Journal of Physical Education and Sport ® (JPES), Vol. 23 (issue 2), Art 69, pp. 555 - 563, February 2023
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

The impact of Optojump training on the power of lower limbs in female triple jumpers

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Published online: February 28, 2023
(Accepted for publication February 15, 2023)
DOI:10.7752/jpes.2023.02069

Abstract:
Explosive power is a defining quality in the triple jump event. The purpose of this study is to evaluate the effects of applying a 5-week complementary training program assisted by the Optojump Next System, which is included in the training program of top triple jumpers to improve power parameters. A total of 7 female triple jumpers [average age 22.4 years (±6.5 years); average body weight 59.1 kg (±3.6 kg); average height 171.9 cm (±3.2 cm)] participated in this experiment between May and June 2022. The testing of the athletes involved the application of tests from the Bosco protocol as well as some adapted tests (squat jump test on both legs, countermovement jump test, 15-s jump test on both legs, 15-s jump test on the right leg and on the left leg, squat jump test on the right leg and on the left leg) before and after the experiment in the form of initial and final tests. The obtained results demonstrated that the assisted training, performed with the Optojump Next System as part of the ameliorative protocol, has a beneficial impact on the parameters of power and explosive force in triple jumpers; the results at the group level highlighted notable differences between the two tests (differences in contact times in the 15-s jump tests at the group level: 0.037, 0.037 and 0.011 s; differences in flight time: 0.020, 0.029 and 0.012 s; differences in height: 3.39, 1.86 and 0.73 cm; power differences recorded: 6.32, 3.04 and 0.90 W/kg). The training with the Optojump Next System can positively affect the explosive strength performance.
Keywords: triple jump, power, lower limbs, Optojump

Introduction

The triple jump is one of the two events in athletics in which the athletes aim to maximize the horizontal distance. It consists of 3 take-off and 3 landing phases; each phase is important and requires maintaining a high level of horizontal speed (Abeer, 2014). During take-offs and landings, the athletes experience extraordinary forces, with a huge pressure on bones, joints and muscles; strength development is essential in the preparation for this event (Newman, 2012). The triple jump is one of the most demanding and complex events in athletics due to its physical and technical requirements. The successful practice of the triple jump event involves the development of the main determinant motor qualities in the performance equation and the continuous improvement of the specific technique, which is insufficiently explored in the specialized studies (Rapotan, 2022).

In many sports, as in the triple jump, strength exercises are performed with the main objective of improving power rather than strength (Zatiorski, 2002).
McGuigan considers strength to be an essential quality that allows athletes to run faster and jump higher (McGuigan, 2017).

Closely related to the force capacity of the triple jumper is the explosive power, which is essential at the moment of take-off to achieve a long jump (Newman, 2012). Thus, to achieve a high level of performance, it is necessary to focus on two areas of activity in sports; first one is to evaluate the current level of explosive power of the lower limbs, and the second one is the possibility to improve the potential of this power by applying specific training (Maćkała, Synówka, Ćorluka, Vodicar, 2021). The explosive power of the lower limbs is the most important aspect of the training process that each track and field coach will try to improve. A high level of explosive power at the lower limbs will have positive effect not only on the height of the vertical jump but also on the speed of movement (Graur, 2014). The vertical jump is a multi-joint movement that requires complicated motor coordination; it has been identified as one of the fundamental movements skill and is used to measure lower body power; thus, it is an indirect measure of performance (Ahsan, Ali, 2021). Vertical jump is also used to evaluate sprint acceleration and deceleration and change of direction (Ahsan, Ali, 2021).

The explosive exercises used in the training program will affect changeable response of the athlete and will ultimately affect his/her sports performance. Improvements in sports performance with the use of explosive exercises may partially depend on movement and speed forms required by the sport and the athlete's training status (Haff, Whitley & Potteiger, 2001; Baştürk, D. & Peker, A.T. 2019). According to the literature, successful

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sports performance is associated with the athletes capacity to accelerate the body mass as fast as possible through the lower limb ballistic movements (França C., Gouveia E.R., Caldeira R., Marques A., Martins J., Lopes H., Costa M., Ihle A., 2021).

To determine the level of explosive power of the lower limbs and the specific parameters of triple jumpers, it is necessary to apply different tests that are based on various types of vertical and horizontal jumps from the Bosco protocol; the most common jumps are the squat jump (SJ), countermovement jump (CMJ) and 15-s jump. These types of testing protocols have been widely used for various sports and purposes: to monitor training progress, to assess the possibilities of maximum performance (Andersen et al., 2018; Campos-Vazquez et al., 2015; Dietze-Hermosa et al., 2020; Goranovic et al.2021, Mackala et al., 2021), to assess strength, to assess asymmetries, and in injury prevention (Borràs et al., 2011; Sattler et al., 2015).

