The Effects of BungeeSkate Training on Measures of On-Ice Acceleration and Speed

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Purpose: Previous research has stated that dryland sled pulling trains first-step quickness in hockey players. Further research has demonstrated that off-ice horizontal training (sled pull, parachute, etc) relates well to on-ice acceleration and speed. However, there is limited literature pertaining to on-ice resistance training that aims to enhance speed and acceleration in hockey players. The purpose of the current study was to determine if on-ice BungeeSkate training would improve on-ice speed and acceleration in youth hockey players.

Methods: Twenty-three Peewee and Bantam hockey players (age 11–14) were recruited, with 20 participants completing the study. Pretesting and posttesting consisted of an on-ice 44.8-m speed test, a 6.1-m acceleration test, and a 15.2-m full-speed test. The training protocol consisted of 8 sessions of 5 BungeeSkate training exercises per session, 2 times per week for a 4-wk period.

Results: The results of this study showed that speed and top speed were significantly increased ($P < .05$) by 4.2% and 4.3%, respectively. Acceleration was also slightly improved but not significantly.

Conclusions: A 4-wk BungeeSkate training intervention can improve acceleration and speed in youth hockey players. This training method could be a valid adjunct to existing strategies to improve skill development in hockey and is shown to improve speed and acceleration in relatively short training sessions. This may be most advantageous for hockey coaches and players who are looking to maximize training benefits with limited ice time.

Keywords: hockey, resistance band, youth, interval training, top speed

Hockey is a sport that encompasses short-duration, high-intensity bursts of energy. Muscle strength and power are important for overall success due to the physical nature of ice hockey. With greater muscle power, skaters are able to extend their knees in a shorter push-off time, which results in increased skating speed. Increased muscular and anaerobic power enhance a player’s ability to fulfill the movements required during any given shift. These skills include skating, rapid changes in velocity, and quick changes of direction.

To better train athletes, training programs should be task specific to match hockey’s energy demands and improve fitness to offset fatigue that is encountered throughout the season. Montgomery stated that glycogen is used from both fast- and slow-twitch fibers; thus, the aerobic and anaerobic systems are important to train. Hockey is an activity with great participation of anaerobic metabolism (69%) compared with aerobic metabolism (31%). A season of hockey play shows gains in anaerobic but no change in aerobic capacity; therefore, on-ice tests and training of this anaerobic activity are crucial.

Youth hockey training has traditionally incorporated both on- and off-ice power and agility exercises to improve players’ skating performance. Greer et al reported that 7 weeks of hockey-specific training consisting of on-ice skating, occasional weighted-vest intervals, and off-ice weight training can improve skating performance scores. In that study, 28 male Bantam players were split into control and training groups. The training group focused on speed-skating drills and weight training 3 d/wk, while the control group only participated in hockey summer leagues. A 24.4-m acceleration test and a 15.2-m top-speed test were used to evaluate skating performance.

Previous studies have demonstrated that off-ice resisted sprint training can lead to improved speed and acceleration while maintaining proper mechanics. Polli suggested that sled pulling while providing enough resistance can help train first-step quickness so a player can focus on quick starts in a normal sprinting or skating motion. However, Lockie et al stated that extended periods of heavily loaded sprint training may lead to lower speed because fast-twitch muscle fibers are adapting to the heavy load rather than sprint speed, which would be detrimental to sprint performance. With lighter sled loads, normal acceleration kinematics can be maintained, which makes it best for use in a training program. Similarly, Tabachnik explained that the advantages of using speed-chute training include strength, acceleration, maximum speed, and explosiveness. In addition, when the chute is subjected to windy weather it can improve...
both body balance and control in ice hockey. Paulson and Braun9 demonstrated that mechanics during chute training in 12 collegiate sprinters resemble those of an unloaded condition. Employing elastic cords to provide an overspeed assistance by pulling the athlete forward during sprint activity has been done in past research. In a study by Bartolini et al,10 female soccer players wore a belt attached to 2 elastic cords during assisted maximal sprint activity. Results showed that sprint times decreased up to 30% with increases in elastic-cord assistance up to 15 yd. The assistance was based on a percentage of body weight, with 30% body-weight assistance being the most effective. Thus, elastic-cord assistance to provide overspeed is also an effective training modality for improving sprint performance.

