ORIGINAL ARTICLE

The effect of 8-week plyometric training on jump height, agility, speed and asymmetry

Sercin Kosova[1ABCD], Rüya Beyhan[2ABD], Merve Koca Kosova[1ABDE]

[1]*Department of Physical Education and Sports Teaching, Faculty of Sports Sciences, Dokuz Eylül University, İzmir, Turkey*

[2]*Department of Physical Education and Sport, Institute of Health Sciences, Muğla Sıtkı Koçman University, Muğla, Turkey*

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Abstract

Background and Study Aim Plyometric training is one of the most preferred methods for athletic performance improvement. This study was designed to measure the effect of 8 weeks of additional plyometric training on jump performance, lower extremity asymmetry, speed, and agility performances of adolescent fencers.

Material and Methods This study was carried out with 26 fencers who participated in national competitions. The fencers were randomly divided into plyometric training (PLY, n = 14) and the control (n = 12) group. The PLY group did plyometric training 3 days per week for 8 weeks in addition to their fencing training. The control group only continued their fencing training. All participants performed countermovement jumps (CMJ), pro-agility, 0-5-m, 5-15–m, 0-15-m sprints, and asymmetry tests before and after 8 weeks.

Results Statistically significant differences were found in CMJ, (p = 0.001), pro-agility (p = 0.001), and 0-5-m (p = 0.036), 5-15-m (p = 0.018), and 0-15-m (p = 0.001) sprint results in the PLY group. However, asymmetry contact time and asymmetry flight time values did not show statistical differences. In addition, group x time interactions of CMJ (p < 0.001), pro-agility (p = 0.001), and 0-5-m (p = 0.015) and 5-15-m (p = 0.009) sprint tests were also found statistically significant.

Conclusions Thus, it can be said that plyometric training contributes positively to the jumping, agility, and speed of fencers. Adolescent fencers and their trainers may be advised to focus on additional plyometric training programs. However, individual differences and training experience should also be taken into account in the determination of plyometric programs.

Keywords: plyometric, vertical jump, change of direction, fencing.

Introduction

Fencing includes anaerobic power, agility, and speed, and a fencing bout is shaped by interactions with the opponent. In this branch, where the capacity of the lower extremities is crucial [1], there may be power differences between the extremities due to the application of technical movements.

Plyometric training has an important place in branches where lower extremity development is critical [2]. The positive effect of plyometric training, which includes quick movements, is related to the system called the stretch-shortening cycle [3]. This training method, which is indispensable for many branches, can be used for many different age groups with appropriate methods. In a study conducted on male athletes aged 13-14 years, it was reported that 8 weeks of plyometric training had a positive effect on speed and explosive strength properties [4]. In another study, basketball players with an average age of 20.1 years performed plyometric training for 6 weeks in addition to their training. At the end of this implementation, it was stated that there was an improvement in strength and agility compared with those who did not do additional plyometric training [5]. Although the performance benefits of plyometric training are frequently shown in the literature [6, 7], more studies are needed to understand the effects of different training methods on athletes of certain age groups and branches. In addition, when using this training method, it should be remembered that the inability to set exercise levels correctly can lead to injuries, so the selection of the exercises according to age and performance level is important.

Although there is not much movement in fencing that is directly applied by jumping, improving the jump will contribute to the fencer's performance [8]. As in many other branches [9, 10], studies are investigating jumping performance in fencing [11]. Investigating asymmetry is also a frequently encountered situation in terms of athletic performance. However, it is considered normal to develop a certain amount of asymmetry in branches where one-way movements are dominant, such as fencing [12]. However, it is important to control the degree of asymmetry and to provide support with appropriate training methods to maintain performance and prevent injuries.

In fencing, where quick responses are made

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as a result of one-to-one interaction in the game, speed and agility are also features that should be emphasized. The practicality of measurement methods and portable devices continue to make the evaluation of these parameters popular in sports sciences. It should not be forgotten that many features such as speed and agility, are intertwined with each other [13]. The current study aimed to examine the effects of plyometric training applied to fencers for 8 weeks on jumping performance, lower extremity asymmetry, speed, and agility.

Material and Methods

A randomized method was used in this study to investigate the effects of plyometric training on vertical jump, agility, speed, and jump asymmetries. The fencers were randomly divided into two different groups as the plyometric training group (PLY, n = 14) and the control group (n = 12). The control group did not do any additional training while continuing their fencing training, but the PLY group performed an additional plyometric training program along with their fencing training. Plyometric training was performed 3 days per week/ 8 weeks. An adjustment session was applied to the PLY group before the measurements. The training program is presented in the Table 1.