The CMJ refers to a vertical jump during which the individual initially moves down, counter to the direction of the jump; upon reaching a predetermined angle, the individual forcefully and without hesitation jumps upward (Guan S et al. 2021). Loaded CMJ jump is considered to be one of the most "explosive" tests owing to both its very short duration and the high intensity involved. Several studies have examined the training volume in terms of the number of sets, frequency, and intensity of plyometric training undertaken to achieve greater power (Chaabene H. & Negra Y., 2017; de Villarreal E.S. et al. 2012; Kobal R. et al., 2017; Ramírez-Campillo R. et al., 2013). One of the most frequently used instruments is the Optojump Next System (Microgate, Bolzano, Italy), which is an innovative movement measurement and analysis system that brings a new philosophy of performance evaluation and optimization to the world of competitive sports; it has been designed for the development of specific and personalized training programs that are based exclusively on accurate objective data. Optojump is an optical measurement system consisting of a transmitting and receiving bars. Each bar contains 96 light-emitting diodes (LEDs) (1.0416 cm resolution).

The LEDs on the transmitting bar communicate continuously with those on the receiving bar. The system detects any interruptions in communication between the bars and calculates their duration. This allows to measure flight and contact times during the performance of a series of jumps with an accuracy of 1/1000 of a second. Starting from these fundamental basic data, the dedicated software allows to obtain a series of parameters connected to the athlete's performance with the maximum accuracy and in real-time. (https://performbetter.co.uk/products/optojump-jump-testing#:~:text=The%20system%20detects%20any%20interruptions.1%2F1000%20of%20a%20second).
Specialized literature (Latorre Román, Villar Macias, García Pinillos, 2017) reveals the integration of the Optojump system for identifying the effects of an isometric and plyometric training program in young basketball players, and the SJ test was also applied. In other articles such as *Assessing Reactive Strength Measures in Jumping and Hopping Using the OptojumpTM System (2016)*, or *Validity Of Two Optoelectric Systems Used For Recording Maximum Vertical Jumping Performance Versus The Gold Standard (2017)*, the accuracy of the Optojump system was validated by taking measurements in parallel with another platform designed to measure reactive force; the testing included jumping on one leg, two legs and from various elevated surfaces; the obtained results indicated that the Optojump system is a valid tool for evaluating the reactive force of athletes; no differences were detected that could be called measurement errors (Healy, Kenny, Harrison, 2016; Słomka, et al., 2017).

Monitoring the indicators with these instruments as well as the interpretation of obtained values in dynamics can suggest the way that we should design the training process, the training contents for specific physical training and technical training. Improving jumping ability through power development can be optimized through different training techniques; therefore, countermovement plyometric loads, which rely heavily on the ability to achieve high levels of force by applying the stretch-shortening cycle (SSC), will play an important role as a responsible modality for power development (McGuigan et al., 2006 ; Blazevich, 2011). Thus, this study aims to evaluate the effects produced by scientifically supported complementary training over a period of 5 weeks on the explosive power of the lower limbs in top national triple jumpers of different age categories.

Materials and methods

Participants

The research was performed on 7 triple jumpers [average age 22.4 years (±6.5 years); average body weight 59.1 kg (±3.6 kg); average height 171.9 cm (±3.2 cm)] between May and June 2022. The analysis of results and interpretation of the experiment was performed individually, each subject representing a case study. Every athlete signed a consent agreement for participation in the experiment.

Procedure/Test protocol/Skill test trial/Measurements/Instruments

The study was performed between May and June 2022, after studying the existing specialized literature to identify the aspects of the optimization and adaptation of the motor behaviour of triple jumpers and after identifying the methods used for the determination of specific parameters. We created a complementary training program aimed to activate the regulation and self-regulation mechanisms of the motor behaviour (power); we introduced the program in the athletes training plan for the outdoor season, for a period of 5 weeks in the pre-competitive and competitive stage, using the Optojump Next optical motion analysis system. The

complementary exercises were performed 2 times a week after a specific warm-up; the exercises were developed and customized for the senior category U23 and for the U20–U16 category; the dosage of exercises was based on the age and category of the athletes. We used a series of tests, before and after the application of the training program, designed to determine the level of specific power.

The structure and content of the workouts were presented and discussed with the coaches and athletes before they were applied; the workouts were performed in accordance with their training plan and competition calendar, avoiding as much as possible disruptions to their training schedule.

The jumping ability measurement

Testing the athletes both at the beginning and at the end of the experiment involved the application of 5 tests from the Bosco protocol, as well as some adapted tests: squat jump test on both legs, CMJ test, 15-s jump test on both legs, 15-s jump test on the right leg and on the left leg, squat jump test on the right leg and on the left leg. All jumps were performed with the upper limbs in a controlled position, with the palms of the hands on the hips; the biomechanics of the movement is specific to each test.

