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ORIGINAL RESEARCH OPEN ACCESS

THE EFFECT OF BUNGEESKATE^{TM} TRAINING VS LATERAL PLYOMETRIC JUMPS ON ON-ICE ACCELERATION AND SPEED

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ABSTRACT

Background/Purpose: Ice hockey is an explosive, physical sport that demands multiple short bursts of extremely vigorous work. Sport-specific on-ice training to improve game performance is a rarity for hockey players due to the high costs and unavailability of ice time. The purpose of this study was to investigate the effectiveness of short-term, on-ice resistance training compared to traditional dryland training on skating performance in Division III Women's college ice hockey players. The present study examined the difference in acceleration, top speed, and speed between two training modalities: on-ice BungeeSkate^{TM} and off-ice Russian Box training. **Methods:** Twenty female Division III hockey players (ages: 18-21 years) participated in this study. Each participant underwent an initial 10-min period where anthropometric variables were measured and recorded. Participants were then randomly assigned into one of two training groups: BungeeSkate^{TM} or Russian box plyometric training. Each training session lasted for 15 minutes and occurred twice a week immediately following team practice. **Results:** A two-way repeated measures ANOVA indicated no group effect for acceleration, speed, and top speed ($p > 0.05$). No time effect was observed for acceleration and top speed, while significant improvements were found in speed (pre-training: 6.87 ± 0.25 sec to post-training: 6.73 ± 0.17 sec). **Conclusions:** A 6-wk BungeeSkate^{TM} training intervention has a similar effect to off-ice training on acceleration and top speed, but can help to improve speed in Division III female college hockey players in relatively short training sessions. On-ice resistance training could be beneficial for hockey coaches and players who are looking to maximize training benefits with limited ice time.

Keywords: hockey, resistance band, female hockey, interval training, top speed, plyometric

INTRODUCTION

Ice hockey can be described as an explosive, physical sport that demands extremely high-intensity work for multiple short bursts. To enhance the training of ice hockey players, training protocols should be tailored towards the various energy systems utilized within the sport. Shifts in a typical college hockey game range from 45 to 60 seconds which places a greater demand on a player's anaerobic metabolic systems (69 %) rather than its aerobic counterpart (31 %) (1, 2). It is clear that being able to recover efficiently between shifts and have the endurance to compete at high levels relies on aerobic metabolism. However, there is more importance placed on the anaerobic aspect in order for players to compete at high speeds and be fully functional throughout every shift in a game. The aforementioned research suggests that training for explosiveness and power provide the most beneficial results to improve skating performance. Any improved difference in skating speed and rate of acceleration play a large role in determining success during play.

In the past, hockey training programs have incorporated both on-ice and off-ice power and agility programs. Behm and colleagues (3) suggested that training methods focusing on short-duration plyometric exercises (e.g., squat-jump, drop-jump, and concentric-only vertical jump) may not be the best method for improving skating speed. Instead, higher amplitude plyometric training involving longer contact time could be more sport-specific and allow a player to generate more power in each stride, making them faster on the ice. There are few non sport specific off-ice modalities that mimic ice-skating, which limit sport specific training methods for ice hockey players. However, a lateral plyometric jump platform (i.e., Russian Box) is one of the most sport-specific off-ice training methods for hockey players as it incorporates all major muscle groups involved in a skating stride (4).

In a study by Janot et al. (5) four weeks of on-ice resistance training consisting of a BungeeSkate™ resistance band system improved acceleration, speed, and top speed in youth Peewee and Bantam ice hockey players. Participants engaged in resisted skate twice a week, and each session incorporated exercises to utilize different muscles and achieve optimum training benefits. The 6.1 m acceleration, 44.8 m speed, and 15.2 m top speed tests were used to quantify changes in skating performance from pre- to post-training and found that speed and top speed can be improved using bungee cord training.

