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PLYOMETRIC PROGRAM EFFECT ON SPRINT AND JUMP PERFORMANCE IN SPEED SKATERS

Ștef Raluca Doina (a)*, Grosu Vlad Teodor (b)
*Corresponding author

(a) Babeș- Bolyai Univeristy, Faculty of Physical Education and Sports, Cluj–Napoca/ Romania, stefralucadoina@yahoo.ca
(b) Tehnical University, Faculty of Automotive, Mechatronics and Mechanical Engineering, Cluj–Napoca/ Romania, vtgrosu@gmail.com

Abstract

The aim of this study was to investigate the effect of a-8week of additional plyometric exercises into the base training and to examine the measures of competitive potential on jump performance and sprint running. We hypothesized that a 8-week plyometric training in junior speed skaters would result in significant changes in (SJ) squat jump, (CMJ) countermovement jump, multiple 5 bound teste and sprint running performance (50m). The subjects (eighteen speed skaters aged 18.1 ± 2.3 years) were divided into two groups, experimental group (E, n = 9) performing plyometric training 2 times per week and control (C, n = 9) normal training. Two jump tests (SJ and (CMJ) were performed using Tendo Power Analyzer WL apparatus to evaluate height of the jumps. Results has been showing that the experimental group has improved in all jumping parameters analysed, squat jump, countermovement jump and multiple 5 bound test comparing to control group. Experimental group showed improvements in (SJ) ($p < 0.001$) and (CMJ) with ($p < 0.01$), but also in sprint velocity over 50m, were significantly improved $p \leq 0.05$ after 8 weeks of additional plyometric exercises. Percentage change between groups were significantly different from pre to post intervention. We conclude that adding plyometric training during off –ice season program improved components of athletic performance in junior speed skaters.

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Keywords: Squat jump, countermovement jump, power, sprint performance

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1. Introduction

1.1. Plyometric training benefits

Plyometric training is an important mean to enhance power in many sports, by introducing jumping, hopping and skipping exercises. Moreover to a similar pattern for skating, as there is needed to produce maximal power in a very short period of time which may increase the sprint acceleration and maximal skating velocity. The plyometric exercises base theory is supporting the action of stretching a group muscle right before a rapid concentric contraction.

In the specific literature this is known as stretch and shortening cycle. This type of contractions are found in the skating pattern as well as in biking or running. Authors, Vissing et al. (2008) consider that gains in maximal strength can be achieved through traditional strength and plyometric training, with the difference that the second method seems to improve more the muscle power.

Recent studies are showing a great contribution of plyometric training in jumping ability. As is shown by the authors Markovic and Mikulic (2010) the SSC enhances the ability of the neural and musculotendinous systems to produce maximal force in the shortest amount of time, prompting the use of plyometric training as a bridge between strength and speed and a more variable effect on running speed, with the greatest improvement seen over short distances.

Plyometric training is a direct action to enhance rate of force development during sprinting and jumping, as the resistance training is shown to increase muscular strength and improve speed acceleration (Fleck & Kraemer, 2004), nevertheless, it seems that athletes of all ages benefit from plyometric training (Sayers & Gibson 2010).

1.2. Plyometric training in speed skating

Power is the most required ability in speed skating. Previous works have reported similarity between long track speed skating start and dry-land sprint start (Song et al., 2017), associations between skating sprint performance and off-ice performance characteristics, such as vertical jump performance (Farlinger et al., 2007).

Another research on this topic shows the importance of plyometric exercises in improving sprint performance (de Villarreal et al., 2008). As running, in speed skating every push requires an explosive movement therefore, plyometric exercises meet the requirements of this sport. In fact, athletes are introducing additional plyometric exercises for a more specific warm-up before training and competitions. This type of exercises includes but are not limited to hops and jumps where the contribution of SSC is to increase specific muscle activation and improve power (Faigenbaum et al., 2009).

Plyometric and resistance training are two of the primary non–sport-specific known as dry-land means used in training programs to improve lower-body performance. Numerous research reports have supported the role of both plyometric and resistance training as part of an overall seasonal training program (Cormie et al., 2011).