Training program

The training program took place over a period of 5 weeks (Table 1) and involved a group of 7 female triple jumpers. The exercises were performed both during the pre-competitive period and during the competitive period; their placement in the weekly training cycle was on different days for each athlete, depending on the goal of the daily training.

Table I. The content and intensity of the training program

Training no. 1	Intensity	Training sessions	Weeks	Break	No. of reps.	Series
1. Jumps in place, with extended knees, performed on both legs, for 15 s, monitored with the Optojump Next system, aiming to obtain the shortest contact time and jump as high as possible	medium	5	5	1 min 2 min (U20)	15 s 15 s	4 (Sen–U23) 3 (U20–U16)
2. Jumps on one leg, with extended knees, performed in place on the right leg, for 15 s, monitored with the Optojump Next system, aiming to obtain the shortest contact time and jump as high as possible	medium	5	5	1 min 2 min (U20)	15 s 15 s	4 (Sen–U23) 3 (U20–U16
3. Jumps on one leg, with extended knees, performed in place on the left leg, for 15 s, monitored with the Optojump Next system, aiming to obtain the shortest contact time and jump as high as possible	high	5	5	2 min	10	4 (Sen–U23) 3 (U20–U16
Training no. 2	Intensity	Training sessions	Weeks	Break	No. of reps.	Series
1. Jumps from the semi-squat position, with hands on hips, monitored with the Optojump Next system, aiming to achieve the highest possible height and a long flight time	high	5	5	2 min	10	4 (Sen–U23) 3 (U20–U16
2. Jumps from the semi-squat position with outstretched arms, holding 2 discs in hands (5 kg for seniors–U23, 2 kg for U20)	high	5	5	2 min	10	4 (Sen–U23) 3 (U20–U16

Results

After analysing the data obtained from the two tests (initial and final), presented in Tables 2–5, we calculated the progress rate for each athlete and interpreted the results as case studies. At the group level, we calculated the arithmetic mean and standard deviation and analysed the differences recorded between the two tests for each athletes. In the text are presented only the athletes initials.

Table II. Results of the 15-s jump test on both legs

Name	Category	Test	Contact T (s)	Flight T (s)	Height (cm)	Power (W/kg)	Progress (%)
B.C.	S	T1	0.183	0.434	23.2	35.79	32.54
		T2	0.176	0.508	32.3	50.59	
T.A.	S	T1	0.280	0.482	28.6	32.32	29.22
		T2	0.211	0.489	38.6	48.88	
M.I.	S	T1	0.286	0.301	11.2	15.04	117.51
		T2	0.223	0.466	26.7	39	
I.D.	U23	T1	0.268	0.454	25.4	38.05	-30.78
		T2	0.190	0.357	15.8	25.43	
C.I.	U20	T1	0.223	0.404	20.1	27.86	4.08
		T2	0.185	0.401	19.9	31.75	
B.A.	U18	T1	0.218	0.436	23.3	31.73	-19.97
		T2	0.224	0.378	17.6	24.7	
G.M.	U16	T1	0.265	0.353	15.3	20.16	22.44
		T2	0.257	0.402	19.9	24.87	

*T – time, S – senior, U23 – under 23, U20 – under 20, U18 – under 18, U16 – under 16

B.C. improved all measured parameters. The contact time measured in the final test was 0.007 s shorter compared to the initial one; the flight time was 0.074 s shorter in the final testing which represents an improvement compared to the initial test. The same upward trend was recorded for the height, which highlights a higher level of adaptation to the test requirements acquired as a result of completing the training protocol proposed by us. From the same perspective, the athlete registered a rate of progress with a value of 32.54%.

During the second testing, athlete T.A. achieved better values for all parameters and a progress of 29.22%. The contact time decreased by 0.069 s, the flight time increased by 0.007 s, the height increased by 10 cm, and the power increased by 16.56 W/kg.

M.I. achieved better values in the final test. The contact time decreases by 0.063 s, the flight time increased by 0.165 s, the height increased by 15.5 cm, and the power increased by 23.96 W/kg. Higher power is an important feature in jumping events. The progress rate following the protocol was 117.51%.

With a negative progress rate value, I.D. improved only her contact time by 0.078 s.

C.I. obtained better values for the contact time and power; the values of the flight time and height were insignificantly lower. Her progress was 4.08%.

B.A. obtained lower values in the second test; the biggest differences were recorded in the flight time where she obtained a lower value, by 0.058 s. In addition, the height was 5.7 cm lower. The athlete had a negative progress rate value.

G.M. scored better values for all tested parameters in the final test, and her progress was 22.44%. The most notable increases were in the flight time and in the power.