Sport-specific training is difficult to incorporate for ice hockey players due to the high costs and unavailability of ice time. This results in many players performing a majority of their training off-ice. Therefore research is needed to develop a short-term, sport-specific on-ice training method that can be incorporated into a practice session without adding financial burdens on ice hockey organizations or teams. Improvements in skating speed and acceleration have been observed using the BungeeSkate™ resistance bands in youth hockey players (5), but it is of interest to examine the effectiveness of the BungeeSkate™ training in other levels of hockey players. Therefore, the purpose of this study was to determine if on-ice training would elicit greater improvements in skating speed and acceleration compared to off-ice training over a 6-wk period in collegiate level ice hockey players.

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METHODS

Of the original 26 participants who were recruited for the study, 21 completed all six weeks of training. The 21 college-aged female hockey players (Ht: 164.8 ± 10 cm, Wt: 66.0 ± 9.6 kg, Age: 18.9 ± 2.1 years), were free from any cardiovascular, metabolic, respiratory, or orthopedic conditions and cleared by the athletic training staff to participate in the study. If any participants suffered an injury throughout the study that would preclude them from giving maximal effort during training sessions, they would be excluded. Participants were recruited from the women's hockey team through word of mouth. Before participation, the potential risks and benefits of the study were fully explained to the participants before signing a written informed consent. The informed consent process was completed according to the guidelines of the Institutional Review Board at the University of Wisconsin – Eau Claire. Participants were given a random identification number to be sure that all data collected would remain anonymous.

Testing Protocol

Prior to on-ice testing of speed, acceleration, and top speed, participants reported to the exercise physiology laboratory in order to gather anthropometric measurements. Each participant's body mass was measured in gym clothes with no shoes to the nearest 0.1 kg with a digital weighing scale (Seca 220, Hamburg, Germany). Body mass was also gathered in order to determine the level of resistance (i.e. number of bands used) each player would be using during resistance band training. The level of resistance respective to body mass was determined using BungeeSkate™ (Bungee Athletics Inc, Gloucester, ON, Canada) manufacturer guidance. Height was measured to the nearest 0.1 cm using a stadiometer (Detecto, Webb City, MO, United States). Upon completion of the height and weight measurements, the participants were arranged into three different categories based on their weight. The weight classes were 45.5 – 59.1 kg, 59.2 – 72.7 kg, and 72.3 – 86.4 kg. This would ensure that both the on-ice and off-ice training groups had an even amount of participants from each weight class. From each weight category, to ensure an equal weight distribution between training groups, participants were randomly assigned to either the on-ice BungeeSkate™ group (n = 12) or the off-ice Russian Box group (n = 9).

Following group assignment, the players performed baseline testing of speed, acceleration, and top speed. The testing protocol (5, 6) consisted of three different tests that are illustrated in Figure 1. These tests were timed using a handheld stopwatch (Accusplit Pro Survivor 601X). In order to assure interrater reliability, the same researcher timed the same test for each participant. The first test measured was top speed and was timed in the 15.2 m between the two blue lines on the opposite side of the ice. The test began at the red line and the participants were to skate behind the net and get up to full speed before reaching the first blue line (Figure 1, #1). The time began when the front skate hit the first blue line and stopped once the front skate hit the second blue line. A researcher stood on the red line, halfway between each blue line, in order to be in the best position to view when the front skate hits each line. The second and third tests were combined to measure two variables in one skating burst. Participants began in the corner and skated diagonally to a face-off circle in the opposing zone. After the first 6.1 m of the sprint (Figure 1, #2), a time for acceleration was taken, followed by a time for speed at the 44.8 m mark (Figure 1, #3). The researcher stationed at the first marker was to signal the start of each individual trial to both the subject and the second researcher stationed at the second marker down ice. This was done by concurrently using verbal cues "ready, set, go" to the subject and visual cues to the second researcher such as lowering of the arm. This was done to ensure that both researchers began their stop watches simultaneously. Every participant was given two trials to complete each test, and the fastest time for each variable was used in the data analyses. Between the trials for each test, participants were given a 3-min rest period in order to fully recover and execute each test at maximum effort.