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Different training protocols have been applied in recent studies to measure the subjects' athletic abilities. The most common exercises that have been used in these protocols are: jumping, sprinting and last but not least agility (Ferley et al., 2020; Whitehead et al., 2018).

Table 1. Training program for experiment group

Week	Sprint test	Reps	Sets	Jumps	Reps	Sets
1	30m sprint	5	4	0.5-m hurdle, SJ and long jump	10/5/ex	5
2	30m sprint	5	5	0.5-m hurdle, SJ and long jump	10/5/ex	6
3	40m sprint	5	4	0.6-m hurdle, SJ and long jump	10/5/ex	5
4	40m sprint	5	5	0.7-m hurdle, box jump and long jump	12/6ex	6
5	40m sprint	5	5	0.7-m hurdle, box jump and long jump	12/6ex	6
6	50m sprint	5	4	0.3-m DJ and single leg side jump	12/6ex	5
7	50m sprint	5	5	0.3-m DJ and single leg side jump	15/7ex	6
8	50m sprint	5	5	0.3-m DJ and single leg side jump	15/7ex	7

SJ = squat jump; DJ = drop jump;

2. Problem Statement

In the development of sprint and jumps height, the most important aspects are the type of training methods and exercises used and the speed at which the movement is executed. In many studies were applied different protocols (exercises, duration) to test the subjects' athletic abilities such as maximal strength, power and speed that involve jumping, sprinting and agility. Until now, there are less sources in which can be found a combination of different studies results.

3. Research Questions

Due to the specific training conditions on dry-land during off ice-season, it can be understood why it is important to proper evaluate the physical capabilities of skaters other way than on ice. Plyometric training is often used in speed skaters training due to the well know benefits, the most important aspect is improving power without adding an extra load.

Even though we can still put under the question if:

Does a 8-week plyometric training has an influence on developing sprint and jump performance in junior speed skaters?

4. Purpose of the Study

The aim of this study was to determine the effect of a 8-week plyometric training, during the winter season training program for speed skaters, regarding the increase in lower limb power. Training combines different explosive movements, with a similar pattern for skating, like squat jumps, hurdle and depth jumps, followed by short sprint trials according to the intervention program for 8 weeks. We hypothesized an increase of muscular power, which may contribute to a better performance of jump height and sprint

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velocity in comparison to control group who has not fallowed any protocol with additional plyometric exercises in their daily training regimen.

5. Research Methods

The aim of this research was to examine whether a 8-week plyometric training program, during the winter season, would increase power and speed performance of speed skaters comparing to control group who did not followed a specific protocol with additional plyometric exercises. In total 18 non-elite skaters volunteered in our study, which have been randomly divided into two groups, respectively, experimental group (E, n = 9) with specific plyometric training (2 times per week) and control (C, n = 9) standard training.

Pre-testing was performed after the beginning of the winter season (week-4) and post testing after the intervention program (end of 8 week plyometric program). Prior to the final testing, a familiarization sessions was held in the 6^{th} week.

Testing protocol intend to evaluate the jumping height in the following explosive exercises: countermovement jump (CMJ), squat jumps (SJ) and drop jump (DJ). The tests were performed in the same experimental conditions and at the same time of the day. None of the test were performed before the competition days, respectively 4-5days after the event. Experimental subjects had no rule from their normal diet except no caffeine intake at least four hours and no food intake or any other supplements for two hours before testing. The researcher ensured the compliance of the protocol by the evaluated subjects and provided necessary indications for deplyments of the research in safe conditions.

5.1. Participants

Eighteen speed skaters aged 18.1 ± 2.3 years, were divided into two groups. The subjects were training for competing in sprint 500m or long distances 3000m events. Their mean experience of training was 4.2 years. A medical control was performed before starting the season to ensure the good health condition of the subjects, all were found to be fit for physical activities.

5.2. Testing protocol

The study took place at the beginning to the middle competitive season during October to November for a period of 8 weeks. Before the beginning of the winter season, in September, followed a two block weight training period, which consisted in a light load resisted training program for the lower limbs. Moreover, during this period two sessions per week included body weight exercises, specific and non-specific to the skating pattern. During the winter season, training program consisted in 6-8 training per week and participated in 2-3 international events per month.