Table III. The results of the 15-s jump test on the right leg and on the left leg

			Right leg					Left leg				
Name	Category	Test	Contact T (s)	Flight T (s)	Height (cm)	Power (W/kg)	Progress (%)	Contact T (s)	Flight T (s)	Height (cm)	Power (W/kg)	Progress (%)
B.C	S	T1	0.271	0.304	11.6	16.29	26.53	0.254	0.333	13.6	11.87	59.39
		T2	0.259	0.351	15.6	21.12		0.245	0.396	19.4	25.71	
T.A.	S	T1	0.301	0.352	15.2	18.6	-21.28	0.281	0.372	17	21.02	-30.76
		T2	0.282	0.298	10.9	14.84		0.278	0.291	10.4	14.36	
M.I.	S	T1	0.281	0.307	11.6	15.58	17.69	0.286	0.301	11.2	15.04	17.37
		T2	0.281	0.342	14.4	18.31		0.304	0.338	14	17.27	
I.D.	U23	T1	0.266	0.327	13.1	17.58	-26.89	0.270	0.330	13.4	17.83	-9.45
		T2	0.271	0.265	8.6	12.77		0.261	0.306	11.5	16.6	
C.I.	U20	T1	0.347	0.257	8.1	10.82	43.67	0.584	0.204	5.5	6.68	129.82
		T2	0.321	0.322	12.8	15.98		0.288	0.339	14.1	17.83	
B.A.	U18	T1	0.276	0.261	8.4	12.32	-2.48	0.266	0.280	9.6	14	1.08
		T2	0.292	0.259	8.2	11.79		0.291	0.285	10	13.62	
G.M.	U16	T1	0.394	0.167	3.5	5.77	51.14	0.363	0.189	4.4	7.97	51.33
		T2	0.353	0.221	6.1	8.47		0.379	0.258	8.3	10.27	

*T – time, S – senior, U23 – under 23, U20 – under 20, U18 – under 18, U16 – under 16

B.C. had better values in the final testing both on the right leg and on the left leg; she improved all of her parameters. For the right leg, the contact time changed from 0.271 to 0.259 s, the flight time – from 0.304 to 0.351 s, the height – from 11.6 to 15.6 cm and the power – from 16.29 to 21.12 W/kg. For the left leg, the contact time changed from 0.254 to 0.245 s, the flight time – from 0.333 to 0.396 s, the height – from 13.6 to 19.4 cm and the power – from 11.87 to 25.71 W/kg. Although it is normal to have differences between the right and left legs, the fact that following the protocol the values obtained for both legs improved, with a progress rate of 26.53% for the right leg and 59.39% for the left leg, represents a very important aspect in achieving performance in the triple jump event, where athletes use both legs.

I.D. improved her flight time, height and power both for the right leg and for the left leg, without any changes in the contact time. She achieved a progress of 17.69% for the right leg and 17.37% for the left leg.

C.I. achieved better results in the final test. The contact time was lower by 0.026 s for the right leg and by 0.0296 s for the left leg. The height increased from 8.1 to 12.8 cm for the right leg and from 5.5 to 14.1 cm for the left leg, with a progress of 43.67% and 129.82%, respectively.

B.A. achieved similar results in the final testing; the differences were not significant.

For G.M., the results were better for all parameters following the implemented protocol, except for the contact time. She achieved a progress rate of 51.54% for the right leg and 51.53% for the left leg.

Table IV. Results for the countermovement jump and squat jump tests on both legs

			CMJ			Squat jump		
Name	Category	Test	Flight T (s)	Height (cm)	Progress (%)	Flight T (s)	Height (cm)	Progress (%)
B.C.	S	T1	0.551	37.2	4.18	0.557	38	1,94
		T2	0.566	39.3		0.564	39	
T.A.	S	T1	0.558	38.2	-1.58	0.552	37.4	-0,94
		T2	0.552	37.4		0.549	36,9	
M.I.	S	T1	0.598	43.8	-0.51	0.585	42	-1.58
		T2	0.596	43.5		0.579	41.1	
I.D.	U23	T1	0.554	37,6	-1,03	0.519	33	7,01
		T2	0.550	37.1		0.543	36.1	
C.I.	U20	T1	0.470	27.1	17.16	0.438	23.5	23.38
		T2	0.522	33.4		0.503	31	
B.A.	U18	T1	0.465	26.5	10,91	0.449	24,7	8.14
		T2	0.498	30.4		0.473	27.4	
G.M.	U16	T1	0.376	17.3	40.82	0.384	18.1	34,97
		T2	0.470	27.1		0.468	26.8	

* CMJ – countermovement jump, T – time, S – senior, U23 – under 23, U20 – under 20, U18 – under 18, U16 – under 16

In the CMJ test, B.C. achieved slightly better values, with the height increasing from 37.2 to 39.3 cm, registering a 4.18% increase in the progress rate; in the squat jump test, the height increased from 38 to 39 cm.