Figure 1. On-ice performance tests: (1) 15.2-m top-speed test, (2) 6.1-m acceleration test, (3) 44.8-m speed test. Illustration from Janot et al, 2013.

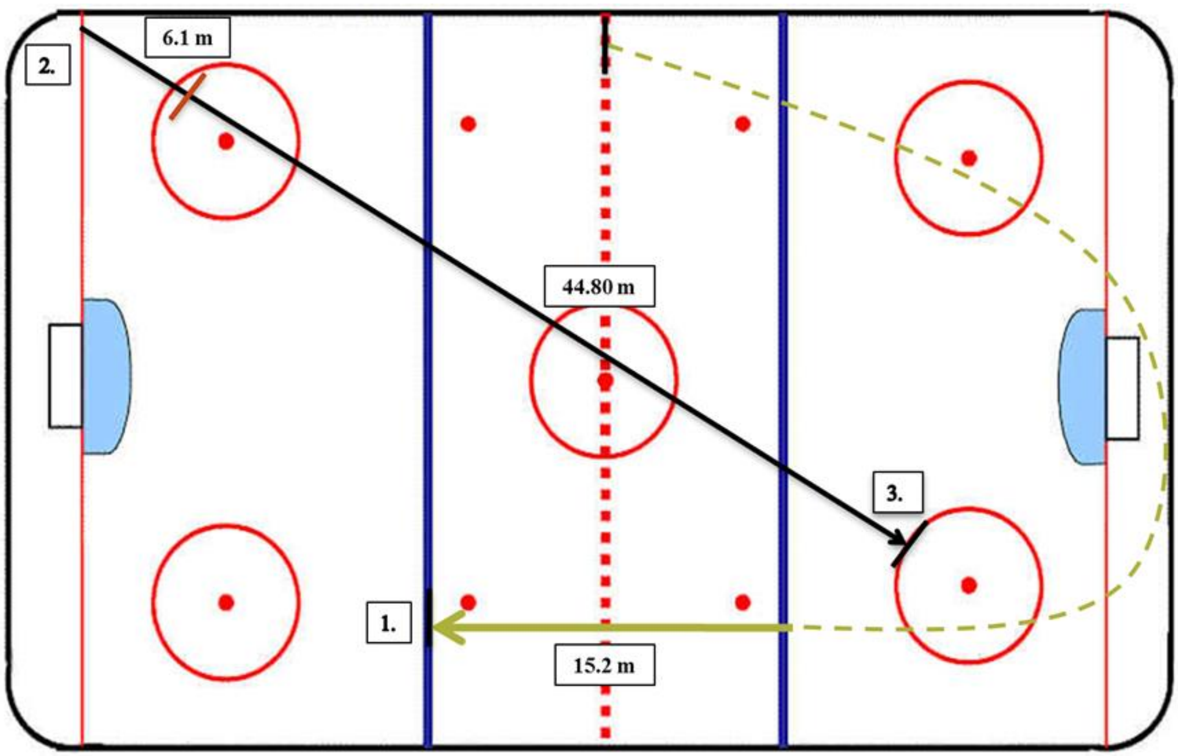

Table 1. Summary of BungeeSkate™ Training Protocol

Day 1 Training			Day 2 Training		
Sets	**Reps**	**Exercise**	**Sets**	**Reps**	**Exercise**
1	5	V-Start	1	5	V-Start
1	5	Crossover right into forward Skate	1	5	Crossover right into forward Skate
1	5	Crossover left into forward Skate	1	5	Crossover right into forward Skate
3	5	High-knee crossover right	3	5	Backward skating c-cut right
3	5	High-knee crossover left	3	5	Backward skating c-cut left

Training Procedures

On-ice training using the BungeeSkate™ resistance bands was performed twice a week for six weeks, having one day between each training session to allow for recovery. During these training sessions, participants were required to wear full hockey gear with a stick in hand. The 10-ft bungee cords (housed in a lycra sheath) were anchored to the side boards. The bungee cords consisted of two different resistances. The large cord provided most resistance while the small cord provided 50% less resistance than the large cord. According to the manufacturer's information, both cords have the same stretch properties and will stretch to 300% of static length. To secure the cords to the participant, a lightweight belt was worn around the player's waist in a manner so that the belt would not hinder their ability to skate.

