STUDIA UBB EDUCATIO ARTIS GYMN., LXIV, 4, 2019, pp. 77 - 90
(RECOMMENDED CITATION)
DOI:10.24193/subbeag.64(4).32

BLOCK PERIODIZATION IN SPEED SKATING: EFFECT OF 4 WEEKS ON MAXIMUM FORCE AND POWER IN JUNIORS

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ABSTRACT. Background: Block periodization has experienced a renewed interest in sports specialists due to proven efficiency in recent years with significant implications for optimizing the training programme by improving the methodology used. **Objectives:** The aim of this study was to investigate the effect of block periodization of the force program by combining traditional resistance training with pliometric exercises and induced changes to maximum force and power and its mean, in lower body, in junior speed skaters. **Materials and Methods:** Twelve subjects participated in this study, experiment group (PB) (n = 6) 17.51 ± 1.1 years (1) block periodization, focusing on alternative development of force and power and control (C) (n = 6) 17.89 ± 1.8 years, (2) linear periodization, focusing on the simultaneous development of force and power. **Results**: This indicate a significant increase in total weight lifted (P = 0.04), in (1RM) test during a back squat for both tested groups (PB = 19.6%; C = 10.4%), with a significant difference between this two. For the mean power measured in jump squat, a significant difference was observed between the pre and post-test period (P = 0.02), where the group (PB) had an increase of + 25.3% and (C) a decrease by-15.7%. **Conclusions:** The present study suggests that the block periodization of resistance training induces superior adaptations to the three studied variables respectively, maximum force and power and its mean in experiment group comparable to the control one that has followed a linear periodization, despite the similar volume and intensity.

Key words: *1RM, vertical jump, maximum power, maximum strength*

REZUMAT. ***Periodizarea în bloc în patinajul viteză: efectul a 4 săptămâni de forţă asupra forţei şi puterii maxime la juniori*****. Introducere:** Periodizarea în bloc revine în atenţia specialiştilor din domeniu datorita eficienţei demonstrate în ultimii ani cu implicaţii semnificative pentru optimizarea programului de pregătire prin îmbunătăţirea metodologiei utilizate. **Obiective:** Scopul acestui studiu a

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fost să investigheze efectul periodizării în bloc a programului de forţă prin combinarea antrenamentului de forţă tradiţional cu exerciţii pliometrice şi modificările induse asupra forţei şi puterii maxime şi media acesteia, la nivelul trenului inferior, la patinatorii de viteză juniori. **Material şi metode:** Doisprezece subiecţi au participat în acest studiu, experiment (PB) (n = 6) 17.51 ± 1.1 ani (1) periodizare în bloc, cu accent pe dezvoltarea alternativă a forţei şi puterii şi (C) (n = 6) 17.89 ± 1.8 ani, (2) periodizare liniară, cu accent pe dezvoltarea simultană a forţei şi puterii. **Rezultate**: Acestea indică o creştere semnificativă a greutăţii totale ridicate (P = 0.04), la testul (1RM) în timpul unei semi-genuflexiuni cu bara în spate pentru ambele grupe testate (PB = 19.6%; C = 10,4%), cu o diferenţă semnificativă între cele două. Pentru media puterii testate la proba săritura în înălţime, s-a observat o diferenţă semnificativă între perioada pre şi post testare (P = 0.02), unde grupul (PB) a avut o creştere cu +25.3% şi (C) o scădere cu -15.7%. **Concluzii:** Studiul prezent sugerează faptul că periodizarea în bloc a antrenamentului de forţă induce adaptări superioare la nivelul celor trei variabile studiate respectiv forţă şi putere maximă şi mediei acesteia la grupul experiment comparabil cu grupul control care au urmat o periodizare liniară, în ciuda volumului şi intensităţii similare.

***Cuvinte cheie**: 1RM, săritura în înălțime, putere maximă, forţă maximă.*

Introduction

Periodization is the modality for sports coach to design the resistance training programs to reach the set objectives trough manipulation of different parameters (e.g. load, repetitions, sets, order of exercise and their number, rest, training frequency) in order to maximize training adaptations and to prevent the onset of overtraining syndrome (Lorenz, Reiman and Walker, 2010).

