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Original Research

Development and Reliability of a 7×15m Repeated On-Ice Sprint Test for Female Ice Hockey Players

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ABSTRACT

International Journal of Exercise Science 14(6): 666-676, 2021. The purpose of this investigation was to design and examine the reliability of a 7×15m repeated on-ice skating sprint test for female ice hockey players. Seventeen women ($\bar{X}$ ± SD age, height and body mass = 21 ± 2 years, 166.2 ± 6.4 cm and 61.9 ± 7.7 kg, respectively) completed 7 consecutive on-ice sprints of 15m repeated every 15s. Two trials of the test were performed on the same day and then repeated on a different day approximately 1 week later for a total of 4 trials. The fastest 15m time, mean time for 7 sprints and total sprint time collapsed across all 4 trials was 2.96 ± 0.12s, 3.05 ± 0.13s and 21.35 ± 0.89s, respectively. There were no significant differences between trials for any variable. Typical error (TE), coefficient of variation (%CV) and intra-class coefficients (ICC) for the fastest 15m time, mean of 7 sprints, and total time were ICC = 0.77, TE = 0.06s and %CV = 2.1; ICC = 0.91; TE = 0.04s and %CV = 1.4; and, ICC = 0.91; TE = 0.29 and %CV = 1.4 for all 4 trials, respectively. Players in the forward position had a faster mean 15m time and lower total time compared to those in the defensive position ($p < 0.05$). These findings show that a 7×15m repeated on-ice sprint test for varsity women ice hockey players was reliable. It was also found that forwards had a better mean of 7 sprint time and faster total time compared to players in the defensive position.

KEY WORDS: Sports performance, skating, velocity, fitness testing

INTRODUCTION

Ice hockey is a sport that involves intermittent activities consisting of short sprints, quick stops and turns, explosive starts, and forceful muscular efforts performed in addition to low intensity activities and cognitive factors associated with game play (6, 11, 12, 20, 25). It has also been shown that the frequency and time spent performing these different in-game movement patterns vary by gender, position, game play situation, and level of competition (12, 20, 21, 24). As well, both on and off ice fitness assessments have been used to evaluate many of these different parameters and differ widely in terms of sprint distances (between 6 and 127m); time to complete (< 2s to ~ 50s); time of recovery allowed between sprints; the inclusion of skill activities or agility components; and, the equipment used (1, 4, 6, 7, 12, 15, 16, 20, 22, 24, 27, 28, 29, 33). As a result, no single test has emerged as the gold standard for repeated sprint performance of ice hockey players. However, physiological assessments of both men and women ice hockey players have proven to be important despite some criticism of the lack of association between certain fitness test results and game play or success (4, 16, 22, 27, 28, 29). The reason for this criticism may be partly due to the lack of specificity of some fitness assessments using off-ice testing protocols to relate to on-ice test results, the variables chosen to represent success of a player, or the fitness tests may not adequately mimic the movement patterns and timing of ice hockey players during a game (4, 16, 22, 27, 28, 29). Regardless, various fitness assessments can provide coaches and trainers with an indication of the current fitness levels of their players; the ability to monitor changes throughout the season; contribute to the evaluation of the timing for return to play after an injury; and, may indicate the effectiveness of particular training programs and on-ice practices (7, 11,15, 22, 25).

An important movement activity performed by both female and male ice hockey players during games is maximal all-out sprinting and the ability to repeat maximal sprinting (3, 7, 12, 16, 17, 20, 21, 24, 29). Our research investigating the movement frequencies and durations during women's varsity ice hockey games showed that players performed maximum forward sprint skating up to 7 times during each period of play and these sprints lasted ~ 2 to 3s at time (21). These maximal skating sprints corresponded to a distance near 15m and often occurred in a linear direction across the neutral zone, breaking out of the defensive zone or during fast back checking during actual game play (21). In support of this, Douglas and Kennedy (12) observed male junior players sprinted distances that were between 14.4 and 19.9m during an ice hockey game. As well, Lignell et al. (24) discovered that NHL players sprint skated a mean length of 15m during a game and the frequency of short, high intensity skating bouts was 7 times a minute. However, both these latter studies (12, 24) were conducted using male participants. Regardless, an on-ice sprint skating test covering a distance of 15m and repeated 7 times in women ice hockey player was justified based on our previous research in players of the same gender, age and level of play (21) and has not been previously reported in women ice hockey players.