One training sessions lasted 45 minutes. Each training included different intensity exercises for agility and coordination, and short sprints of 30m, 40m, 50m with maximal velocity followed by flexibility exercises. Before the two days test, researcher, have checked the state of each subject, all have been found in good physical condition. Test protocol was applied after 3-4 days from the last official event or plyometric training for a proper recovery. Before testing a standardized warm-up was performed by each subject tested: 8 min. running, easy jumping exercises followed by very short sprints for a proper and

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specific activation of the main group muscles of lower limbs. First test day included the series of jumps: squat jump, countermovement jump and drop jump and the second test day multiple-5-bound test (MB5) and sprints (30m, 40m, and 50m).

1st day

Height jump for: CMJ, SJ and DJ was evaluated using Tendo WL Analyser (TENDO Sports Machines, Trencin, Slovak Republic) attached to the subjects waist perpendicular to the floor trough a nylon cord and the systems sensor unit is connected to a computer with matching software collecting data Tendo Softaware Computer V-5 (Version 6.0.1, Slovak Republic). Data reliability has been reported before in the research of authors Thompson et al. (2010).

Each squat jump started at a knee angle of 90˚, performed without any additional movements, hands resting on the hips followed by a maximal vertical jump. Countermovement jump started with a pre-stretch action (concentric) with hands on hips before take-off with maximal effort (eccentric action). Fort the drop jump teste, subjects had to rebound from a 0.3m box followed by a vertical jump with minimal contact. No arm swing was allowed during jumping. Between trials three minutes of rest was permitted. The best jump result was recorder and used for analysis. Three attempts were allowed.

2nd day

From a static position, each subject performed a 5 Bound Test: five forward jumps with left-right leg contact, alternatively, to reach the farthest point from start. The distance was measured to the nearest 5 mm reach point.

50m maximal sprint test was performed on an indoor tartan track. Time was recorded with Seiko stopwatch S141 (Seiko, Japan). Participants performed the test two times with a five minutes rest.

5.3. Intervention program

Intervention training program of experimental group is described in Table 01. During the 8-week program, Tuesday and Thursday, a session of 45 min plyometric training was implemented into the regular training regimen. A standardized warm up was performed for 15-minutes (running, easy jumping, and very short sprints). As indicated by the researcher, all exercises had to be done with maximal effort, according to the direction of the movement vertical or horizontal, to reach the farthest point from start or standing position. For an optimal propulsion, hurdle and drop jump was requested to be performed with a small joint angles. The drop jump from the 0.3m box consisted in a set of 10 vertical jumps (rebounds) with 5 sec. rest between jumps (Markovic et al., 2007). Hurdle jump trial involved performing a 10-15 continuous jumps by the subjects over hurdles spaced at 1m distance between each other.

5.4. Statistical analysis

Standard methods were used to determine means and standard deviation using SPSS Statistics Program version 20 (SPSS, Inc, Chicago, IL, USA). Difference between groups and percentage changes over the 8-week intervention program was assessed with T test, according to Levene's test we could determine the homogeneity of variance. Two-way analyses of variance with repeated measures was performed. The calculation formula for percentage changes is as follows: ([posttraining value - pretraining value]/pretraining value) x 100. Alpha was set at $p \leq 0.05$ as criterion for statistical significance.

6. Findings

Statistical analyses showed an increase of explosive power in lower limbs. Comparing to control group, results confirm a better jump performances in all vertical test applied: squat jump and countermovement jump but also in multiple 5 bound jump test (Figure 01, Table 02 and Table 03). Sprint velocity over 50m, were significantly improved $p \leq 0.05$ after 8 weeks program of additional plyometric exercises (Table 03).

Percentage change between groups were significantly different from pre to post plyometric training for experiment group, where: SJ improved with 14.9% and MB 5 8% at a significant level of ($p \leq 0.001$); CMJ 11% and DJ 14.7% ($p \leq 0.01$) and 50m sprinting 4.9% ($p \leq 0.05$).