Other studies have identified various off-ice variables that correlate to on-ice performance.11,12 Bracko and George12 stated that 40-yd-dash time was the strongest predictor of skating speed in women’s ice hockey players. In addition, there was a reasonably strong correlation between vertical jump and on-ice aerobic capacity, but no studies have found an off-ice fitness variable that predicts skating agility. According to Farlinger et al,11 off-ice tests correlated with on-ice skating performance and measures of horizontal leg power (off-ice sprint and 3 hop jump) were the best predictors of skating performance in 36 male hockey players age 15 to 22 years. Behm et al13 suggested that instability resistance training enhanced players’ overall balance. Since skate blades require a balance component on ice, their use combined with horizontal training, jumps, and resistant bungees is projected to enhance overall on-ice performance.

By implementing on-ice resistance training, these drills will become more sport specific, allowing for greater muscle strength and power needed for the increased demand of hockey performance. Paulson and Braun9 stated that the external load applied by the resistance modalities creates a greater muscle force to overcome the added resistance, which may lead to increases in sprinting performance over time. This would result in an improvement in horizontal power. Matthews et al14 found that the intensity and duration of a single resisted sprint are sufficient to produce improvement in a 25-m on-ice sprint. A 2.6% decrease in times was observed between pretest and posttest sprints. It was concluded that heavily resisted sprints on ice may provide a biomechanically suitable exercise for inducing effectiveness before speed-training drills.

Based on previous research, off-ice resisted sprinting activity has been shown to improve sprinting performance and may develop skating speed and acceleration. However, there are limited data regarding on-ice resisted sprinting to evaluate its overall effectiveness to improve skating performance. Therefore, the purpose of the current study was to determine if on-ice BungeeSkate training twice a week for 4 weeks would improve on-ice speed and acceleration in youth hockey players.

**Methods**

**Participants**

Twenty-three Peewee and Bantam hockey players, 20 males and 3 females, were selected to participate in this study (Table 1). Participants were recruited via word of mouth from a local youth hockey association. Exclusion criteria included current or recent injury that precluded participants from giving full effort during skating activity and being under or exceeding age for Peewee (12 or under) or Bantam (14 or under) as defined by USA Hockey. Before participation, potential risks and benefits were fully explained before written informed consent was gathered according to the guidelines of the institutional review board at the University of Wisconsin-Eau Claire. Parental or legal-guardian consent was required for participation because participants were minors. No conflicts of interest exist to the participants in the current study.

**Testing Procedures**

Before testing, participants were randomized into 2 groups: control (n = 11) and training (n = 9). On the day of testing, body weight was assessed using a Tanita digital scale with participants dressed in gym shorts and T-shirts. Next, participants completed skating tests (adapted from Bracko and George12 and Bracko15) to measure acceleration, speed, and top speed (Figure 1). All tests were timed using a handheld stopwatch (Accusplit Pro Survivor 601X). Intraclass correlations were calculated to ensure reliability for each measure (acceleration: \( r = .66, P < .01 \); speed: \( r = .85, P < .01 \); top speed: \( r = .88, P < .01 \)).

Participants were tested (and trained) wearing full hockey gear with stick in hand. They participated in a 5-min general skating warm-up as part of early practice skating led by coaches. These activities were low to moderate intensity in nature, with short bursts (~5 s) of high-intensity skating, and they were kept similar for both pretesting and posttesting days. Top speed (Figure 1, #1) was assessed along the distance from one blue line to the next blue line (15.2 m). The test began on the opposite side of the rink from the red line. Participants were instructed to slowly gather speed and continue around the net area, whereupon they progressed to top speed. Participants were to be at top speed once reaching the first blue line and attempt to maintain that speed to the opposite blue line. Time was started once a skate touched the first blue line.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total group (N = 23)</th>
<th>Training (n = 9)</th>
<th>Control (n = 11)</th>
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<tbody>
<tr>
<td>Age (y)</td>
<td>12.3 ± 1.1</td>
<td>11.7 ± .5</td>
<td>12.6 ± 1.2</td>
</tr>
<tr>
<td>Weight (lb)</td>
<td>114.0 ± 40.7</td>
<td>99.8 ± 25.0</td>
<td>123.1 ± 46.9</td>
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**Table 1 Participant Characteristics**
line and stopped once the skate touched the other blue line. A researcher was positioned halfway between the blue lines, perpendicular to the direction of the skater, to accurately start and stop timing within the measurement period. As with all testing, the researcher maintained a standing position on skates. The 6.1-m acceleration test (Figure 1, #2) was timed in conjunction with the 44.8-m speed test (Figure 1, #3). Participants were instructed to begin the test in a V-start position (heels touching) to maximize first-step quickness. Time was started on the first positive, forward movement of the front skate and stopped once the front skate crossed the end point of each test. For the acceleration test, the researcher was positioned at the end of the measured distance to accurately stop and start timing. For the 44.8-m speed test, a different researcher was positioned at the halfway point to better view the first forward movement of the skater. Once time was started, the researcher glided backward to the end point to accurately stop time once the skater crossed the line. Participants completed each test 2 times and the best value was used for data analysis. A 5-minute rest period was allowed between testing trials for full recovery to allow for maximal effort on all trials.