Therefore, the purpose of this study was to design and assess the reliability of a repeated on-ice sprint test for female ice hockey players that would mimic the sprint skating demands observed during ice hockey games. It was hypothesized that a repeated 7×15m on-ice sprint test would be a reliable assessment of sprint skating ability in female varsity ice hockey players. We also hypothesized that forwards would present with faster times across the repeated skating sprints compared to players in the defense position. Previous research has shown that players in the defense position may have a greater body mass than forwards (15, 21) and this may influence on-ice sprint times.

METHODS

Participants
This study used a convenience sample of 11 forward (mean ± SD: age = 21 ± 2 years; height = 165.5 ± 7.0 cm and body mass = 60.2 ± 7.4) and 6 defensive players (age = 22 ± 2 years, height = 167.4 ± 5.8 cm and body mass = 65.2 ± 7.5) that belonged to the same women's varsity ice hockey team and volunteered to participate in this study. The statistical power for this sample size given an effect of 0.40 and an alpha of 0.05 was 0.78 based on the analysis of the primary variable of peak 15m sprint time compared across all four trials (10). Each participant was confirmed to be healthy and free from injury by email and verbally when scheduled for testing. This study was approved by a University Research Ethics Board and was "in accordance to the ethical standards" of the International Journal of Exercise Science (26). Note that this ice hockey team contended for the Canadian University (USPORT) national championship in the same year this study was undertaken.

Protocol
Each participant attended an orientation meeting when all aspects of the study were explained and consent forms were signed. Demographic information was obtained and participants were provided with pretest guidelines with respect to nutrition, hydration, rest and sleep. All testing was performed during the early in-season (September, October) for the Canadian University ice hockey league. Each participant completed 2 trials of a repeated 7×15m on-ice sprint test (ROIST) on the same day separated by approximately 20-30 minutes of recovery. Two more trials of the test were repeated approximately 1 week later for a total of 4 trials. The schedule was designed to ensure recovery, maintain testing at the same time of day for each participant as much as possible, accommodate ice time and players practice times, game and personal agendas. Players were also required to not perform any physical activity on the day prior to testing. It is important to note that the players had the same practice and game schedule throughout the experimental testing. All testing was performed on freshly flooded ice in the same facility by the same arena staff and the specific area on the ice used for the skating test was shifted to limit any deterioration of ice conditions during testing.

Players were tested individually after donning their game ready, full hockey equipment excluding hockey sticks and after performing a warm-up that included 5-10min of skating, stretching and ~ 3 short acceleration sprints followed by a brief resting recovery (~ 5min). At this point, the test protocol was verbally repeated by an investigator. Note that the players did not use their hockey sticks to reduce the risk of prematurely tripping a timing light (22). Despite some suggestion that not carrying a stick may alter skating mechanics (5), there is little evidence to show that not carrying a stick negatively affects short, linear maximal sprint skating time in female ice hockey players.

Timing lights were mounted on tripods set at a height of 1m that corresponded to near waist height of the participants (27) and were placed at the starting point (0m) and at 5, 10 and 15m intervals that were also marked with pylons. Note that the 5m split times were used to create a skating velocity profile (see explanation in Discussion); however, only starting and 15m pylons are required for the core test protocol. The on-ice sprint test began with each player choosing their preferred standing start body position that they previously practised and were requested to maintain this stance for all 7 sprints for consistency. The players aligned themselves immediately behind the starting line and between 2 pylons for the starting position. Players were provided with a verbal "go" but timing did not begin until the timing light placed at the starting point was tripped which reduced any error due to the reaction time response to the verbal command. At the end of each sprint the players were required to skate back to the start line using a combination of gliding and low intensity skating and mentally prepare for the subsequent sprint that began 15s from the start of each sprint. Verbal commands and a count down from 10s by the investigator ensured that the players started each sprint on time and from a full stop. Thus, each sprint plus recovery interval required a total time of 15s to complete and this was repeated 7 times for a total test duration of 105s. The players were asked to perform every sprint with their maximum ability and not to pace themselves in any way. A second trial of the test was repeated during the same session after a 20-30min recovery that included light skating and stretching.