Participants

In this study, 26 athletes who trained regularly and participated in national competitions voluntarily took part. The descriptive characteristics of the participants are presented in Table 2. Necessary legal permission was obtained from the Local Research Ethics Committee (Decision Number: 2021/10-39). In addition, fencers and legal representatives of them were informed about the protocol, and each signed approved informed consent forms.

Procedures

Athlete's heights were measured with a metal tape measure. Body weights and body fat ratios were determined by body composition analysis scale (Tanita BC 730, Japan). The participants were given a 10-minute warm-up. After that, CMJ for vertical jump, pro-agility, 0-15-m sprint, and jump asymmetry tests were performed, respectively.

Countermovement Jump: Two repetitions were performed with the hands free on the mat (Smart Speed Pro-Fusion Sport, Australia). There were 45 seconds of rest between repetitions. The highest value was used for analysis.

Pro-agility Test: An electronic photocell system (Smart Speed Pro-Fusion Sport, Australia) was used for the test. Each participant performed the test twice and the best duration was used.

0-15–m sprint: The times of the participants at 5 m and 15 m were recorded. Smart Speed Pro-Fusion Sport (Australia) was used for measuring (Figure 1).

Figure 1. 0-15-m sprint test design

Asymmetry test: In the jump test measured using My Jump 2 (IOS app), the participants' right and left foot depth jumps (40-cm bench height) were recorded. Thanks to the high-speed video recording feature, the first moment of contact with the ground, the first moment of the flight phase, and the first moments of contact with the ground were marked, and the level of asymmetry between the contact and flight times of the two feet was calculated as a percentage.

Statistical Analyses

The pre and post-test values of the data were evaluated in order using boxplots, the Shapiro-Wilk normality test, homogeneity of Levene variances, box's M tests, and covariances. Two-way mixed pattern analysis of variance was used for the main effects and interactions of the plyometric training. The effect sizes were evaluated as partial Eta-squared and converted to Cohen's d. Descriptive statistics were showed as mean ± standard deviation and statistical significance was determined as <0.05. Lastly, for analyses, the IBM SPSS Statistics Ver. 20 program (Armonk, NY: IBM Corp., 2011) was used.

Results

The demographic data of the participants are presented in Table 2.

After 8 weeks of training, the performance improvement of the PLY group in 0-5-m sprints (-0.128 ± 0.04 sec, p = 0.04) were statistically significantly different compared with the control group. As a result of the training, the increase in the CMJ results of the PLY group was not statistically significant compared with the control group (0.687 ± 3.04 cm, p = 0.823). Likewise, there were no significant differences in the pro-agility test (-0.120 ± 0.15 sec, p = 0.437), 5-15-m sprint (-0.037 ± 0.06 sec, p = 0.577), 0-15-m sprint (-0.148 ± 0.10 sec, p = 0.164), asymmetry contact time (3.482 ± 3.00%, p = 0.258), and asymmetry flight time values (3.285 ± 3.72%, p = 0.387).

CMJ test results showed a statistical difference in the PLY group [F(1,13) = 28.915, p = 0.001, $\eta p2$ = 0.690)] before and after 8 weeks of training, but in the control group [F(1,11) = 2.736, p = 0.126), $\eta p2$ = 0.199)], no statistically significant difference was observed.

Table 1. Training programme

Week	Bounce	Plyometrics	Set x Reps	Workload
1st	90	Side to side ankle hops	**2 X 15**	Low
		Standing jump and reach	**2 X 15**	Low
		Front cone hops	**5 X 6**	Low
2nd	**120**	Side to side ankle hops	**2 X 15**	Low
		Standing long jump	**5 X 6**	Low
		Lateral jump over a barrier	**2 X 15**	Moderate
		Double leg hops	**5 X 6**	Moderate
3rd	**120**	Side to side ankle hops	**2 x 12**	Low
		Standing long jump	**4 x 6**	Low
		Lateral jump over a barrier	**2 X 12**	Moderate
		Double leg hops	**3 X 8**	Moderate
		Lateral cone hops	**2 X 12**	Moderate
4th	**120**	Side to side ankle hops	**2 x 12**	Low
		Standing long jump	**4 x 6**	Low
		Lateral jump over a barrier	**2 X 12**	Moderate
		Double-leg hops	**3 X 8**	Moderate
		Lateral cone hops	**2 X 12**	Moderate
5th	**140**	Diagonal cone hops	**4 X 8**	Low
		Standing long jump with lateral sprint	**4 X 8**	Moderate
		Lateral cone hops	2 X 12	Moderate
		Single-leg bounding	4 X 7	High
		Lateral jump, single leg	4 X 6	High
6th	140	Diagonal cone hops	2 X 7	Low
		Standing long jump with lateral sprint	4 X 7	Moderate
		Lateral cone hops	4 X 7	Moderate
		Cone hops with 180-degree turn	4 X 7	Moderate
		Single-leg bounding	4 X 7	High
		Lateral jump, single leg	2 X 7	High
7th	**140**	Diagonal cone hops	2 X 7	Low
		Standing long jump with lateral sprint	4 X 7	Moderate
		Lateral cone hops	4 X 7	Moderate
		Cone hops with 180-degree turn	4 X 7	Moderate
		Single-leg bounding	4 X 7	High
		Lateral jump, single leg	2 X 7	High
8th	**120**	Diagonal cone hops	**2 X 12**	Low
		Hexagon drill	**2 X 12**	Low
		Cone hops with a change of direction sprint	**4 X 6**	Moderate
		Double-leg hops	**3 X 8**	Moderate
		Lateral jump, single leg	**4 X 6**	High

