scanlan, Dascombe, Kidcaff, Peucker, & Dalbo, 2015). The change-of-direction ability involves physical aspects, including acceleration or deceleration movements, from a previously planned stimulus, being very common to perform them during a match, especially after dribbling and during finishing by lay-up (Sheppard & Young, 2006).

Training methods have been investigated, aiming to enhance the physical conditioning of athletes, and plyometric training (PT) is one of the most used (Chaabene, Negra, Moran, Prieske, Sammoud, Ramirez-Campillo, & Granacher, 2019; Correia, Freitas-Júnior, Lira, Oliveira, Santos, Silva, & Paes, 2020; Idrizovic, Gjinovci, Sekulic, Uljevic, João, Spasic, & Sattler, 2018). The PT consists of performing muscle actions that involve the stretching-shortening cycle, a physiological mechanism that takes advantage of the elastic energy produced during the change from the eccentric to the concentric phase, increasing motor strength (Kazem, Reza, Mohsen, & Alireza, 2016; Markovic & Mikulic, 2010). Among the benefits of its use are the ease of application and its low economic cost, which can be used in the most diverse environments (Oxfeldt, Overgaard, Hvid, & Dalgas, 2019).

Specifically involving adult athletes, several studies have shown a positive effect of PT on the speed of change of direction (Cherni, Jlid, Mehrez, Shephard, Paillard, Chelly, & Hermassi, 2019; Asadi, 2013). In the same direction, other studies point to positive effects of PT on the sprint (Ramírez-Campillo, Álvarez,

Henríquez-Olguín, Baez, Martínez, Andrade, & Izquierdo, 2014; Kazem, Reza, Mohsen, & Alireza, 2016; Ramírez-Campillo, Vergara-Pedrerros, Henríquez-Olguín, Martínez-Salazar, Álvarez, Nakamura, De La Fuente, Caniuqueo, Alonso-Martínez, & Izquierdo, 2016).

In young athletes, the results are scarce and diverge. Thomas, French, and Háyes (2009) investigated the effect of two six-week PT techniques on young soccer athletes. The athletes were divided into two groups: depth jump and countermovement jump (CMJ). The results showed that both groups did not reveal significant differences in the sprint performance of 5, 10, 20, and 30 m. In contrast, Hammami, Negra, Aouadi, Shephard, and Chelly (2016) showed increases in the sprint of 5, 10, and 20 m in young soccer athletes after eight weeks of applying the PT. Other investigations also showed positive effects on the sprint after using the PT (Chaabene, Negra, Moran, Prieske, Sammoud, Ramírez-Campillo, & Granacher, 2019; Hammami, Gaamouri, Suzuki, Shephard, and Chelly, 2020). Regarding the speed on change of direction, the study by Gottlieb, Eliakim, Shalom, Dello-Lacono, and Meckel (2014) pointed out that there were no significant improvements after the application of the six-week PT in young basketball athletes. In addition, this study did not show significant improvements in the sprint time of 20 m (Sp20m). In disagreement with the study mentioned above, recently, Bouguezzi, Chaabene, Negra, Ramírez-Campillo, Jlalía, Mkaouer, and Hachana (2020) investigated the effect of eight weeks of PT on young soccer players, and the results showed a positive impact on speed of change of direction.

Given these divergences, this study aimed to verify the effect of PT for six weeks on sprint performance and the speed of change of direction in young basketball athletes. The hypothesis is that the PT contributes to the improvement, both in the sprint and in the change-of-direction ability in young basketball athletes.

Materials and Methods

Participants

Participated in the study 16 male and 23 female athletes, which were analyzed separately. The selection of participants was intentional and not probabilistic. They were randomly divided into two groups, the control (CG) and the experimental (EG). In the male group, the experimental group (MEG) consisted of six athletes (age = 15.83 ± 0.75 years, height = 1.83 ± 0.07 m, body mass = 70.78 ± 11.83 kg). The control group (MCG) was composed of seven athletes (age = 15.43 ± 1.13 years, height = 1.74 ± 0.13 m, body mass = 72.94 ± 24.13 kg). In females, 11 athletes were part of the experimental group (FEG) (age = 14.45 ± 0.69 years, height = 1.60 ± 0.07 m, body mass = 53.72 ± 9.01 kg). The control (FCG), 10 athletes were the members (age = 15.30 ± 1.16 years, height = 1.63 ± 0.08 m, body mass = 59.98 ± 16.74 kg). Athletes linked to the National confederation of basketball were included, who had at least one year of experience with physical training and did not have muscle injuries that would prevent them from participating in activities to the maximum of their efforts. Athletes who did not attend 75% of the training sessions and presented injuries during the study application period were excluded. The athletes were informed about the risks and benefits and signed the Informed Consent Form. The Ethics Committee on Human Research approved the study at the Federal University of Pernambuco - CEP under the opinion number: 2385105.