T.A. obtained slightly lower values; the flight time for the CMJ test is 0.006 s lower, and for SJ test, it is 0.003 s lower. The athlete had negative progress rate values.

M.I. obtained similar values for the first and final tests. In the initial test, she had the best results from the group; after the training, she managed to maintain her parameters at the same high level, but had negative values in the progress rate, as shown in Table 4.

The results obtained by I.D. for the CMJ test are similar for both tests. For the SJ test, the flight time increased by 0.024 s, and the height by 3.1 cm, which confirmed that following the training protocol, she could achieve much better values, with a progress rate of 7.01% for the SJ test.

C.I. showed an increase in all parameters in both tests, including the progress rate. For the first test, the flight time increased from 0.470 to 0.522 s and the height – from 27.1 to 33.4 cm; for the second test, the flight time improved by 0.65 s and the height – by 7.5 cm.

B.A. slightly improved both the flight time and height in both tests, with a progress rate value of 10.91% for the CMJ test and 8.14% for the SJ test.

The results obtained by G.M. in the final testing are much better; the height increased by 9.8 cm in the CMJ test, and in the SJ, the flight time increased from 0.384 to 0.468 s. These results indicate that specialized training improves the ability to reach much higher power values.

Table V. The results for the squat jump test on the right leg and on the left leg

			Right leg			Left leg		
Name	Category	Test	Flight T (s)	Height (cm)	Progress (%)	Flight T (s)	Height (cm)	Progress (%)
B.C	S	T1	0.446	24.4	0.95	0.455	25.4	3.57
		T2	0.449	24.7		0.466	26.6	
T.A.	S	T1	0.373	17.1	-2.13	0.391	18.7	-0.79
		T2	0.368	16.6		0.389	18.5	
M.I.	S	T1	0.463	26.3	-1.08	0.450	24.8	4.16
		T2	0.460	25.9		0.462	26.2	
I.D.	U23	T1	0.361	16	3.26	0.393	18.9	4.70
		T2	0.371	16.6		0.405	20.1	
C.I.	U20	T1	0.296	10.7	25.87	0.360	15.9	5.58
		T2	0.344	14.5		0.373	17.1	
B.A.	U18	T1	0.331	13.4	10.94	0.332	13.5	19.66
		T2	0.354	15.4		0.374	17.1	
G.M.	U16	T1	0.269	8.9	17.37	0.273	9.1	41.03
		T2	0.299	11		0.341	14.3	

*S – senior, U23 – under 23, U20 – under 20, U18 – under 18, U16 – under 16, T – time

Although the improvements were not significant, B.C. registered better results for both legs in the final test, which is particularly important in an event like the triple jump. She had a progress rate value of 0.95% for the right leg and 3.57% for the left leg.

In the SJ test on the right leg and on the left leg, T.A. did not achieve notable differences between the two tests; the height for the right leg was 0.5 cm lower at the final testing, and for the left leg, it was 0.2 cm lower, with a negative progress values for both legs.

M.I. obtained values that were similar to the initial tests; the flight time for the right leg insignificantly decreased from 0.463 to 0.460 s, and for the left leg, it increased from 0.450 to 0.462 s. The athlete had a negative progress rate value of −1.08% for the right leg and a positive value of 4.70% for the left leg.

In the SJ test on the right leg, I.D. recorded similar values to the initial testing, and for the left leg, she recorded an increase of 0.012 s in the flight time, and an increase of 1.2 cm in the height. The progress rate values are positive for both tests.

C.I. showed visible improvements in all parameters for both legs, with the height increasing from 10.7 to 14.5 cm for the right leg and from 15.9 to 17.1 cm for the left leg; the training protocol produced significant parameter adjustments. As can be seen from Table 5, the progress rate values are 25.87% for the right leg and 5.28% for the left leg.

B.A. improved her parameters in the SJ test on the right leg and on the left leg, with the flight times increasing by 0.023 s for the right leg and by 0.042 s for the left leg, with a progress rate value of 10.94% for the right leg and 19.66% for the left leg.

G.M. visibly improved all parameters, as shown by the progress rate values of 17.37% and 41.03%. The height for the right leg increased from 8.9 to 11 cm and from 9.1 to 14.3 cm for the left leg. She significantly improved her parameters for both legs following the protocol, which is extremely important in the triple jump event, which requires a very good explosive power for both legs.

Group analysis

To analyse the trends at the group level, we determined the mean values of every parameter presented in the following tables.