Table 2. Anthropometric characteristics of the participants

Variables	**Plyometric Group**	**Control Group**
	Mean±SD	**Mean±SD**
Age (year)	15.16 ± 0.74	15.22 ± 0.86
Height (cm)	166 ± 0.08	172 ± 0.08
Weight (kg)	61.82 ± 15.33	63.30 ± 11.36
BMI	22.18 ± 4.77	21.22 ± 3.02
BFR %	22.45 ± 8.63	18.43 ± 6.85

BMI: Body mass index, BFR: Body fat ratio

The duration of the pro-agility test did not differ significantly between the pre-test and post-test values in the control group [F(1,11) = 1.523, p = 0.243, ηp2 = 0.122)], but a statistically significant difference was found in the PLY group [F(1,13) = 27.291 p = 0.001, ηp2 = 0.677)].

A significant difference was observed between pre-test and post-test values in 0-5-m [F(1,13) = 5.500 p = 0.036, ηp2 = 0.297)], 5-15 m [F(1,13) = 7.255, p = 0.018, ηp2 = 0.358)] and 0-15-m [F(1,13) = 22.837. p = 0.001, ηp2 = 0.637)] sprint performance in the PLY group. No difference was observed between the pre-test and post-test values in the 0-5-m [F(1,11) = 1.993, p = 0.186, ηp2 = 0.153)], 5-15-m [F(1,11) = 3.975, p = 0.072, ηp2 = 0.265)] and 0-15-m [F(1,11) =0.029, p = 0.868, ηp2 = 0.003)] sprint performance in the control group.

Asymmetry contact time pre-test and post-test values in the PLY group [F(1,13) = 0.018 p = 0.894, ηp2 = 0.001)] and the control group [F(1,11) = 2.401, p = 0.150, ηp2 = 0.179)], did not show statistical differences. Similarly, there were no significant differences in asymmetry flight time values in the PLY [F(1,13) = 1.063 p = 0.321, ηp2 = 0.076)] and control groups [F(1,11) = 2.373, p = 0.152, ηp2 = 0.177)].

Group, time and group x time interactions as Anova outcomes are presented in Table 3.

Discussion

The effect of 8-week plyometric training on the performance parameters of fencers was investigated in the current study. The important findings of the current study were that the CMJ, pro-agility, and sprint results at different intervals of the participants who performed the plyometric program in addition to their regular training showed better results and these differences were not observed in the other group. In addition, the increase in the 0-5-m sprint after the plyometric program was different compared with the control group.

It has been shown in the literature that plyometric training has positive effects on athletic performance in young athletes age group [14]. It is important to perform the movements with the correct technique to see the expected effect from plyometric training. If the correct technique can be performed, the benefits of training can be seen regardless of the level of the athletes [15]. Although the athletes in this study were not adults, they all had similar fitness levels and had been training for many years. The improvements seen as a result of the study may show that the training is suitable for athletes at this level and that technique is not impaired while performing the movements.

Considering the improvement in CMJ

Table 3. Mean and SD of the outcome measures for each group before (pre) and after (post) the intervention period.