Skating times were recorded to one hundredth of a second over distances of 0-5m, 5-10m, 10-15m and 0-15m from an electronic photo cell timing system custom designed by an electronic technologist from our laboratory. The fastest 15m sprint time, the mean of all 7 sprint times and total sprint time that was calculated as the sum of all 7 sprint times were the dependent variables. Note that 85% of the time, the fastest sprint was the first one and 79% of the time the slowest was the last sprint. This exceeded the 69% and 65% of the time, respectively reported by Boland et al. (4).

Statistical Analysis

The means and standard deviations for sprint skating times were determined using Microsoft Excel (2010). Reliability was assessed using a 3-tiered approach for the fastest 0-15m sprint skating time, mean 15m time for all 7 repeated sprints and total time for all 7 sprints. Separate one-way ANOVAs with repeated measures were performed to determine if there were any significant differences between the dependent variables across all 4 trials (Statistica 12, Statsoft, Oklahoma). As well, intra-class coefficients (ICC), typical error (TE) and the typical error expressed as a % coefficient of variation (%CV) using log transformed data were determined using the spreadsheet developed by Hopkins (19) across all 4 trials as well as for intra-session reliability during each day of testing (i.e. day 1: trial 1 vs. trial 2; and, day 2: trial 3 vs. trial 4) and inter-session reliability between the first trial conducted on day 1 versus day 2 (i.e. day 1, trial 1 vs. day 2, trial 3) and the second trial on days 1 and 2 (i.e. day 1, trial 2 vs. day 2, trial 4). Interpretation of the reliability indices was based on Smith and Hopkins (30). As well, separate two-way ANOVAs with repeated measures (4 trials) was used to compare the dependent variables by player position (forward vs. defense). Alpha was pre-set at $p < 0.05$.

RESULTS

Table 1 shows the 7-sprint skating split times every 5m and the fastest 0-15m sprint time as well as the mean 0-15m sprint time for all 7 sprints and total sprint for all 4 trials. Note there were no significant differences for fastest 0-15m time, mean 0-15m time for all 7 sprints and total 0-15m sprint time between trials.

Table 1. Skating times for each 5m sprint interval, fastest 0-15m time, mean 0-15m time for all 7 sprints and total 0-15m sprint time for all 4 trials of the 7×15m ROIST for female ice hockey players (values are $\bar{x}$ ± SD).