Table VI. The mean values of the parameters recorded in the 15-s jump test on both legs, and on each leg in the initial and final testing

Test	Contact Time (s)	Dif	Flight Time (s)	Dif	Height (cm)	Dif	Power (W/kg)	Dif
15-s jump Test 1	0.246	0.037	0.409	0.020	21.01	3.39	28.71	6.32
15-s jump Test 2	0.209		0.429		24.40		35.03	
15-s jump Left Test 1	0.329	0.037	0.287	0.029	10.67	1.86	13.49	3.04
15-s jump Left Test 2	0.292		0.316		12.53		16.52	
15-s jump Right Test 1	0.305	0.011	0.282	0.012	10.21	0.73	13.85	0.90
15-s jump Right Test 2	0.294		0.294		10.94		14.75	

*Dif – difference

At the group level, we noticed remarkable differences between the initial and final testing. In the 15-s jump test, the contact time decreases by 0.037 s, the flight time increases by 0.020 s, the power increased by 6.32 W/kg, and the height increased by 3.39 cm, as shown in Table 6. In the 15-s jump test on the left leg, the contact time was 0.037 s faster, the flight time was 0.029 s longer, the height was 1.86 cm higher and the power was 3.04 W/kg higher. In the 15-s jump test on the right leg, we also observed better results in the final test, with the contact time being 0.011 s faster, flight time 0.012 s longer, height 0.73 cm higher and power 0.90 W/kg higher.

Table VII. The mean value of the parameters recorded in the SJ test on both legs, SJ on the right leg, SJ on the left leg and CMJ at the initial and final testing

Test	Flight Time (s)	Dif (s)	Height (cm)	Dif (cm)
SJ Test 1	0.498	0,028	30.96	3,09
SJ Test 2	0.526		34.04	
CMJ Test 1	0.510	0,026	32.53	2,93
CMJ Test 2	0.536		35.46	
SJ Left Test 1	0.379	0,022	18.04	1,94
SJ Left Test 2	0.401		19.99	
SJ Right Test 1	0.363	0,015	16.69	1.13
SJ Right Test 2	0.378		17.81	

*Dif – difference, *CMJ – countermovement jump, *SJ – squat jump

In the SJ and CMJ tests, the results recorded by the athletes in the second test were better, as shown in Table 7. The recorded differences show an increase in the flight time in the SJ test by 0.028 s, and the height increased by 3.09 cm. In the CMJ test, the flight time increased by 0.026 s, and the height increased by 2.93 cm. In the SJ test on the left leg, the flight time increased by 0.022 s, and the height increased by 1.94 cm. For the right leg, we observed an increase in the flight time by 0.015 s and by 1.13 cm in the height.

Discussion

According to Glatthorn et al. (2011), the Optojump photocell system is a valid and reliable tool for the assessment of vertical jump height on the field and/or in the laboratory, and it can be used with confidence to detect within-group changes in longitudinal assessments to verify the effectiveness of a specific training program (Glatthorn J.F., 2011).

Owing to the reduced number of participants within the national championship in the triple jump event in the last years, it was not possible to conduct an experiment with a control group and an experimental group. At the individual level, we noticed that the vast majority of athletes improved their parameters following the training protocol performed with the Optojump Next System. The lack of progression at the individual level was also influenced by the fact that the specialized training was performed in combination with other specific activities, and not as an independent training unit. Some studies have not shown any improvement in jump height after a 6-week plyometric training program, meanwhile other studies confirmed that an 8-week long training session with biweekly plyometric training improved jump performance during the season in elite male handball players (Cazan F., Georgescu A., Gidu D., Mușat G., 2022).

Following the analysis of the results at the group level, we observed an improvement in all parameters in the second test. In the 15-s jump test, the contact time decreased by 0.037 s, the flight time increased by 0.020 s, the power increased by 6.32 W/kg, and the height increased by 3.39 cm. In the 15-s jump test on the left leg, the contact time was 0.037 s faster, the flight time was 0.029 s longer, the height was 1.86 cm higher, and the power was 3.04 W/kg higher. In the 15-s jump test on the right leg, the contact time decreased by 0.011 s, the flight time increased by 0.012 s, the height increased by 0.73 cm, and power increased by 0.90 W/kg. In the SJ and CMJ tests, the recorded results showed an increase in the flight time in the SJ test by 0.028 s and by 3.09 cm in the height. In the CMJ test, the flight time increases by 0.026 s, and the height increased by 2.93 cm. In the SJ test on the left leg, the flight time increased by 0.022 s, and the height increased by 1.94 cm. For the right leg, we observed an improvement in the flight time by 0.015 s and by 1.13 cm in the height.