Procedures and instruments

Study design

An experimental study was developed during the team's pre-training season, lasting eight weeks. In the first week, anthropometric and physical tests were performed. From week two through week seven, PT and the regular basketball routine for the EG and only the regular basketball routines for the CG were applied. In the last week, physical reassessments were performed (Figure 1). The physical tests administered were: the Sp20m test and The Illinois Agility Test (IAT). PT and basketball training were performed on non-consecutive days, twice a week (Monday and Wednesday) and three times a week (Monday, Wednesday, and Friday), respectively. All athletes were instructed not to do any training other than that carried out in the study. Before the evaluation period, the athletes were familiarized with the testing protocols, and during each PT session, the technical committee guided and supervised the performance of all jumps.

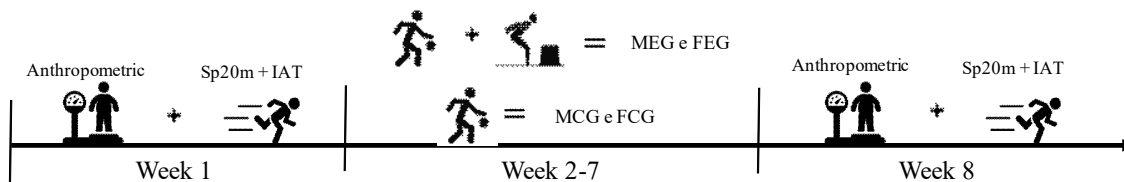


Figure 1. Study design.

Note: Sp20m = 20 m sprint test; IAT = Illinois agility test; MEG = male experimental group; MCG = male control group; FEG = female experimental group; FCG = female control group.

20 m sprint test (Sp20m)

This test was used to evaluate the sprint and consists of running a 20 m run as quickly as possible. Each athlete had three attempts, and the time was analyzed using a manual stopwatch that recorded the course times. The best time for each athlete was chosen for analysis. The athletes had a five-minute break during the sprints (Loturco, Pereira, Kobal, Zanetti, Kitamura, Abad, & Nakamura, 2015). The test was performed on an indoor basketball court, and all athletes were familiar with it.

The Illinois Agility Test (IAT)

The IAT was used to assess the athletes' speed on change of direction. The test started after the evaluator's voice command. Athletes had to move immediately in a linear direction to the first cone 10 m from the start. After reaching the second cone, the athletes had to go around it and move to the center, where they found four cones separated by a distance of 3.3 m and had to go around them. Then, they had to move to the cone in the right corner, go around it until they reached the last cone at a distance of 10 m (Roozen, 2004). The athletes were familiar with the test avoiding the learning effect, and the best attempt among the three was used for analysis. Between the attempts, the athletes rested for about five minutes (Asadi, 2013).

Training program

Details of the PT are shown in (Table 1). It started from the warm-up, including running and dynamic stretches, totaling approximately 10 minutes. PT sessions took place before basketball training, lasting between 30 and 60 minutes. The volume of the PT was quantified from the number of jumps each week. An increase in the number of jumps was observed to promote adaptations by increasing the training volume. The rests between the jumps were: 30 seconds and the series: 120 seconds. However, there was no rest between the jumps in the serial forward hops, privileging your speed. All athletes were instructed to perform the jumps, just as they were instructed to perform with maximum effort. All jumps were performed under the same conditions of environment, time, and ground. Basketball training consisted of small-sided games and tactical systems (offensive and defensive), lasting 90 minutes per session. The team's technical committee prescribed both training sessions.