Strength is the foundation for all other physical qualities like power, velocity, agility, and so on. This type of organization contributes to proper strength, speed, power development and sports performance (Behringer, Vom Heede, Matthews and Mester, 2011). It appears from the available strength training literature that periodization is usually needed for maximal strength gains to occur (Fleck and Kraemer, 2004). It seems that even that daily planning is more beneficial that the lack of one to record progress at the level of this qualities (Hoffman and Ratamess, 2009).

Block periodization involves highly concentrated, specialized workloads. Each step in the training cycle has a large volume of exercises focused on specific, targeted training abilities to ensure maximum adaptation (Issurin, 2010) and for maintaining the same level of development during the competitive period

and even for long term. The linear periodization model focuses on the development of basic qualities (in the general form) but they tend to decline during a winter competition season such as in the case of speed skating. Issurin, (2010), has proposed that power and strength can be maintained for up to 30 days while peak performance can be maintained for 5-8 days.

Another example of differences in the block approach is the concept of "complex training," whereby a strength exercise is followed by a biomechanically similar plyometric exercise (i.e. back squat followed by a squat jump) (Malisoux, Francaux, Nielens and Theisen, 2006), but in a strict order (there are two different methods of developing force and power addressed separately). However complex training is also used in other forms of periodization that have a longer duration.

The positive results obtained in the studies of Helgerud et al., (2007), Marques, Franchini, Drago, Aoki and Moreira, (2017), Manchado, Cortell-Tormo and Tortosa-Martinez (2018), can partly explained by the fact that the test was short and high in intensity, parameters that have a direct correlation with sports performance. It also seems that this type of training has given superior results for athletes participating on several competitions over the year (e.g. cycling, skiing, and so on.). Conducting more studies in this area is necessary before formulating definitive conclusions.

Our attention in this study was focused on two qualities determinants in speed skating, in a 4-week block training. In a meta-analysis by the authors Harries, Lubans and Callisterr, (2015) they suggested the implementation of working blocks lasting between 2-6 weeks providing an adequate and new stimulus for the development of force overcoming a possible plateau.

The traditional method of measuring maximum force is testing a maximum repetition (1RM). The force is closely correlated with the ability to quickly produce a high level of force and as a results the development of the maximum force should present a first target set for athletes with a lower force level (Cormie, McGuigan and Newton, 2011).

Exercise intensity or load is commonly accepted as one of the critical components for achieving strength based adaptations. This is fairly well supported in the literature and the common recommendation of loads approximately >80% of 1RM in trained individuals should build the foundation of most programming for strength (Peterson, Rhea and Alvar, 2005).

Power development can be subdivided into a focus on muscular strength, rate of force development, and maximal force at high velocities of movement (Cormie et al., 2011). There are excellent arguments for a high load approach (50-70% of one repetition maximum 1RM) as well as for a low load approach (<50% [1RM]) in exclusion but a "mixed methods approach" combining both appears to be the most beneficial (Stone, et al., 2002). By the previous mentioned

author, this approach to training for power has been suggested as optimal since it combines heavy resistance training with higher velocity work in order to develop power production across the entire force/velocity spectrum.

Ballistic exercises e.g. squat jump, throwing ball, jumping over obstacles, have a great impact on the high velocity area of the force-velocity curve. This method is in contrast to force training with heavy loads that have a greater effect on this relationship. The concept of optimal load training indicates that training loads should be chosen to allow for maximal power output as this is the most effective means of further power development (Bride et al., 2002). It seems plausible to perform additional ballistic/plyometric exercises in addition to traditional heavy resistance training, a combination that develops maximum force (1RM) and muscle strength more that it would have been possible through a traditional training alone due to the increase in the rate of force development.