The group analysis revealed that all results recorded during the final test improved, with better values in the contact time (which needs to be as short as possible, under 0.200 s for women), flight time, height and strength. In the CMJ test and squat jump on both legs, a flight time above 0.500 s is considered to be good.

Conclusions

The obtained results give us an idea about the level of anaerobic power, the level of maximal explosive power, the level of muscular elasticity and the level of reactive power; this information can be used in the training process.

The results recorded in the two tests and the fact that all athletes improved their results confirm that the training program applied two times per week and monitored with the Optojump Next System contributes in a positive way to the improvement of the contact time, flight time, height and power of the female triple jumpers. Our findings suggest that training with the Optojump Next System can positively affect the explosive strength performance. The determination of some parameters of the explosive power of the lower limbs for each tested athlete can suggest coaches in what direction the physical training must go and what changes should be made to achieve better results in the triple jump event.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgements

The authors would like to thank Falcon Scientific Editing (https://falconediting.com) for proofreading the English language in this paper.

References:

Abeer, E. (2014). Biomechanical Evaluation of the Phases of the Triple Jump Take-Off in a top Female Athlete. Journal of Human Kinetics. retrieved at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4096103/

Andersen, E., Lockie, R. G., & Dawes, J. J. (2018). Relationship of absolute and relative lower-body strength to predictors of athletic performance in collegiate women soccer players. Sports, 6(4), 106.

Ahsan, M., Ali, F. M. (2021), Determining the relationship between VO2max and explosive power of lower leg muscles in soccer and rugby university players. Journal of Physical Education and Sport ® (JPES).Vol 21 (Suppl. issue 6. DOI:10.7752/jpes.2021.s6419. retrieved at https://efsupit.ro/images/stories/noiembrie2021/Art%20419.pdf

Baştürk, D. & Peker, A.T. (2019). The Effect of a 8 Week-Explosive Power Training on Some Performance Parameters of Students who Study in Sports High School. Higher Education Studies; Vol. 9, No. 4. DOI:10.5539/hes.v9n4p155

Blazevich, A. (2011) The stretch–shortening cycle (SSC). Strength and Conditioning: Biological Principles and Practical Applications. Edith Cowan University. Australia

Borràs, X., Balius, X., Drobnic, F., & Galilea, P.V. (2011) Vertical jump assessment on volleyball: A follow-up of three seasons of a high-level volleyball team. Journal of Strength and Conditioning Research, 25, 1686–1694. retrieved at https://www.academia.edu/32555468/Vertical_Jump_Assessment_on_Volleyball_A_Follow_Up_of_Three_Seasons_of_a_High_Level_Volleyball_Team .

Campos-Vazquez, M. A., Romero-Boza, S., Toscano-Bendala, F. J., Leon-Prados, J. A., Suarez-Arrones, L. J., & Gonzalez-Jurado, J. A. (2015). Comparison of the effect of repeated-sprint training combined with two different methods of strength training on young soccer players. Journal of Strength & Conditioning Research, 29(3), 744-751.

Cazan, F., Georgescu, A., Gidu, D., Mușat, G. (2022). The influence of a pre-competition training program containing plyometric exercises on the training of performance handball players. Journal of Physical Education and Sport (JPES). Vol. 22 (issue 8). Art 235. pp. 1863 – 1868. retrieved at https://efsupit.ro/images/stories/august2022/Art%20235.pdf

Chaabene, H., Negra, Y. (2017). The Effect of Plyometric Training Volume on Athletic Performance in Prepubertal Male Soccer Players. Int. J. Sports Physiol. Perform. 12. 1205–1211.

de Villarreal, E.S., Requena, B., Cronin, J.B. (2012) The Effects of Plyometric Training on Sprint Performance: A Meta-Analysis. J. Strength Cond. Res. 26, 575–584

Dietze-Hermosa, M. S., Montalvo, S., Cubillos, N. R., Gonzalez, M. P., & Dorgo, S. (2020). Association and predictive ability of vertical countermovement jump performance on unilateral agility in recreationally trained individuals. Journal of Physical Education and Sport (JPES). 20, 2076-2085.

França, C., Gouveia, E.R., Caldeira, R., Marques, A., Martins J., Lopes H., Costa, M., Ihle, A. (2021). Predictors of explosive leg power in elite football players. Journal of Physical Education and Sport. Vol. 21 (issue 6), Art 483, pp. 3599 – 3605. retrieved at https://efsupit.ro/images/stories/decembrie2021/Art%20486.pdf

Glatthorn, J.F., Gouge, S., Nussbaumer, S., Stauffacher, S., Impellizzeri, F.M., Maffiuletti, N.A. (2011). Validity and Reliability of Optojump Photoelectric Cells for Estimating Vertical Jump Height. Journal of Strength and Conditioning Research 25(2): p 556-560. DOI: 10.1519/JSC.0b013e3181ccb18d. retrieved at https://journals.lww.com/nscajscr/fulltext/2011/02000/validity_and_reliability_of_optojump_photoelectric.37.aspx