The off-ice training using the Russian Box trainer was performed twice a week for six weeks, having one day between each training session to allow for adequate recovery. During training sessions, participants wore team-issued athletic apparel. The Russian Boxes (Figure 5) were marked at 0.298 meters from the base of the box with visible tape to provide a minimal height at which participants must laterally jump over each consecutive jump for each repetition of each set for both phase 1 (weeks 1-3) and phase 2 (weeks 4-6).

The training sessions were performed 5-10 minutes following a standard hockey practice where each participant engaged in the same on-ice drills lead by the head coach. During training sessions, each participant was closely monitored for appropriate instruction and to ensure proper rest periods. The on-ice training protocol consisted of four drills organized into sets of five repetitions each (Table 1). A 3:1 rest-to-work ratio provided roughly 45 seconds of rest between sets. Starting resistance for each participant was determined from their weight class. During phase 1, those who weighed 45.5 – 59.1 kg, 59.2 – 72.7 kg, and 72.3 – 86.4 kg were given a resistance of 3 bands, 3.5 bands, and 4 bands, respectively. During phase 2, resistance was increased by 0.5 bands, only if correct skating mechanics could be maintained while using new resistance. The specific increase in resistance involved the attachment of an additional large or small cord to the belt harness. Attendance and resistance was tracked for each participant during training sessions. For the Russian Box group, each participant performed 5 sets of 20 second lateral plyometric jumps with a 30-sec rest period between each set for Phase 1. During Phase 2, there was an increase of 10 seconds in jumping time for each set. Rest periods remained constant at 30 seconds.

On-ice V-start and crossover start were forward-skate exercises. The starting position for the V-start was heels together and front facing (Figure 2). The right and left crossover start required a side facing position and began with crossing the foot closest to the side boards (rear foot) over the other and then continued into a forward skating stride (Figure 3). When performing the backward skate (Figure 4), the participants started by facing the side boards and performing a C-start skating maneuver followed by a backward crossover sprint. The last specific training drill was the right and left high knee crossover consisting of a side facing start followed by repetitive crossovers away from the boards while always facing parallel to their plane of motion. All of the exercises used during training were aimed at improving speed, acceleration, and explosive power.

Figure 2 – The V-start Skating Exercise

Figure 5 – Russian Box

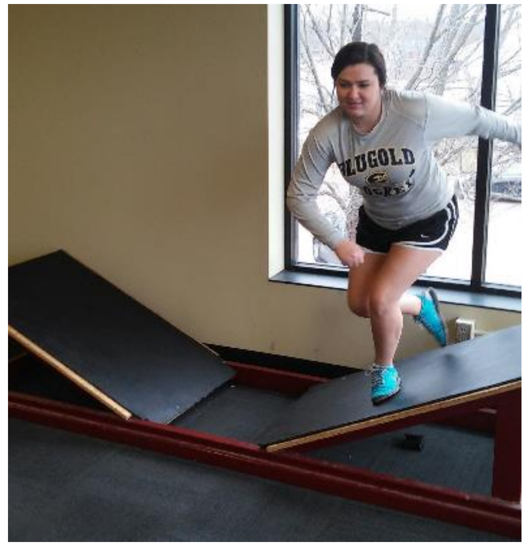

Figure 3 – Crossover to forward skate

Figure 4 – Backwards Skating Exercise

Statistical Analysis

This study was a pre–post randomized group design with the control group being the Russian Box training group. Data were analyzed using IBM SPSS version 19.0 (IBM Corp, Armonk, NY). Descriptive statistics (means and standard deviations) were used to determine participant characteristics. Baseline speed, top speed, and acceleration measures were compared to determine group differences prior to training using an independent *t* test. A factorial ANOVA was used to examine the differences in speed, top speed, and acceleration between groups and pre- and post-training. Alpha level was set at .05 to determine statistical significance. In order to maintain a moderate effect size (Cohen's d -0.5) at an alpha level of 0.05, a sample size of 20 total participants (10 per group) was needed to maintain a statistical power of 0.80.