The same testing procedures involving the same researcher timing each measure were administered during the posttesting period, which occurred 4 weeks after pretesting. The control group completed the prepost testing trials while continuing scheduled practices for 4 weeks. The training group participated in 8 training sessions of on-ice BungeeSkate training over a 4-week period as part of the same scheduled practices. The last training session was exactly 4 weeks after pretesting. Participants were given a recovery day between the last training session and posttraining testing. Both groups were tested concurrently on the day of posttraining testing.

**Training Procedures**

Training sessions were scheduled to allow for 24 hours rest between sessions. Participants were allowed 2 familiarization sessions with the bungee-skating exercises before beginning the training program. The bungee training system (Bungee Athletics Inc, Gloucester, ON, Canada) consisted of an anchor strap secured to the side boards to which 10-ft bungee cords (housed in a Lycra sheath) were attached. Two types of bungee cords were used with the system to provide resistance during training. The large cord provided the most resistance and the small cord provided 50% less resistance. Both cords have the same stretch properties and will stretch to 300% of static length, according to the manufacturer’s information. The cords were also attached to a lightweight waist belt worn by the participant, and this did not interfere with skating mechanics.
Before each session, participants performed a 5-minute general skating warm-up. Each exercise was performed to a maximum distance of 30 ft from the side board. Each participant was closely supervised for proper instruction and monitoring of rest periods during each session. Participants were removed from the study if 2 training sessions were missed. The control group engaged in normal practice activities, while the training group performed the bungee-skating activities. Once the training group finished the 15-minute program, they resumed their normal practice. To control for day-to-day training variability, coaches who ran practices were asked to perform the same drills in the same time period during each training session. The drills performed were more skill-based in nature and less focused on high-intensity exercise for conditioning. This was also done to control, as much as possible, for differences in overall exercise volume between the groups.

The training program consisted of 5 drills organized into sets of 5 repetitions (Table 2). A 3:1 rest-to-work ratio provided approximately 30 seconds of rest between sets. The starting resistance for each participant was set using general recommendations from the manufacturer (Bungee Athletics Inc) based on the participant’s overall age, weight, and level of experience. During phase 1 (wk 1–2), 2 large bands were used for Peewees and 3 large bands for Bantams. During phase 2 (wk 3–4 of training), resistance was increased accordingly only if proper skating form could be maintained with the new resistance. The specific increase in resistance involved the attachment of an additional large or small cord to the belt harness. Thus, the addition of each cord incrementally increased the resistance each participant had to skate against. Workout logs were kept to track resistance (number of cords attached to harness) and performance during each training session.

The V-start and crossover start were forward-skate exercises designed to improve speed and acceleration. The starting position for the V-start was heels together and facing forward. The crossover start (Figure 2) required a side-facing position (right and left) and began with a crossing of the rear foot over the front. Participants began the backward skate (Figure 3) by facing the boards and then performing a C-start skating maneuver to start followed by a backward crossover sprint. This drill was implemented to train in a different manner muscles recruited during forward skating. High-knee crossovers and frog jumps were used to improve explosive power. High knees consisted of repetitive crossovers while maintaining a side-facing position with shoulders parallel to the movement. Frog jumps (Figure 4) closely resemble land-based broad jumps with participants jumping repetitively with skates in a “V” position.

<table>
<thead>
<tr>
<th>Table 2 Summary of BungeeSkate Training Protocol</th>
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<tbody>
<tr>
<td><strong>Day 1 Training</strong></td>
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<tr>
<td>Sets</td>
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<td>1</td>
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Figure 2 — The crossover-start skating exercise.

Figure 3 — The backward-skating exercise.
Results

Of the 23 participants enrolled in the study, 3 were removed (1 control and 2 training) because they were either unable to complete the minimum number of training sessions or were unavailable for posttesting. The training program was well tolerated, and no adverse events or injuries were observed. Of the 9 participants in the training group, 5 missed 1 session and 2 missed 2 sessions. No differences between groups were detected at baseline for mean speed \((P = .190)\), top speed \((P = .609)\), and acceleration \((P = .205)\).

