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Original Article

The Effect of a Complex Training Program on Skating Abilities in Ice Hockey Players

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Abstract. [Purpose] Little data exist on systemic training programs to improve skating abilities in ice hockey players. The purpose of this study was to evaluate the effectiveness of a complex training program on skating abilities in ice hockey players. [Methods] Ten male ice hockey players (training group) that engaged in 12 weeks of complex training and skating training and ten male players (control group) that only participated in 12 weeks of skating training completed on-ice skating tests including a 5 time 18 meters shuttle, t-test, Rink dash 5 times, and line drill before, during, and the training. [Results] Significant group-by-time interactions were found in all skating ability tests. [Conclusion] The complex training program intervention for 12 weeks improved their skating abilities of the ice hockey players.

Key words: Ice hockey, Complex training, Plyometric training

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INTRODUCTION

Ice hockey is characterized by high-intensity intermittent skating and rapid changes in direction and velocity, as well as frequent body contact. Ice hockey games are 60 minutes in duration and consist of three 20-minute periods. The typical player plays for 15 to 20 minutes; however, star players could have 30 to 35 minutes of ice time[1)]. All activity in ice hockey occurs on ice, and so some tests for ice hockey players also need to be performed on ice. In spite of these necessaries, little data exist on systemic training programs and proper test methods to improve skating abilities in ice hockey players so far. Skating ability is one of the most important factors for ice hockey players. Therefore, ice hockey players, compared with other athletes, are required to continuously improve their levels of fitness and require systemic and organized training programs that help them improve their skills.

Recently, the use of complex training as a method of combining weight and plyometric exercises during the same training session is growing in popularity[2)]. Verkhoshansky[3)] introduced the term complex training, which describes a "complex of exercises for the development of reactive ability is fulfilled in a background of heightened excitability of the central nervous system, brought about by preliminary fulfillment of exercise requiring great power." Despite the fact that questions remain about the potential effectiveness and development and implementation of this type of training, results of recent studies are useful in guiding practitioners in the development and implementation of complex training programs[4)]. The proper combination of plyometric training and weight training is thought to be useful for developing athletic power. Complex training alternates biomechanically similar high-load weight-training exercises with plyometric exercises, set for set, in the same workout[5–8)]. An example of complex training would include performing a set of squats followed by a set of jump squats[5–8)]. Chu[9)] suggested that high-intensity weight training can improve the excitability of the motor nerve and that this provides the best condition for plyometric training that follows immediately after. Plyometrics may be defined as "jumping exercises that involve a rapid deceleration of body mass followed immediately by rapid acceleration of that body mass in an opposing direction"[10)]. Weight training facilitates concentric performance to a greater extent, whereas plyometric training emphasizes the eccentric component and rate of force development[11)]. Therefore, effective complex training workouts rely on a succession of successful marriages of a resistance (weight) training exercise and a plyometric training exercise[9)]. The purpose of this study was to evaluate the effects of complex training on skating abilities of ice hockey players using the 5 time 18 meters shuttle, t-test, Rink dash 5 times, and Line drill before, during, and after training.

SUBJECTS AND METHODS

This study was approved by the Institutional Review

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Table 1. The physical characteristics of the subjects

Variables	Control group (n=10)	Training group (n=10)
Height (cm)	176.2±4.0	176.0±4.2
Weight (kg)	75.5±9.2	74.8±10.7
Body fat (%)	16.1±3.6	16.2±4.3

Values are expressed as means ± SD

Table 2. Complex training combination

Types		Items
Upper body	Weight training	1. Bench press 2. Biceps curl 3. Lying triceps extension 4. Crunch 5. Lat pulldown
	Plyometric training	1-a. Chest pass 2-b. Depth push-up 3-c. Two hand overhead throw 4-d. Sit-up pass 5-e. Two Hand side throw
Lower body	Weight training	1. Back squat 2. Leg curl 3. Leg extension 4. Standing calf raise 5. Hip sled
	Plyometric training	1-a. Squat jump 2-b. Tuck jump 3-c. Pike jump 4-d. Depth jump 5-e. Double-leg zigzag hop