Parameters	PLY (n = 14)		CN (n = 12)		ANOVA outcomes		
					Group	Time	Group X Time
	Pre	Post	Pre	Post	F (1,24), p (d)	F (1,24), p (d)	F (1,24), p (d)
CMJ	35.94±7.08	38.03±7.10	37.57±8.64	37.34±8.43	F=0.024, 0.878 (0.001)	F=18.028, **<0.001**** (0.429)	F=27.761, **<0.001**** (0.536)
Pro-agility (sec)	5.82±0.24	5.51±0.34	5.61±0.43	5.63±0.43	F=0.109, 0.744 (0.005)	F=20.015, **<0.001**** (0.455)	F=24.897, **0.001*** (0.509)
0-5-m (sec)	1.19±0.09	1.14±0.08	1.25±0.10	1.27±0.12	F=6.571, **0.017*** (0.215)	F=1.482 0.235 (0.058)	F=6.897, **0.015*** (0.223)
5-15-m (sec)	1.68±0.11	1.62±0.14	1.64±0.19	1.65±0.19	F= .000 0.984 (0.001)	F = 4.276, **0.050*** (0.151)	F =7.994, **0.009*** (0.250)
0-15-m (sec)	2.87±0.19	2.76±0.21	2.89±0.28	2.90±0.31	F=0.879, 0.358 (0.035)	F = 2.500, 0.127 (.094)	F= 3.687, 0.067 (0.133)
Asymmetry contact time (%)	11.13±8.02	10.72±6.98	9.77±8.37	7.23±8.33	F=0.916, 0.348 (0.037)	F= 0.661, 0.424 (0.027)	F=0.342, 0.564 (0.014)
Asymmetry flight time (%)	7.27±4.67	10.93±10.07	8.40±8.53	7.65±8.73	F=0.174, 0.680 0.007	F=0.565, 0.459 (0.023)	F=1.296, 0.266 (0.051)

*P<0.05, P<0.01, PLY: plyometric training group; CN: control group; sec: second; ANOVA: analysis of variance; d: by converted partial eta squared to Cohen's d.

performance, it should be emphasized that Ntai, Tsolakis [16] stated that CMJ was an important parameter that reflected the step-lunging exercise, which is a necessary technique for fencing. Based on this finding, it can be said that participants whose CMJ performance improved as a result of additional plyometric training in this study achieved improvements that could directly contribute to fencing performance. It is also important to see improvement in pro-agility results since fencing athletes frequently change their direction when the execute special training and also in championships [17]. In addition, it is known that the results of the pro-agility test may be related to features such as jumping and sprinting [18]. Thus, it can be concluded that the 8-week program performed on the athletes in the study provided a versatile contribution to their athletic performance. When evaluated specifically for the sprint, the improvement seen in every sprint distance can be an indication that it contributes to both acceleration and the speed in the total distance run.

In this study, no significant difference was found between the percentages of asymmetry contact time and asymmetry flight time in both groups after 8 weeks. It is expected that some asymmetry will occur in a branch where the same leg is always in front and the same arm is holding a weapon. The percentages of asymmetry in this study are also within the normal range [19]. The lack of a significant change in the rates with the effect of plyometric training may be because all participants continued their daily fencing training, which included asymmetrical technical movements.

Finally, there was a significant difference in the group x time interaction of the CMJ, pro-agility, and 0-5–m and 5-15–m sprint tests. In another study investigating the effect of 8-week balance and plyometric training on performance, group time interactions were significant for drop jump and change of direction tests, but not for CMJ or sprint tests [20]. Parameters such as the branches of the participants, their sports backgrounds, their anthropometric characteristics, the content of the training performed, and whether the participants performed it correctly may cause different results. To interpret the reasons for the differences between studies from a physiologic point of view, measurements such as muscle cross-section area or motor unit activation should also be performed [21].

Conclusions

It was seen that additional plyometric training performed 3 days per week for 8 weeks improved jumping, agility, and speed parameters in adolescent fencers. Regular plyometric training will contribute to performance in branches such as fencing, where lower extremity strength is so important. For this reason, it can be recommended for coaches to perform plyometric training while the athletes are in the adolescence period. However, points such as individual differences and sports experience should be carefully evaluated and appropriate programs should be selected for athletes.

Conflicts of Interest

The authors declare no conflicts of interest.

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Information about the authors:

Sercin Kosova; PhD; https://orcid.org/0000-0003-1005-3387; sercin.kosova@gmail.com; Faculty of Sport Sciences, Dokuz Eylül University; İzmir, Turkey.

Rüya Beyhan; https://orcid.org/0000-0002-5942-7039; ruya.byhn@gmail.com; Department of Physical Education and Sport, Institute of Health Sciences, Muğla Sıtkı Koçman University; Muğla, Turkey.

Merve Koca Kosova; (Corresponding Author); https://orcid.org/0000-0003-0454-2790; merve.koca@deu.edu.tr; Faculty of Sport Sciences, Dokuz Eylül University; İzmir, Turkey.

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