Previous studies have observed associations between skating sprint performance and off-ice performance characteristics, such as vertical jump performance (Farlinger, Kruisselbrink and Flowles, 2007) and muscular strength (Feser et al., 2016), though for the latter, other studies have provided conflicting results (Potteiger, Smith, Maier and Foster, 2010). However, the vertical jump is an accurate way of measuring the ability to produce power of the lower limbs (Bride et al., 2002).

Speed skating requires a high level of performance in many different physical qualities. Those mentioned before muscular strength, power and VO2max are viewed as important physical determinants in ice skating performance (Roczniok et al., 2016), and there qualities should be developed during off season to improve the performance in winter competition season (Farlinger et al., 2007).

During the last years, focus has been shed on the potential benefit of block periodization (Issurin, 2010; 2016), wherein shorter training periods are dedicated to focus on improving a few selected abilities (Ronnestad, Hansen, Thyli, Bakken and Sandbakk, 2016). However, it has also been indicated that block periodization of strength training leads to superior adaptations in strength and power in well-trained athletes (Painter et al., 2012), though this finding does not seem to be universal (Bartolomei, Stout, Fukuda, Hoffman and Merni, 2015).

Objectives

The present study investigates the effects of block periodization of strength and power training, where one intervention group is focusing on alternating block development of strength (2 weeks) and power (2 weeks), while the control group is focusing on simultaneous development of strength and power. Overall, the two

groups performed equal volumes and intensities of both force and power, training during the 4-weeks training intervention. We hypothesized that block periodization would induce superior adaptation in peak power output and mean observed in vertical jumping and maximal force trough total maximum load lifted (1RM).

Materials and Methods

Participants

In this study participated 12 junior speed skaters, experiment group (BP) (block periodization) (n = 6) 17.51 ± 1.1 years with a specific training protocol and control group (C) (n = 6) 17.89 ± 1.8 years. Informed written consent were obtained from all participants prior to participation. Written consents were also obtained from the legal guardians of participants that were under the age of 18 at the time of study start-up.

Training protocol

The training program for the experiment group followed a model of block periodization focusing on the alternative development of the maximum force and power, in which the volume was progressively reduced in detriment of the increase in intensity. The test periods were performed pre and post after the 4-week intervention period. Each week included three resistance trainings with a duration of approx. one hour. The first two weeks assumed the achievement of a specific training for the development of maximum force being divided into two stages. In the first, the subjects performed 3-4 sets of 4-10 repetitions with 70-85% of 1RM previously determined and in the second 3-4 sets of 2-4 repetitions with 85-100% of 1RM.

In the next two weeks the emphasis was on developing power, training consisting in the realization of two classical exercises (performed in the previous two weeks) to which 4 other ballistic and plyometric exercises were added. In the first stage the subjects achieved 3-4 sets of 6-8 repetitions with 30-50% of 1RM and in the second 3-4 sets of 4-6 repetitions with 40-60% of 1RM, exercises in which focus was on the speed and explosive execution.

The plyometric exercises were performed at the beginning of the training followed by the resistance training (American College of Sports Medicine, 2002), 2 sets of a 4-6 repetitions with maximum effort, jumping over obstacles (fence) on one foot forward and sideways (2 min. rest between sets), in length, with elan, side jumping (skaters jump) Table 1. The control group followed a linear periodization

in witch attention was concentrated on the simultaneous development of the two qualities. During the 4-weeks the two groups achieved a similar workload and intensity, the difference consisting of the periodization model.

Table 1. Training protocol for experiment group

Exercise	Stage 1 (2 weeks)		Stage 2 (2 weeks)	
Strength 70-100% of 1RM	Sets *x* repetitions	Rest	Sets *x* repetitions	Rest
Back squat	4 x 6	2 -3 min.	4 x 2-3	3 - 4 min.
Single leg squat	3 x 4	2 -3 min.	3 x 2	3 - 4 min.
Press	3 x 8	2 -3 min.	3 x 4-6	3 - 4 min.
Front squat	3 x 10	2 -3 min.	4 x 6	3 - 4 min.
Sideway squat (single leg)	3 x 4	2 -3 min.	3 x 3	3 - 4 min.
Power 30-60% of 1RM				
Jump squat (30-50% of 1RM)	4 x 8	2 -3 min.	40-60% 1RM 4 x 6	3 - 4 min.
Jump single leg squat	2 x 5	2 -3 min.	3 x 3-4	3 - 4 min.
Lean single leg squat	2 x 6	2 -3 min.	2 x 4	3 - 4 min.
Squat with dumbbell	2 x 8	2 -3 min.	2 x 6	3 - 4 min.
Hang clean	3 x 4	2 -3 min.	3 x 2-3	3 - 4 min.
Sideway push (single leg)	3 x 6	2 -3 min.	3 x 4	3 - 4 min.