Table 2. Intraclass correlation coefficients and reliability of jump tests and sprint velocity*.

Tests	ICC	95% CI
Squat jump (m)	0.96	0.94 – 0.99
Countermovement jump (m)	0.96	0.93 – 0.99
Drop Jump ($m \cdot s^{-1}$)	0.94	0.91 – 0.98
Multiple– 5 bound test	0.95	0.92 – 0.98
50m sprint	0.86	0.64 - 0.95

*ICC = intraclass correlation coefficient; CI = confidence interval.

The reliabilities data showed in Table 02 of the height jumps: squat jump, countermovement jump and also drop jump were analysed using intraclass correlation coefficients. Values confirmed the reliability for all of our measurements and parameters.

The results confirm for the jumps and sprint tests the following values:

- Statistical significant difference were observed from pre to post plyometric training in squat jump height and multiple– 5 bound test for experiment group compared to control: 0.29 ± 0.01 vs. 0.20 ± 0.03 and 11.1 ± 0.9 vs. 10.2 ± 0.5, $p \leq 0.001$;
- Statistical significant difference were observed also for countermovement jump and drop jump, 0.27 ± 0.02 vs. 0.19 ± 0.03, $p \leq 0.01$;
- Statistical significant difference was observed in 50m sprint test, where experiment showed an improvement of 7.5 ± 0.8 vs. 7.1 ± 0.6, at the level of $p \leq 0.05$.

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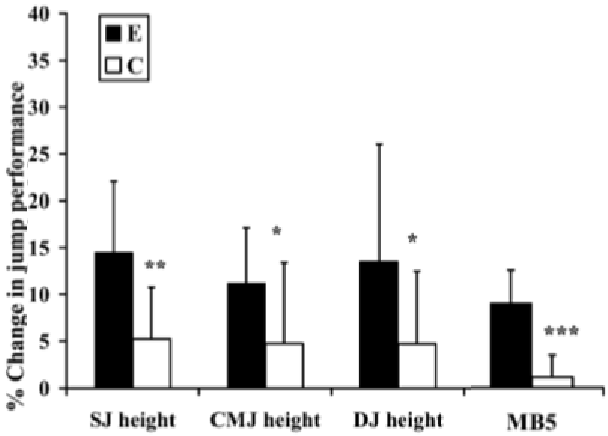

Figure 1. Percentile changes in vertical jump height (SJ), (CMJ), (DJ) and (M5B) across the intervention program

Note: (E) = experimental group performing the plyometric program; C = control group normal peogram. *Student t-test statistical significant at $p \leq 0.05$. **Student t-test statistical significant at $p \leq 0.01$. ***Student t-test statistical significant at $p \leq 0.001$.

Table 3 Presents the results obtained for each jump and sprint test, pre to post plyometric training. Significant differences were observed for all variables measured, to evaluate explosive power and maximal velocity.

Table 3. Values compared pre and post 8-week intervention program for jump and sprint performance between group (E) and (C)

Tests	Test	E	C
SJ (m)	Pre	0.26 ± 2.1	0.19 ± 0.03
	Post	0.29 ± 0.01†.	0.20 ± 0.03
CMJ (m)	Pre	0.28 ± 0.02	0.20 ± 0.04
	Post	0.30 ± 0.02*	0.21 ± 0.04
DJ (W)	Pre	1.183 ± 228	965 ± 131
	Post	1,452 ± 381*	996 ± 183
Multiple– 5 bound test	Pre	10.4 ± 0.8	10.1 ± 0.5
	Post	11.1 ± 0.9†	10.2 ± 0.5
50m sprint	Pre	7.3 ± 0.8	7.0 ± 0.6
	Post	7.5 ± 0.8⸸	7.1 ± 0.6

SJ = squat jump; CMJ = countermovement jump; DJ = drop jump; MB5 = multiple-5bound test; Statistical significance training effects at ⸸ $p \leq 0.05$; $^{*}p \leq 0.01$; † $p \leq 0.001$.