		Time (s)			
		Day 1		Day 2	
Sprint #	Distance (m)	Trial 1	Trial 2	Trial 3	Trial 4
1	0-5	1.26 ± 0.07	1.29 ± 0.09	1.27 ± 0.07	1.30 ± 0.07
	5-10	0.87 ± 0.04	0.88 ± 0.03	0.88 ± 0.03	0.90 ± 0.03
	10-15	0.79 ± 0.04	0.79 ± 0.04	0.81 ± 0.05	0.80 ± 0.04
	0-15	2.93 ± 0.10	2.96 ± 0.13	2.96 ± 0.11	2.98 ± 0.13
2	0-5	1.33 ± 0.08	1.30 ± 0.11	1.29 ± 0.09	1.29 ± 0.08
	5-10	0.88 ± 0.04	0.89 ± 0.04	0.90 ± 0.03	0.91 ± 0.03
	10-15	0.80 ± 0.05	0.81 ± 0.05	0.81 ± 0.04	0.81 ± 0.04
	0-15	3.01 ± 0.17	3.00 ± 0.16	3.00 ± 0.12	3.01 ± 0.14
3	0-5	1.28 ± 0.08	1.31 ± 0.10	1.31 ± 0.08	1.29 ± 0.09
	5-10	0.90 ± 0.04	0.90 ± 0.04	0.91 ± 0.04	0.91 ± 0.04
	10-15	0.82 ± 0.05	0.82 ± 0.04	0.83 ± 0.04	0.83 ± 0.04
	0-15	3.00 ± 0.12	3.03 ± 0.14	3.04 ± 0.13	3.04 ± 0.14
4	0-5	1.30 ± 0.07	1.33 ± 0.09	1.31 ± 0.08	1.31 ± 0.07
	5-10	0.89 ± 0.06	0.91 ± 0.04	0.91 ± 0.04	0.92 ± 0.05
	10-15	0.84 ± 0.06	0.83 ± 0.04	0.83 ± 0.03	0.84 ± 0.04
	0-15	3.03 ± 1.10	3.07 ± 0.14	3.05 ± 0.14	3.07 ± 0.14
5	0-5	1.31 ± 0.09	1.35 ± 0.10	1.33 ± 0.09	1.32 ± 0.09
	5-10	0.91 ± 0.04	0.91 ± 0.04	0.92 ± 0.05	0.93 ± 0.04
	10-15	0.84 ± 0.07	0.84 ± 0.04	0.84 ± 0.05	0.85 ± 0.05
	0-15	3.05 ± 0.14	3.10 ± 0.15	3.08 ± 0.15	3.10 ± 0.16
6	0-5	1.33 ± 0.10	1.34 ± 0.12	1.33 ± 0.10	1.31 ± 0.09
	5-10	0.93 ± 0.06	0.92 ± 0.04	0.93 ± 0.04	0.92 ± 0.04
	10-15	0.84 ± 0.05	0.85 ± 0.05	0.85 ± 0.05	0.85 ± 0.05
	0-15	3.09 ± 0.14	3.11 ± 0.18	3.11 ± 0.17	3.08 ± 0.15
7	0-5	1.33 ± 0.11	1.32 ± 0.09	1.34 ± 0.09	1.32 ± 0.09
	5-10	0.92 ± 0.04	0.93 ± 0.04	0.93 ± 0.04	0.94 ± 0.04
	10-15	0.86 ± 0.08	0.85 ± 0.04	0.84 ± 0.06	0.85 ± 0.05
	0-15	3.11 ± 0.17	3.10 ± 0.15	3.12 ± 0.17	3.11 ± 0.16
Fastest 15m Sprint		2.93 ± 0.10	2.96 ± 0.13	2.96 ± 0.11	2.98 ± 0.13
Mean of 7 Sprints		3.03 ± 0.12	3.05 ± 0.14	3.05 ± 0.13	3.06 ± 0.13
Total Sprint Time (s)		21.22 ± 0.85	21.38 ± 0.97	21.37 ± 0.89	21.43 ± 0.93

Table 2 displays the reliability data for the dependent measurements across all 4 trials as well as for the intra- and inter-session reliability. The ICCs for fastest 15m sprint time, mean time for 7 sprints and total time were interpreted to be very good to near perfect (29) for all 4 trials as well as for the intra- and inter-session reliability. Correspondingly, the TE (range 0.03-0.42s) and %CV (range 1.0-2.5%) were low for all variables. It is noted that the ICCs were slightly lower during the inter-session testing which was likely due to an increased variability associated with testing on different days versus testing on the same day.

Table 2. Intra-session and inter-session reliability data between trials of the 7×15m ROIST on the same testing day and between trials on different testing days for female ice hockey players (values are x̄ ± SD).

Variable		All 4 Trials	Intra-Session Day 1: T1 vs. T2	Intra-Session Day 2: T3 vs. T4	Inter-Session Day 1, T1 vs. Day 2, T3	Inter-Session Day 1, T2 vs. Day 2, T4
Fastest 0-15m time	ICC	0.77	0.87	0.86	0.75	0.71
	TE (s)	0.06	0.05	0.05	0.06	0.07
	%CV	2.1	1.6	1.7	2.0	2.5
Mean time for 7 sprints	ICC	0.91	0.90	0.95	0.80	0.88
	TE (s)	0.04	0.04	0.03	0.06	0.05
	%CV	1.4	1.4	1.0	2.0	1.6
Total Time	ICC	0.91	0.90	0.95	0.80	0.88
	TE (s)	0.29	0.30	0.22	0.42	0.34
	%CV	1.4	1.5	1.0	2.0	1.6

ICC = Interclass correlation coefficient; TE = typical error; %CV = percent coefficient of variation; T = trial.