Force testing

For testing the maximum force, the 1RM was applied to the subjects of both groups before and after our intervention. The warm-up consisted of 10 minutes cycling with a standard resistance of 105 W (XTPRO Bike 600, Tehnogym Usa Corp., U.S. A) followed by 5 minutes mobility exercises. Prior to the actual testing a specific warm-up with weights was carried out, which assumed a set of 5-8 repetitions performed with 40-60% of the maximum load presumed for each subject. After a 3 minutes rest, 3-4 attempts were allowed (with 2-3 minutes rest) to determine the maximum load. Repetition was considered correct when the angle formed by the knee flexion was 90˚ specific to each subject. During the test, the researcher and coach were present.

Power testing

Power testing was performed 48 hours after strength testing were measured during a vertical jump using Tendo Weightlifting Analyser (TENDO Sports Machines, Trecin, Slovak Republic), data being analyzed with Tendo

Softaware Computer V-5 (Version 6.0.1, Slovak Republic). Before the testing took place, each subject performed a standard warm up – 10 min. cycling on ergometric bicycle. The test consisted in a vertical jump, from a static position (the angle between the calf and the thigh being 90 °) without a previous elan and as high as possible avoiding any complementary movement of the arms (Hoffman et al., 2005). 3 attempts were allowed, the height of the jump, the maximum power and the average of the best jump was recorded for analysis. The additional load used in this test was 30% of 1RM considered optimal by the authors Wilson, Newton, Murphy and Humphries, (1993).

Statistical Analysis

Standard statistical methods were used to calculate means and standard deviations which were used to describe all performance data. A 2 × 2 repeated-measures analysis of variance was used to analyze all performance data. Subsequent Tukey's post hoc tests were used to determine pairwise differences when significant F ratios were obtained. For all statistical tests, a probability level of $P \leq 0.05$ was established to denote statistical significance. The size effect was calculated after the following formula ([Mean (PB) – Media (C)] / SD (standard deviation) of (C). According to the author, Rhea, (2004), a value between 0.5-1.0 represents a moderate effect and > 1.0 great effect. For all statistical tests, a probability level of $P \leq 0.05$ was established to denote statistical significance.

Results

The results showed that subjects of both groups tested, experiment (PB) group with block periodization and control (C) group with linear periodization after 4 weeks, maximum force measured trough (1rm) test, significantly improved. The difference between the two groups and testing periods (pre to post) is statistically different (P = 0.04) to (PB) (pre 89.7 kg vs. post 111.5 kg, with a difference of + 21.8 kg and for (C) (pre 92.3 kg vs. post 102.9 kg with a difference of + 10.6 kg (Fig. 1).

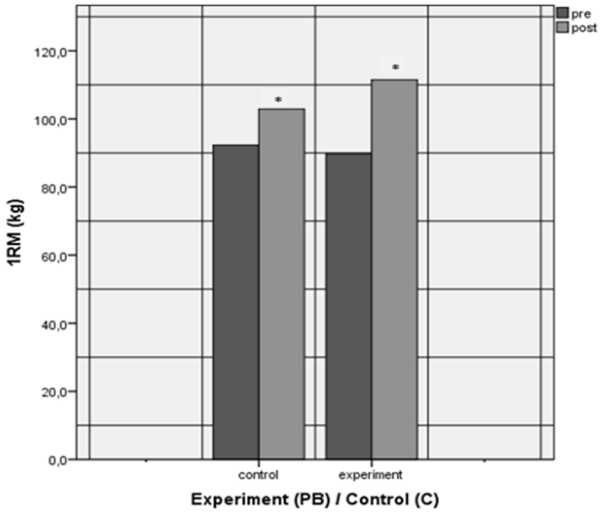

Fig. 1. Difference observed between (PB) and (C) groups in maximum force (1RM).
*Indicating a significance ($P < 0.05$) between pre and post period.