Figure 5 displays the differences in top speed between the training and control groups. Top speed improved \((P = .038)\) in the training group \((2.11 \pm 0.12 \text{ to } 1.99 \pm 0.17 \text{ s from pretesting to posttesting})\). In contrast, the results were not altered \((P = .060)\) in the control group \((2.10 \pm 0.15 \text{ to } 2.02 \pm 0.14 \text{ s from pretesting to posttesting})\). A 4.2% increase in top speed was observed in the training group. Figure 6 shows 44.8-m sprint time (speed) in the training and control groups. Sprint time was improved \((P = .008)\) in the training group \((7.14 \pm 0.38 \text{ to } 6.84 \pm 0.83 \text{ s from pretesting to posttesting})\), whereas speed did not change \((P = .578)\) in the control group \((6.83 \pm 0.59 \text{ to } 6.90 \pm 0.31 \text{ s from pretesting to posttesting})\). These data show a 4.2% reduction in the 44.8-m sprint time after bungee training. Figure 7 illustrates changes in acceleration for the training and control groups. Although the results were not statistically significant \((P = .411)\), acceleration improved by 3.4% in the training group from pretesting to posttesting \((1.48 \pm 0.1 \text{ to } 1.43 \pm 0.13 \text{ s})\). In contrast, acceleration was improved by 6.3% \((P = .022)\) in the control group \((1.53 \pm 0.09 \text{ to } 1.44 \pm 0.07 \text{ s from pretesting to posttesting})\).
Discussion

In the current study, speed and top speed were improved in the training group, with acceleration slightly improving. Speed and top speed, as defined in the current study, are characterized as the shortest time achieved over a specified distance. Previous studies have not clearly stated the difference between speed and top speed when discussing training interventions.

Matthews et al\textsuperscript{14} examined the acute effect of off-ice resisted sprints to enhance sprint performance on ice. Results showed that heavily resisted sprints are sufficient to enhance sprint performance on ice. Bartolini et al\textsuperscript{10} suggested that resisted sprinting enhanced speed after 3 training sessions. These data from Matthews et al\textsuperscript{14} and Bartolini et al\textsuperscript{10} are consistent with those of the current study.

In one of the few studies that differentiated between speed and top speed, Greer et al\textsuperscript{5} designed a study using weighted vests and lower center-of-gravity positioning to increase lower-muscle activity with skating, similar to the added resistance of a bungee. On-ice intervals with weighted vests were used to elicit gains in speed and top speed. When sprint time and top speed were examined, top speed improved after the 7-week training program in contrast to no change in sprint time. Although Greer et al\textsuperscript{5} found no increase in top speed, the current study used an...
on-ice measurement, which could explain differences in results between Greer et al12 and the current study. The same on-ice test to measure top speed was used in both studies.

Hollering and Simpson16 investigated the effect of a 6-week skating program using a partner as resistance. The 3-sessions-per-week program focused on enhancing skating speed. On-ice skating speed was not significantly improved through this training. It is possible that partner resistance is not effective at providing a consistent load to work against compared with the methodology used in the current study. These results were consistent with those of Kober,17 who found that speed was not improved when ankle weights were used to increase lower-leg muscle involvement.

Zafeiridis et al18 also found results differing from those of the current study. Two groups, 1 that sprinted with load and 1 without, were used in their study. It was found that maximum speed was not improved when pulling a 5-kg load during training. However, acceleration was enhanced when training with the additional 5-kg load. The current study also used plyometric-type exercises (ie, high-knee crossovers and frog jumps) in combination with sprinting activities. This combined effort may have been more effective at building speed than just sprinting alone.

Acceleration is defined as the ability to develop maximal sprint speed in as short a time as possible.19 Furthermore, according to Cronin and Hansen20 the ability to accelerate may be the most important to performance in many sporting activities. Past studies that aimed to increase acceleration in athletes used varying methods including chute running, weighted vests, and resisted towing. The current study involved a sport-specific method to increase acceleration through the use of the BungeeSkate training system. The training group did not significantly improve acceleration, although a 3.4% reduction in acceleration, interpreted as the participants’ reduction in acceleration, was observed. Contrary to the current findings, Kafer et al21 found that weighted-sled towing increased 20-m sprint times by 0.08 second. Similarly, Bosco et al22 found that wearing a weighted vest (7–8% body weight) morning until evening and during training greatly improved the athletes’ ability to produce force at higher velocities. Bosco et al22 did not test sprint performance; however, the improvement in force production from wearing the vests may increase the ability to store elastic energy and improve power output and thus increase acceleration.23,24 Moreover, Blatherwick and Knoblauch25 found that a training protocol that uses sprint interval running, hill running, and weighted plyometrics significantly improved acceleration.