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Table 2 – *Pre- and Post-training data for Acceleration, Speed, and Top Speed (n=21)*

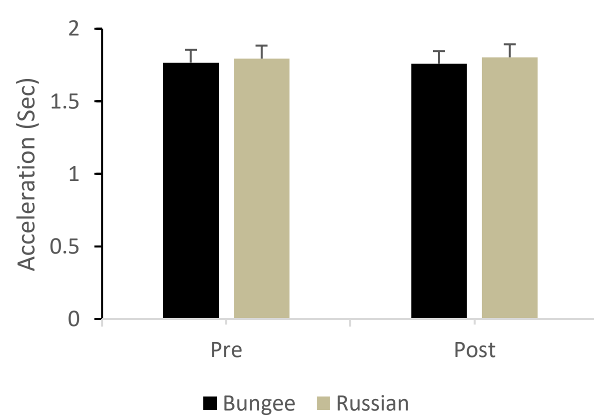
Training	Time	Mean	Standard Deviation	95% Confidence Interval	
				Lower Bound	Upper Bound
Acceleration					
Bungee	Pre	1.77	0.02	1.72	1.81
	Post	1.76	0.03	1.70	1.82
Russian	Pre	1.79	0.03	1.74	1.85
	Post	1.80	0.30	1.74	1.87
Speed					
Bungee	1	6.79	0.07	6.65	6.94
	2	6.69	0.05	6.59	6.79
Russian	1	6.97	0.08	6.81	7.14
	2	6.79	0.06	6.67	6.90
Top Speed					
Bungee	1	1.88	0.03	1.83	1.93
	2	1.87	0.02	1.82	1.91
Russian	1	1.89	0.03	1.83	1.95
	2	1.89	0.03	1.84	1.95

RESULTS

Of the 26 participants recruited for this study, five were removed (4 Russian Box and 1 BungeeSkate™) because they were unavailable following the pre-testing. The training program required an adequate amount of effort and no adverse effects of injuries were reported by the study participants. Of the 21 total participants, none missed any training days. No significant differences between groups were detected at baseline for mean speed (p = 0.140), top speed (p = 0.835), and acceleration (p = 0.429).

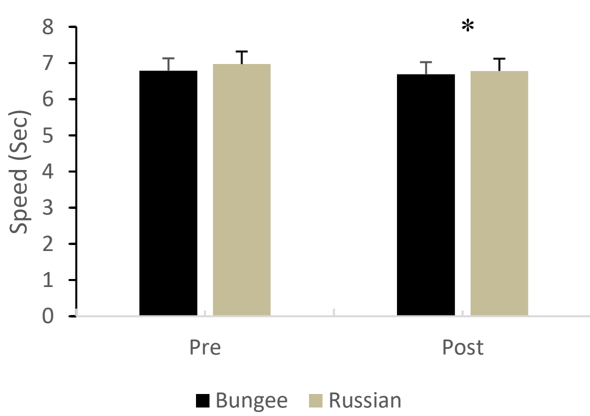
Using an alpha level of 0.05, a two-way repeated measures ANOVA indicated there was not a significant interaction between Group (BungeeSkate™ vs. Russian Box) and Time (pre- and post-training) on acceleration ($F(1,19) = 0.25$, $p = 0.621$). The main effect for Group was not significant, ($F(1,19) = 1.14$, $p = 0.298$) and the main effect for Time was also not significant ($F(1,19) = 0.001$, $p = 0.987$). See Table 2 for descriptive statistics for Acceleration by Group and Time. Figure 6 illustrates a change in acceleration from pre- to post-training between groups.