The progress obtained in vertical jump by the (PB) group was significantly between the two periods with + 5.5 cm (pre 18.7 cm, SD = 0.20 vs. 24.2 cm, SD = 0.37) and between the two (PB) and (C) post test (24.2 cm, SD = 0.37 vs. 1 9.8 cm, SD = 0.21), $P = 0.05$, where the size effect is high ES = 1.25 in favor of the (PB).

The mean power and maximum power recorded during the vertical jump between the pre and post period shows a significant difference in mean power ($P = 0.02$), ES = 2.97. The difference observed between the two groups was statistically significant for the mean power with a difference for (PB) group of (+ 367.7 W) and control group (-203.8 W) and for the maximum power difference for (PB) of (+ 233.6 W) and for (C) of (-189.2 W) (Table 2).

Tabel 2. Results obtained by the (PB) and (C) groups for power testing in jump height.

	Experiment (PB)	Control (C)
High jump mean power (W)		
Pre	1087.9 ± 135.2	1303.1 ± 78.8
Post	1455.6 ± 79.7*	1099.3 ± 156.4
High jump maximum power (W)		
Pre	1842.2 ± 141.3	1956.5 ± 112.9
Post	2075.8 ± 89.7	1767.3 ± 103.6

PB = experiment group block periodization; C = control group linear periodization.
*$P < 0.05$ between groups.

Discussion

Following the literature review on this topic, we can say that this is the first study comparing the effect of block periodization specifically quantifying the development of dynamic force, trough combining traditional resistance training and additional plyometric exercises on the maximum force and power and its mean with linear periodization, in junior speed skaters.

The results obtained in the present study indicates that resistance training can lead to increases in maximum force determined by the maximum total load lifted respectively (1RM) (kg). Following the introduction of plyometric exercises, a significant improvement was observed in the maximum power and its mean on the lower body, progress reflected in the results achieved in vertical jump test by the subjects of experiment group.

In our research the results indicates the acceptance of the hypothesis that the block periodization could increase the value of maximum power and its mean observed in vertical jump and maximum force determined by the total load lifted (1RM).

The most relevant discovery of this study was that combining traditional resistance training with plyometric exercises results in a significant improvement in mean power in vertical jump test for the (PB) group with block periodization compared to control group with linear periodization at the post intervention period (PB) 1455.6 W ± 79.7 * vs. (C) 1099.3 W ± 156.4. These differences were evident despite the fact that the study protocol investigated the effect of a 4 weeks training during the dry-land preparation (0ff-season) in junior speed skaters.

The progress observed is similar to the one obtained in a study measuring force and power and the jump height in handball players (Manchado, Cortell-Tormo, & Tortosa-Martinez, 2018). Although there are some methodological differences, the results indicate that block periodization is more effective that the linear model when comes to increasing force (Painter et al., 2012) and could be a reason why the (PB) group in our study has achieved this progress focusing on power at week 3 and 4. Moreover, this model of periodization is in accord with the benefits suggested by Issurin, (2010).

Previous studies have registered improvements in endurance following a block periodization in sports that requires both strength, power and endurance such as athletics (Painter et al., 2016) or judo (Marques, Franchini, D Rago, Aoki and Moreira, 2017) but none of these studies included a control group, which makes it difficult to interpret the efficiency of block vs. linear periodization.

The linear periodization includes a large volume of work as for elite athletes and this can lead to compromising development of muscle strength and power (Wilson, Marin, Rhea, Wilson, Loenneke and Andreson, 2012). It has been

argued that many studies concerning block periodization do not include variations in the variables studied from one week to another so that they evaluate general models and not periodization itself (Bartolomei et al., 2015).