Graur, C. (2014). Comparative techniques analysis of lower limb explosive power to the triplejumpers. The International Scientific Conference eLearning and Software for Education; Bucharest, Vol. 1. Retrieved at

https://proceedings.elseconference.eu/index.php?r=site/index&year=2014&index=papers&vol=16&paper=212042d77c39d95bc2d0b95fbdd0d585

Goranovic, K., Lilić, A., Karišik, S., Eler, N., Anđelić, M., & Joksimović, M. (2021). Morphological characteristics, body composition and explosive power in female football professional players. Journal of Physical Education and Sport (JPES),, 21(1), 81-87.

Guan, S., Lin, N., Yin, Y., Liu, H., Liu, L., Qi, L. (2021). The Effects of Inter-Set Recovery Time on Explosive Power, Electromyography Activity, and Tissue Oxygenation during Plyometric Training. Sensors (Basel). 21(9): 3015

Haff, G. G., Whitley, A., & Potteiger, J. A. (2001). A brief review: Explosive exercises and sports performance. Strength and Conditioning Journal, 23(3), 13-25. https://doi.org/10.1519/00126548-200106000-00003

Healy, R., Kenny, I.C., Harrison, A.J. (2016). Assessing Reactive Strength Measures in Jumping and Hopping Using the OptojumpTM System. Journal of Human Kinetics. (1):23-32. retrieved at https://www.researchgate.net/publication/311589099_Assessing_Reactive_Strength_Measures_in_Jumping_and_Hopping_Using_the_Optojump_System

Kobal, R.; Pereira, L.A.; Zanetti, V.; Ramirez-Campillo, R.; Loturco, I. (2017) Effects of Unloaded vs. Loaded Plyometrics on Speed and Power Performance of Elite Young Soccer Players. Front. Physiol., 8, 742.

Latorre Román, P.A., Villar Macias, F.J., García Pinillos, F. (2017). Effects of a contrast training programme on jumping, sprinting and agility performance of prepubertal basketball players. Journal Sports of Science. 36(1):1-7. retrieved at https://www.researchgate.net/publication/317783459_Effects_of_a_contrast_training_programme_on_jumping_sprinting_and_agility_performance_of_prepubertal_basketball_players .

Maćkała K., Synówka A., Ćorluka M., Vodicar J. (2021). Impact of plyometric training on the power of lower limbs in moderately advanced female volleyball players. Acta Kinesiologica, 15 Supp. 1: 5-12

McGuigan, M.R., Doyle, T.L., Newton, M., Edwards, D.J., Nimphius, S., & Newton, RU. (2006). Eccentric utilization ratio: Effect of sport and phase of training. Journal of Strength and Conditioning Research, 20, 992–995.

McGuigan, M. (2017). Developing Power. Human Kinetics Publishing. USA

Newman, N. (2012). Horizontal Jumps. JumPR Publishing. USA

Ramírez-Campillo, R.; Andrade, D.C.; Izquierdo, M. (2014). Effects of Plyometric Training Volume and Training Surface on Explosive Strength. J. Strength Cond. Res. 2. 2.2714–2722.

Rapotan, A., Mihailescu, L., Mihai, I. (2022). The paradigm of the manifestation level of proprioception in triple jumpers – case studies. Journal of Physical Education and Sport (JPES), Vol. 22 (issue 8), Art 242, pp. 1914 – 1921, retrieved at https://efsupit.ro/images/stories/august2022/Art%20242.pdf

Sattler, T., Hadzić, V., Dervišević, E., & Marković, G. (2015) Vertical jump performance of professional male and female volleyball players: Effects of playing position and competition level. Journal of Strength and Conditioning Research, 29, 1486– 1493

Słomka, K.J., Sobota, G., Skowronek, T., Rzepko, M., Czarny W., Juras, G. (2017). Evaluation Of Reliability And Concurrent Validity Of Two Optoelectric System Sused For Recording Maximum Vertical Jumping Performance versus The Gold Standard. Acta of Bioengineering and Biomechanics. 19(2):141-147. retrieved at https://www.researchgate.net/publication/319320793_Evaluation_of_reliability_and_concurrent_validity_of_two_optoelectric_systems_used_for_recording_maximum_vertical_jumping_performance_versus_the_gold_standard

Zatiorski, V. (2002) The Science and Practice of Strength Training – High Performance Sport. CCPS. Bucharest. Appeared in Romanian. Retrieved at (https://performbetter.co.uk/products/optojump-jump-testing#:~:text=The%20system%20detects%20any%20interruptions,1%2F1000%20of%20a%20second