Figure 6 – Acceleration (6.1 m sprint time) between BungeeSkate™ (n = 9) and Russian Box (n = 12) groups.



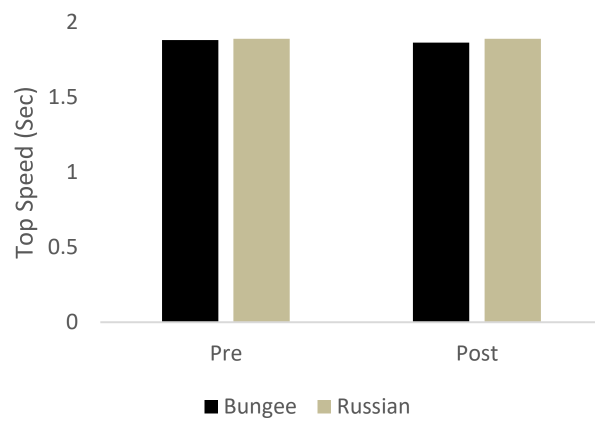
For Speed, a two-way ANOVA indicated there was not a significant interaction between Group and Time ($F(1,19) = 1.51$, $p = 0.235$). The main effect for Group was not significant ($F(1,19) = 2.67$, $p = 0.119$); however, a main effect for Time was significant ($F(1,19) = 17.53$, $p = 0.001$). See Table 2 for descriptive statistics for Speed by Group and Time. Speed significantly improved from pre- (6.87 ± 0.25 sec) to post-training (6.73 ± 0.17 sec) for the entire sample. Figure 7 illustrates a change in Speed from pre- to post-training between groups.

Figure 7 – Speed (44.8 m sprint time) between BungeeSkate™ (n = 9) and Russian Box (n = 12). *Post-training speed significantly less than pre-training (p<0.05)



For Top Speed, a two-way repeated measures ANOVA indicated there was not a significant interaction between Group and Time ($F(1,19) = 0.37$, $p = 0.553$). The main effect for Group was not significant ($F(1,19) = 0.26$, $p = 0.613$) and the main effect for Time was also not significant ($F(1,19) = 0.28$, $p = 0.603$). See Table 2 for descriptive statistics for Top Speed by Group and Time. Figure 8 illustrates no change in top speed from pre- to post-training for either group.

Figure 8 – Top Speed (15.2 m sprint time) between BungeeSkate™ (n = 9) and Russian Box (n = 12) groups..



DISCUSSION

The purpose of this study was to investigate the relationship between on-ice BungeeSkate™ resistance training and off-ice lateral plyometric training (Russian Box) in skating performance among Division III Women's college ice hockey players. Findings of this study show that there was not a significant interaction between Group (BungeeSkate™ vs. Russian Box) and time on acceleration, speed, and top speed. The participants, regardless of group, did improve their skating speed from pre- to post-testing.

Many recent studies have shown that there is a strong correlation between off-ice training and on-ice performance. Thus, authors have concluded that on-ice performance can be strongly predicted by off-ice performance tests. A previous study found that off-ice tests such as the 40-yard dash and the vertical jump test were the best predictors of select on-ice skating variables in Division III Women's college hockey players (7). This study suggested that training programs should be task-specific to match hockey's energy demands and improve fitness to offset fatigue that is encountered throughout a hockey game. Ice hockey is a sport where success is heavily determined by the skating skills of the player. The ability to sprint, accelerate, gain top speed, change direction, and stop, ultimately plays a significant role in successful athletic performance. The training protocol in the present study was designed with the goal of improving sport specific skills.