The lack of improvement in acceleration from the BungeeSkate training protocol may have been due to a number of factors. The first was that participants may have been underloaded at the start of the 3 sprint exercises (V-start, crossover start, and backward start). This starting period consisted of the first 2 to 3 skating strides before full resistance occurred. According to Newton et al,26 to enhance force development training should involve rapid acceleration against resistance and should extend throughout the movement with no intent to decelerate at the end. Moreover, it has been suggested that greater resistance should be used for training the acceleration phase of a sprint and lighter loads be used to train the maximum-velocity phase of the sprint.8,27,28 Thus, the current training protocol differed from what past research suggests to increase acceleration and speed. Overall, the bungee-training protocol used progressively increasing loads during the early acceleration phase (first 2–3 strides) and greater loading during the speed phase of the training exercises.

Past research studies have aimed to improve sprint performance by increasing stride rate. Resisted sprint training has been shown to improve acceleration by shortening strides and increasing ground-force application.7,20,29 In addition, the use of overspeed training has been shown to increase maximal velocity by means of increasing stride length and rate.23,30 It is likely that the participants in the current study increased stride rate enough to improve speed endurance and top speed due to resisted, on-ice training, although this was not tested.

The results of the current study cannot be fully interpreted without considering other extraneous factors that may have hindered a significant increase in acceleration from training. Due to the age of the participants in the study (11–14 y), the effects of development could have aided or hindered the athletes’ coordination during the testing trials. In addition, the short duration of the acceleration test (6.1 m, ~1.5–1.9 s) may have added to a potential, systematic human error in timing. However, since the test–retest reliability was appropriate for the timing of each test, this may not be a likely reason.

What may be more likely is that regular practice activity compared with the substituted bungee-training program was more effective at focusing on acceleration improvement. The training group may have had overall less volume of specific activities or drills that included acceleration as a component. In addition, it is possible that the training group was inadequately loaded during all training exercises. Cronin and Hansen20 stated that different loads should be used for developing acceleration versus speed: higher resistance for improving acceleration and lower loads used for speed. Although the most effective time duration has not been determined for BungeeSkate training, 15-minute sessions may have been inadequate. It is clear that further research is needed to develop methods to increase on-ice acceleration in Pee wee and Bantam hockey players.

A main limitation of the study was the timing system used. Considering the very small changes that occurred with training, a photoelectric timing system designed for use on ice may have improved the accuracy of measured variables. However, past research studies11,13,16 have employed the use of a hand timing system to produce valid on-ice testing results. The methodology used to time participants in this study may also be more applicable to youth coaches or strength and conditioning specialists who test their athletes. In addition, the overall small sample size may be another limitation of this study. While statistical power may have been
adequate, a smaller training group could have contributed to greater variability between participants within the group. The standard deviations for the pretraining and posttraining acceleration means were greater (.10 and .13) for the training group than for the control (.09 to .07). Therefore, it is possible that greater variability within the training group made it less likely to observe a significant mean difference pretraining to posttraining. Finally, this study did not fully control exercise outside of training and dietary intake before each training or testing session, which may have had an effect on the results. Participants were instructed to follow normal exercise and dietary patterns during the duration of the study. However, training logs were not kept to monitor other activities.

**Practical Application and Conclusion**

In conclusion, the current study provides data suggesting that speed and top speed can be improved using bungee-cord training. Participants did demonstrate an improvement in acceleration; however, it was not significantly different. It appears that the BungeeSkate training system and the training protocol, with combined sprinting and plyometric-type activity, were successful at building on-ice speed compared with acceleration.

Developing explosive movements is critical to hockey performance as it is primarily an anaerobic sport requiring short bursts of speed. The BungeeSkate system, when supervised by appropriate and qualified professionals, has been demonstrated to be a safe and alternative means of training on ice. The use of BungeeSkate training during on-ice practice times can be a practical and effective means of improving skating performance in a short period. With the increasing demand to develop young athletes, the use of on-ice resistance training during practice should be a priority for hockey associations, coaches, and conditioning professionals working with youth.

Future research is needed to determine the effects of BungeeSkate training on anaerobic skating performance. A longer study that includes an increase in overall length and training duration may be more effective. In addition, providing resistance immediately may enhance the acceleration component of hockey players. Although previous research has compared on-ice and off-ice resistance training, the use of BungeeSkate off-ice with rollerblades may be effective in improving on-ice skating performance.

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**References**