7. Conclusion

Our research is showing that a program of 8-week plyometric training increased the explosive power of lower limbs and, as a result, improving jump and sprint performance of junior speed skaters when comparing to control group who did not performed any additional plyometric program and followed their normal training regimen. Data analysed for experimental group confirmed significant improvement in vertical jump height (SJ, CMJ, and DJ), horizontal jump length MB5 and sprint velocity 50m (Table 03).

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7.1. Sprint performance

Base theory about sprint velocity is indicating that there is the possibility to divided it into two main phases: acceleration phase that typically continues to 30 m and a phase of maximal velocity reached shortly thereafter (Mero et al., 1992). Later after the authors, Delecluse et al. (1995) believed that the duration of acceleration depends on various factors including age, gender and conditioning level, whereas well trained sprinters can accelerate over 60m. For this research and age group selected we assumed that acceleration was complete approximate after 35m, considering the velocity reached between 40 and 45m estimates the maximal speed point.

To the best of our knowledge, this is the first investigation that has measured sprint velocities over 50m in junior speed skaters. Studies conducted in the field investigated the effect of dry-land sprint start training in sprint performance on ice. After brief specific dry-land sprint start training, a small improvement was observed in both dry-land and on ice, suggesting that sprint performance can be improved through a brief dry-land sprint training program (Haug et al., 2019). However, we consider that our results can not be compared too closely with these findings, because we evaluated the velocity over 50m distance and the study presented early is measuring only 14.43m.

Fifty meters sprint velocities were statistically significant increased after intervention program. Some studies are suggesting that is more difficult to improve initial acceleration than maximal velocity due to smaller margin for development (Christou et al., 2006). However, our research is indicating the possibility to develop maximal velocity in junior speed skaters after 8 weeks of plyometric training. More then that, as described in our intervention program, experimental subjects attended two sessions per week, like in the study of the author Christou et al. (2006).

7.2. Jump performance

Data resulted in statistical analysis is showing that our plyometric program had an positive impact, gains in explosive power of lower limbs has been observed and an increase in jumps performance (SJ, CMJ, and DJ) and multiple 5 bound test (MB5). Many studies analysed plyometric training in different sport and in conjunction with other training means and has been shown a significant increase in jump performance (Haug et al., 2015).

Following the intervention program it was observed an augmentation of jump performance both vertically and horizontally, which has been proven in previous power training researches. As mentioned before, values analysed before and after the plyometric program are showing in MB5 an significant increased ($p < 0.001$). Our results as strongly demonstrating the positive effect of additional plyometric exercises combined in a block training or with other training means to develop explosive power which can lead in achieving a higher or a longer jump performance in junior speed skaters.

Related to the multiple 5 bound teste, authors Diallo et al. (2001), confirm a significant development ($p < 0.01$) in experimental group in relation with control group where has been observed no changes between pre and post testing period. Another finding of authors Michailidis et al. (2013), has proven a significant increase ($p \leq 0.05$) in jump performance in experimental group following a specific training program (plyometric training) compared with control group.

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In a study conducted by the authors Markovic et al. (2007), was observed a performance increases of vertical jump for and late puberty as well as in adults. Authors Wilson et al. (1993) are explaining that gains in vertical jump performance may be due to the changes in rate of force development, as has been shown in studies testing adults. It is also possible that plyometric training with specific and non-specific exercises may develop power transfer in between concentric and eccentric phases of muscle action (Hedrick, 1994).

Our findings were limited to nine junior speed skaters, and these results should be extended in younger skaters. Furthermore, to verify the effect of plyometric training should be conducted different types of exercises with different intensities and volumes to identify the optimum dosage for this mean training during winter season. Finally, further researches need to be done to find out that development or gains are not obtained due to an increase in duration of normal conditioning training.

Our research indicates that a 8-week of plyometric program with and without specific skating exercises during the winter season, in junior speed skaters, can significantly develop explosive power in lower limbs and increase jump performance both vertically and horizontally and as a results maximal velocities over 50m sprint. We consider this training method is an important mean to develop performance potential for speed skaters and we suggest implementation of plyometric training to the normal conditioning training program during the winter season. This, not only will increase performance off-ice but will contribute to a better performance on-ice.

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