Table 3. Complex training program

Phase	1st Phase (1–6 weeks)	2nd Phase (7–9 weeks)	3rd Phase (10–12 weeks)
Complex training	Weight training / plyometric training	Weight training / plyometric training	Weight training / plyometric training
Intensity	70–75% of 1 RM.	80–85% of 1 RM.	Over 95% of 1 RM.
Frequency	3 days/1 week	3 days/1 week	3 days/1 week
Sets	3 sets	4 sets	5 sets
Resting time	2–3 mins	2–3 mins	2–3 mins
Repetitions	12 times^{WT} /10 times^{PT}	7–8 times^{WT} /13 times^{PT}	2–3 times^{WT} /15 times^{PT}

^{WT}: Weight training, ^{PT}: Plyometric training

Board of Sahmyook University (SUCB 11-001). Twenty male ice hockey players, 18 to 22 years of age, volunteered to participate in a complex training program for 12 weeks. The subjects were assigned randomly to either the control group (C group, 10 subjects) or the training (experimental) group (T group, 10 subjects). The general physical characteristics of the subjects are shown in Table 1.

Each subject signed an informed consent form and completed a health history questionnaire. The T group participated in a complex training program that consisted of 10 weight-training exercises and 10 plyometric-training exercises targeting each body part and 4 on-ice training exercises for 12 weeks. The subjects in the C group were asked to refrain from any weight and plyometric-type training and only participated in on-ice training for the same period. Table 2 shows the complex training combination. For each body part trained, subjects performed one exercise from the weight portion and one to match it from the plyometric portion.

The complex training was divided into three phases and performed by the T group as shown in Table 3. The plyometric training were performed after completing weight training, that is, between weight training. The frequency, intensity, number of sets, resting time, and number of repetition for the complex training program are shown in detail in the table.

In addition, both the T and C groups participated in on-ice training, which consisted of the 5 times 18 meters shuttle, T-test, rink dash 5 times, and line-drill. The methods of on-ice training described below.

As shown in Fig. 1, the total distance between one blue line and the other blue line is 18 meters. Going back and forth between the two blue lines five times represents a total distance of 90 meters. The 5 time 18 meters shuttle tests both the stopping movement and speed of ice hockey players.

As shown in Fig. 2, the T-test is performed with the player skating the 9 meters from the blue line to the center of the center circle. The player starts when he hears a whistle being blown. First, he skates to the center line and stops. Second, he steps forward, turn to the left, and skates to the end of the center circle. Third, he aligns his feet, turns to the right, and then skates to the end of the circle and stops. Fourth, he steps forward, turns to the right, and skates to the middle of the center circle and stops. Fifth, he skates backwards to the blue line. The T-test tests both the abil-