Table 1. PT Program

Exercise	W1	W2	W3	W4	W5	W6
CMJ	2x10	1x10	1x15	1x10		2x10
Side Jump	2x10	1x10	1x15		1x10	
Horizontal Jump	1x10	2x10	2x10	2x10	2x10	2x10
High Knee Jump		4x5		2x10	2x10	
Split Squat Jump			4x5			2x10
Serial Forward Hops				6x5		
Single Leg Vertical Jump					4x5	4x5
Single Leg Lateral Hops					4x5	4x5

W: week; PT: plyometric training; CMJ: countermovement jump.

Statistical analysis

Data are presented with means and standard deviations. The normality of the data was confirmed using the Shapiro-Wilk test. The repeated measures ANOVA test was used to compare the results of the pre- and post-intervention tests. The percentage difference ($\Delta\%$) was measured using the following equation: $[(\text{post-intervention} - \text{pre-intervention}) \times 100 / \text{pre-intervention}]$. In addition, the effect sizes (ES) of the analyzed variables were calculated based on the D'Cohen. ES with values of ≥ 0.2 , 0.2-0.5, 0.5-0.8, and ≥ 0.8 were considered to represent trivial, low, moderate, and wide effects, respectively (Cohen, 1988). Significance was set at 5%. All statistical analyzes were performed using the SPSS statistical package (version 21.0, Chicago, IL, USA).

Results

Table 2 shows the mean and standard deviation results per group in the IAT and Sp20m tests. It was observed that, in males, both groups, MCG and MEG, showed improvements comparing the results of the pre-versus post-training tests, both for Sp20m ($F(2.14) = 11.38$; $p = 0.006$), and for the IAT ($F(2.14) = 15.33$; $p = 0.002$). In females, both the FEG and FCG improve in Sp20m ($F(2.22) = 8.68$; $p = 0.008$). In the IAT, none of the female groups showed improvements ($F(2.22) = 3.25$; $p = 0.86$). In the sprint, the analysis of $\Delta\%$ showed values of (-4.15%) and (-7.16%) for MEG and FEG, respectively. In the MCG and FCG, the values for the sprint were (-1.94%) and (-3.02%). The IAT presented values of (-3.65%) for the MEG and (-2.29%) for the FEG. The MCG and FCG presented values of (-1.97%) and (-1.12%) in the IAT, respectively. Two athletes were excluded for being injured in basketball training and three for not attending at least 75% of the training sessions.

Table 2. Effect of PT on Sp20m and IAT.

	MEG			MCG		
	Pre	Post	ES	Pre	Post	ES
	mean±SD	mean±SD		mean±SD	mean±SD	
Male						
Sp20m (s)	3.61±0.14	3.46±0.16*	-1.07	3.59±0.24	3.52±0.29*	-0.29
IAT (s)	16.95±0.75	16.33±0.85*	-0.82	17.73±1.22	17.38±1.72*	-0.28
Female						
	mean±SD	mean±SD		mean±SD	mean±SD	
Sp20m (s)	3.77±0.29	3.50±0.76*	-0.96	3.97±0.40	3.85±0.38*	-0.30
IAT (s)	17.88±0.74	17.47±0.77	-0.55	18.64±1.51	18.43±1.30	-0.18

Note: ES= effect size; Sp20m = 20 m sprint test; IAT = Illinois agility test; MEG = male experimental group; MCG = male control group; FEG = female experimental group; FCG = female control group; SD = standard deviation; * = different from pre ($p < 0,05$).

Discussion

This study looked at the effect of the six-week PT on sprint performance and change-of-direction ability in young basketball athletes. The present study's findings revealed that PT had more significant effects on EG compared to CG on Sp20m performance in both sexes. Both the MEG and the MCG showed substantial improvements at the IAT but found greater effects in the MEG. In females, there were no significant improvements in IAT; however, both groups showed improvements and found greater effects in EG.

As a result of research in the specialized literature, it was concluded that few studies are conducted with young basketball athletes involving PT, making comparisons have been made in other sports for the same age group. Regarding the sprint in the FEG, the results of the present investigation showed an increase of 7.16% with wide effects ($ES = 0.96$). These results agree with the findings of Idrizovic, Gjinovci, Sekulic, Uljevic, João, Spasic, & Sattler (2018), who investigated the effects of PT lasting 12 weeks and showed significant improvements in Sp20m performance ($\Delta\% = -5.7\%$) in young volleyball athletes (age 16.6 ± 0.6 years). In addition, the ES of the sprint for the time and group was medium and large, respectively.