Therefore, the variation in our study assumed the decrease in volume and intensity and exercises performed in the experiment group, while a balance was kept between the two qualities (similar number of sets but different exercises and repetitions) and between the two groups during the intervention period.

In line with our observations, it has been suggested that the ability to achieve high power values and rate of force development is positively interfered with the combination of force and speed rather than applying maximum force at a low velocity (Rhea et al., 2008). The results confirm a great effect size of power development seen between the two tested groups.

Despite the progress, more clearly achieved by the experiment group in vertical jump, a statistically significant difference between the two groups and test periods was observed. A significant difference was seen in vertical jump for mean power where the control group decreased between the two test periods (C) (-203.8 W) and increase in experiment group (PB) (+ 367.7 W). The difference is statistically significant between the two groups (PB) + 25.3% and (C) -15.7%.

The observed progress of mean power in vertical jump showed that combined resistance training with plyometric exercises organized in block training have a positive effect on the development of force and power. Control group was observed a significant decrease in mean power. These results are in agreement with another study that showed, linear periodization in which is addressed alternately the development of force and power (without additional plyometric exercises), Bartolomei, Stout, Fukuda and Hoffman, (2015), and could have a potentially negative impact on power in lower body.

Our results instead demonstrate the importance of including the most specific plyometric exercises in the resistance training for optimum power development. The increase in power observed could in turn increase the probability of reaching the maximum force area by increasing to a greater extent the total load of 1RM.

For the second variable assessed, maximum power, no statistically significant improvement was observed in any of the groups, (PB) + 11.3% and (C)-9.7% at the post intervention time. The lack of statistical significance of maximum power in the intervention group can be attributed to a small number of subjects (PB) n = 6 and to a relatively small significance level *(P* = 0.41) that could mask the increase in mean power observed in the conducted study. In another study by the authors Kraemer, Ratamess, Volek, Mazzetti and Go´mez, (2000), authors they failed to indicate the statistical significance of maximum power value obtained despite the difference of means when the number of subjects was 17 or less. Thus, a larger sample may be necessary to confirm main effects of improving maximum power.

With regard to the assessment of maximum force, results obtained by the both groups investigated recorded progress with (PB) 19.5% and (C) 10.4% improvement showing that the results differ significantly between them. These data are in accord with those of authors Hofman et al. (2005), observing significant improvements for 1RM test in a group of olympic athletes compared to another group that followed a traditional method of resistance training. Subjects researched regardless of the group they were part of, are elite athletes who regularly performed resistance training before the start of the study and had more experience with this type of exercise.

The changes in our study reflected a great familiarity which may indirect suggest that the additional plyometric exercises to the traditional resistance training may have a potentially higher effect when individuals have reached a greater muscular strength level and can be used as an additional incentive technique and sometimes even to prevent the installation of a plateau and may partially explain the progress made by both groups in 1RM test (in particular in control group), but still statistically significantly differ between the two test periods and groups.

Both strength and power of the lower limbs improve the sprint velocity on the ice in speed skaters. These two qualities were previously associated with an increase in speed (displacement) in sprint distances (Felser et al., 2016). The results obtained in our study can have a direct practical implications for speed skaters, as confirmed by the previous mentioned authors that these qualities are important for improving sport performance on ice. Among the limitations of this study, seems to be the duration of intervention period that was limited to 4-weeks and future research should investigate the effects of block periodization in both physical capacity and sports performance on and off ice, but also for a longer period of time.

Conclusion

In conclusion, the present study suggest that block periodization in resistance training (by combining traditional resistance training with plyometric exercises) can induce superior adaptations in both studied variables: maximum force and power and mean compared to linear periodization in which focus is on traditional methods of development the above mentioned qualities (by alternative approach of the two with similar volume work and intensity), to junior speed skaters. The results have positive implications for the inclusion of this type of exercises for coaches and athletes aiming to increase maximum force, respectively 1RM.

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