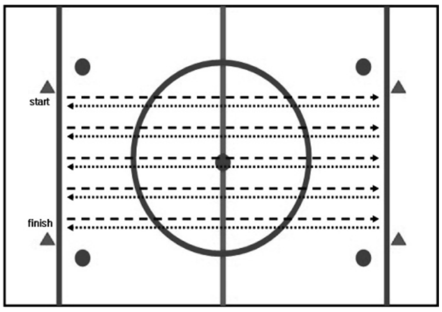

Fig. 1. Five times 18 m shuttle on ice

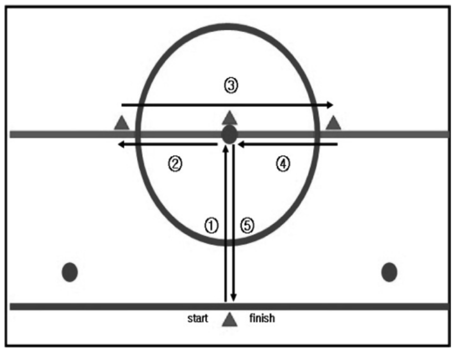

Fig. 2. t-test on ice

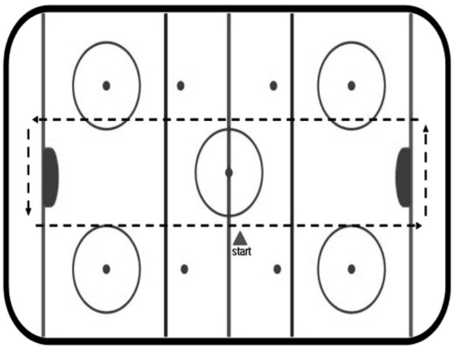

Fig. 3. Rink dash five times on ice

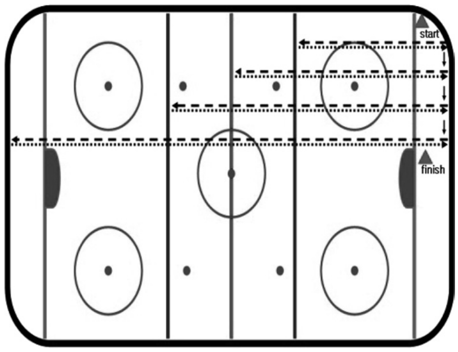

Fig. 4. Line drill on ice

ity to rapidly change direction and the agility of ice hockey players.

As shown in Fig. 3, rink dash 5 times is performed by skating from one side of the rink to the other, around the back of the net, back down to the other side, and then around the back of the net on that side at top speed 5 time. This test measures the endurance of an ice hockey player.

As shown in Fig. 4, the line drill starts behind the end line. First, the player skates to the closest blue line and returns to the end line. Second, he skates to the center line and returns to the end line. Third, he skates to the second blue line and returns to the end line. Fourth, he skates to the end line on the opposite side of the link and returns to the original end line, where he stops. This drill requires continuity and skating at top speed. The line drill also tests both the stopping movement and endurance of ice hockey players.

The T-test and link dash 5 times were performed on Monday, Wednesday, and Friday, and the 5 time 18 meters shuttle and line drill were performed on Tuesday, Thursday, and Saturday. The on-ice training program is shown by phase in Table 4.

The tests of ice skating abilities on ice consisted of the 5 time 18 meters shuttle, T-test, rink dash 5 times, and line drill. To evaluate skating abilities, all subjects completed the tests before (0 week), during (6 weeks), and after training (12 weeks). Each test was measured with 1/100-sec, accuracy by using a stopwatch. All tests were measured twice, and the better record of two was selected for each test. All subjects took a rest of 10 min between tests. The intensity of all tests was measured by checking the subject's pulse over the carotid artery for 10 seconds. Then their heart rate was evaluated by multiplying the number by 6. Maximal heart rate was calculated by subtracting the subjects age from 220, and all subjects were asked to exert their maximum effort and maintain their maximal heart rate during every test.

Table 4. On-ice training program by each phase

Phase	1st Phase (1–6 weeks)	2nd Phase (7–9 weeks)	3rd Phase (10–12 weeks)
Frequency	3 times/wk	3 times/wk	3 times/wk
Intensity	Dash	Dash	Dash
Resting time	2 mins	2 mins	2 mins
Sets	3 sets	4 sets	5 sets

The data analysis of this study was performed by using the IBM PC SAS package (Release 6.12 Windows), and the mean and standard deviation for each measurement item were calculated in each group. The interaction effects were examined between group and time variation by two-way repeated measures ANOVA. We used block design ANOVA to compare values from before, during, and after training with respect to the overall training effects in players. Duncan's Multiple Range test was used for Post-hoc analysis if significant differences existed. P values of <0.05 were considered statistically significant.