Today's hockey players are training for power as well as endurance. Plyometric training has been shown to increase a player's endurance and power by utilizing the stretch shortening cycle in exercises such as jumping (8). Other examples include box jumps, one legged jumps or hops, tuck jumps, and squat jumps. Previous research suggests training methods that focus on short duration plyometric exercises may not be the most sport-specific method for improving skating performance (3). Rather, higher amplitude plyometric training involving longer contact time could be more sport-specific. Because of this, our study used a traditional lateral plyometric exercises (Russian Box). The results of this study show that improvements were made in speed. These results are similar to those found in a study conducted by Runner and Lehnard where athletes who have a higher vertical jump were more likely to improve their skating speed between pre- to post-testing (9). The advantage of using a Russian Box trainer is that it is focused on single-leg movements, which is most specific to skating in hockey.

It is essential for any athlete to practice in their "sport-specific environment" to perform to the best of their abilities in competition. Therefore, research looking at on-ice resistance training for ice hockey would be beneficial. Although many studies have involved analyzing the use of skill tests off-ice, very few have looked at performing skill tests on-ice (10). This is also consistent with training methods as little data exists on systematic training programs and proper testing methods to improve skating abilities in ice hockey players (11).

In a study performed by Janot et al. (5) on-ice resistance bands (BungeeSkate™) were utilized to determine improvements in skating performance. The results of this study showed that acceleration, speed, and top speed all improved from pre- to post-training. As for Lee et al. (2013), subjects in the training group who continued complex training for 12 weeks showed improved skating abilities, such as stopping ability, agility, ability to change direction, and endurance, compared with the control group (11). Both studies showed skating improvements in those who participated in resistance exercises on-ice compared to off-ice training methods.

A limitation of this study was the timing system used. It is possible that a photoelectric timing system specifically designed to be used on-ice may have led to more accurately measured variables. However, the methodology used in this study may be more applicable to a larger population of players and coaches and would therefore be a more practical way to test acceleration, speed, and top speed. Also, previous work done in this area of research used a similar timing system as was employed in this study, which did not affect the results (5). Additionally, the time when training took place may have been a limitation in this study. All training sessions took place after a 1-2 hour long practice. Training post-practice could have caused a greater amount of fatigue in the players; thereby, affecting maximum effort and thus training effectiveness. However, this is the most practical application of this type of training in-season and the most realistic timing for both coaches and players considering the limitations of ice time. Lastly, baseline testing took place prior to the season starting with follow-up testing taking place closer to mid-season. Testing and training in the off-season may have been a more effective time to engage this group of players to ensure both good mental and physical preparedness compared to in-season testing and training.

From the results of these studies, understanding the off-ice fitness variables that predict on-ice skating performance and fitness can help a coach structure a sport specific program tailored towards hockey players of different age groups and sex. These variables are relatively easy to measure and are highly correlated with skating performance. Because no off-ice measures can truly replicate on-ice performance, coaches may also want to take advantage of using on-ice resistance training whenever possible to improve the performance (acceleration, speed, and top-speed) of their players. The use of BungeeSkate^{TM} training during on-ice practice times can be a practical and effective way to improve skating performance in a short period of time. With the increased demand for improved performance in the hockey world, the utilization of on-ice resistance training during practice should be of high priority for coaches and players alike.

CONCLUSION

In conclusion, the current study provides data suggests that on-ice BungeeSkate^{TM} training can improve a player's skating speed. These results suggest that BungeeSkate^{TM} resistance bands may be a better alternative to traditional lateral plyometric training when looking to improve on-ice skating speed.

Explosive and powerful movements are critical to the sport of ice hockey. The BungeeSkate^{TM} system provides a safe and alternative method of on-ice training. Using BungeeSkate^{TM} training during on-ice practice can be a short yet effective way to improve skating performance. Having an effective method for improving skating performance would allow coaches to improve players more efficiently.

In the future, more research is needed to determine proper on-ice resistance training protocols that would not only continue to improve speed, but also improve acceleration and top speed. A study that increases both overall span, duration, and intensity of training may elicit more significant results. Future research should also target on-ice resistance exercises combined with over-speed training with populations such as professional and or collegiate men's hockey players.

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