The sprint findings for males point to percentage improvements and a large effect on MEG ($\Delta\% = -4.15\%$; $ES = 1.07$), with values similar to the results of previous studies. Chaabene and Negra (2017) showed that the low-volume (LPT) and high-volume (HPT) PT showed significant statistical effects of time and group, respectively in the sprint of 10 ($ES = 0.85$ and 0.75), 20 ($ES = 0.64$ and 0.83) and 30 m ($ES = 0.57$ and 0.78). In addition, it showed significant $\Delta\%$ both in the LPT for the 10 (-4.04%), 20 (-3.46%) and 30 m (-7.39%) sprint, and in the HPT for the 10 (-4.12%) sprint, 20 (-2.87%) and 30 m (-2.68%). Considering the test performed in the present study (Sp20m), similar values were found in the LPT group and can be explained due to the similarity in the volume of PT.

Basketball training can positively influence the performance of Sp20m. This was shown in the results of the present investigation through the decrease in time, both for the MCG ($ES = 0.29$ $\Delta\% = -1.94\%$) and the FCG ($ES = 0.30$; the importance of applying PT in young athletes. These increases can be explained by neuromuscular factors that are potentiated by plyometric exercises (mainly horizontal jumps, serial forward hops, and CMJ), promoting a decrease in the time of contact with the ground during the sprints (Chaabene & Negra, 2017; Kotzamanidis, 2006; Markovic & Mikulic, 2010). Therefore, the study provides data that suggest the application of PT to improve sprint.

Regarding the speed on change of direction, the present study showed significant improvements in the performance of the IAT both in the MEG ($\Delta\% = -3.65\%$; $ES = 0.82$) and in the MCG ($\Delta\% = -1.97\%$; $ES = 0.28$). However, the MCG showed lower values and a low ES, requiring caution in generalizing the results. As in the sprint, studies that sought to investigate the effects of PT on the speed of change of direction in basketball athletes are scarce, especially in the young population.

In agreement with the hypothesis of the present investigation, Ramírez-Campillo, Álvarez, Henríquez-Olguín, Baez, Martínez, Andrade, & Izquierdo, (2014) showed a decrease of 3.5% in the IAT after replacing soccer exercises with plyometric exercises, lasting seven weeks. In the present study, only the MEG showed significant improvements and wide effects on the IAT. The mechanisms that can explain these improvements are neural adaptations, with an emphasis on the greater recruitment of motor units and the improvement in intermuscular coordination promoted by plyometric exercises (Asadi, Arazi, Young, & Villarreal, 2016; Markovic & Mikulic, 2010; Miller, Herniman, Ricard, Cheatham, & Michael, 2006).

In the female sex, Meszler and Vácsi (2019) investigated the influence of the seven-week PT program on young basketball athletes. The results showed that the group that performed the PT and the CG did not show improvements in the IAT (16.21 ± 0.81 for 16.95 ± 1.07 s) and (16.85 ± 0.71 to 17.34 ± 0.93 s), respectively. The present study results also did not show significant improvements for the FEG ($\Delta\% = -2.29$). However, there was a decrease in time in the test, showing that PT can be a method effective from a practical view because even

if these improvements are not significant, there has been an improvement and, with that, it can optimize the athletes' performance.

The present study showed important results in sports training. However, it also has limitations that need to be reported: the small number of participants and the failure to assess the internal load and biological maturation. Thus, further investigations are suggested to evaluate biological maturation and quantify the internal load in the PT programs. In addition, future research should be conducted with a larger number of participants, as well as investigating the influence of PT on other physical valences (sprint, speed of change of direction, vertical jump, horizontal jump, strength, balance, anaerobic resistance) in young athletes, as well as in other sports.

Conclusion

It is possible to conclude that the implementation of a PT program lasting six weeks promotes significant improvements in Sp20m and IAT in the GEM. In the GEF, the PT provided a significant improvement in sprint performance and greater effects compared to the GCF. The present study provides data that indicate the application of plyometric exercises in physical training that seek to improve the physical conditioning of young athletes of both sexes. Coaches are encouraged to include PT in the periodization of training for young athletes seeking improvements in sprint performance and speed of change of direction.

Conflicts of interest

The authors declare no conflict of interest.

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