Table 5. Results of skating ability tests

Test	Group	Before (sec)	During (sec)	After (sec)	Δ (%)
5 times 18 m shuttle***	Control	36.73±1.20	36.97±1.09	37.47±1.44	2.01
	Training###	40.36±1.84	38.28±1.14	36.80±0.87	−8.82
t-test***	Control	9.42±0.61	9.70±0.42	9.69±0.38	2.87
	Training ###	11.51±0.78	10.21±0.43	9.53±0.43	−17.20
Rink dash 5 times***	Control	86.59±2.47	86.68±1.95	86.62±2.02	0.03
	Training ###	92.76±4.44	88.33±2.17	86.64±2.10	−6.60
Line drill	Control ###	53.04±1.26	51.46±1.73	49.11±2.09	−7.41
	Training ###	55.79±1.66	51.50±1.38	50.56±3.67	−9.37

Values are expressed as means ± SD. ** p< 0.01 (group); *** p< 0.001 (group); ### p< 0.001 (time)

RESULTS

Table 5 shows the results of two-way repeated measures ANOVA analysis of skating ability as means and standard deviations.

As shown in Table 5, significant group-by-time interaction was found in the 5 time 18 meters shuttle, T-test, and rink dash 5 times test (p<0.0001). Significant differences were found in either the C or T group in the 5 times 18 meters shuttle, T-test, and rink dash 5 times test during the training period. Significant differences were also found in each time variations on training group. Also, significant group-by-time interaction was found in the line drill test (p<0.01). Significant differences during the training period were observed in time variation, but, no significant differences were observed between the groups.

As started above, the 5 times 18 meters shuttle, T-test, Rink dash 5 times, and line drill were performed as on-ice training and measurement methods in this study. The present study showed that the 10 players in the T group who continued complex training for 12 weeks showed improved skating abilities, such as stopping ability, agility, the ability to change directions, and endurance, compared with the C group.

DISCUSSION

Previous studies have demonstrated an enhancement of motor performance associated with plyometric training combined with weight training or the superiority of plyometrics compared with other methods of training[12–14]. The rationale for this study was based on the hypothesis that skating abilities, which are related to the real performance on ice, in ice hockey players are influenced by a complex training program intervention off the ice for 12 weeks. Findings of the present study support this hypothesis.

Evans et al.[15] examined the complex training effect of combined bench press and medicine ball throws and demonstrated improved plyometric performance in the complex condition with 10 college-age males. The subjects performed a seated medicine ball put before and four minutes after performing a bench press with a 5RM load. The results indicated a significant increase in medicine ball put distance of 31.4 cm (no standard deviation available) following the 5 RM bench press compared with the medicine ball put distance before the bench press[15]. The researchers also reported a strong correlation between improvement in medicine ball put distance and 5 RM bench press strength[15]. In the present study, the T group performed a medicine ball chest pass after performing a bench press, and the results demonstrated improvement of skating abilities in ice hockey players. Although many training studies have also been conducted to examine the effectiveness of complex training, few studies have been conducted to examine the effectiveness of complex training with sport-specific training in ice hockey players.

Another training study examined the effects of a three-week complex training program with seven division I college female basketball players[16]. The data from this investigation show that the complex training program was effective in eliciting statistically significant improvement in speed in the 300-meter shuttle[16]. Ebben & Watts[6] suggest that the complex training program design must consider important variables such as exercise selection, load, and rest between sets. For example, recent research suggests that three to four minutes of rest between the weight training and plyometric training portions of complex training may be optimal[15, 17, 18].

Many ice hockey coaches are teaching players with their own training methods and are also applying their own methods of measurements to them. Unfortunately, systemic training programs for ice hockey players have so far been insufficient. Everybody is keenly aware of the need for systemic training programs based on scientific theories as well as methods of measurement to improve skating abilities in ice hockey players. Therefore, complex training programs are recommended for ice hockey players based on the present study. In addition, developing speed should be emphasized in training programs to improve the overall performance of ice hockey players. Future studies should examine the effects of more systemic training programs on on-ice performance in ice hockey players.

In conclusion, continuous complex training, including on-ice skating training, produced a significant improvement in the skating abilities of ice hockey players. This improvement is suggested to be due to improved speed resulting from the complex training program intervention.

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