There was a significant main effect for player position illustrating that players in the forward position had a better mean sprint time across all 7 sprints and faster total time ($p < 0.05$) compared to players in the defensive position (Figure 1). Despite a faster 15m time for forwards, no significant differences were observed between positions for this variable ($p = 0.08$; Figure 1).

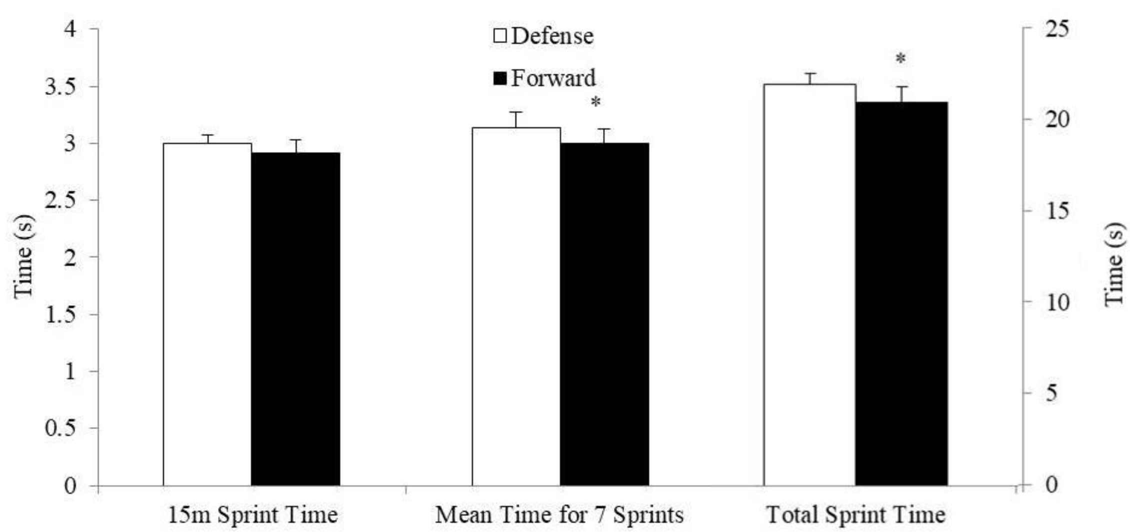

Figure 1. Comparison of the fastest 15m sprint time, mean time for 7 sprints and total sprint time (secondary Y axis) for the 7×15m ROIST between forwards and defense in women ice hockey players. Values are M ± SD. * = forwards significant different from defense, main effect, $p < 0.05$.

DISCUSSION

This study was undertaken to design a repeated on-ice sprint test for female varsity ice hockey players and assess its reliability. The present study showed that there were no significant differences between 4 trials of the 7×15m ROIST performed on the same day or across different days for the fastest 15m time, mean time or total time for all 7 sprints. This finding indicated that the test was consistent and that little learning effect occurred between trials. Based on the relatively high intra-class correlation coefficients and corresponding low typical error and coefficient of variation, the results were deemed to have high inter- and intra-session reliability and low variability (8, 30). Finally, forwards had a significantly faster mean 15m skating time for all 7 sprints and lower total 15m sprint time compared to players in the defensive position.

Movement patterns of female ice hockey players during game play include maximal short distance sprinting within a shift that may be repeated over all three periods of a game (4, 31, 16, 21, 22). It has also been suggested that forward linear skating speed is a valuable trait for ice hockey players (16, 29). Previous research has examined a variety of different on-ice field tests for women (4, 7, 15, 22) and men (1, 5, 13, 27, 28, 32, 33) that often include sprinting as a component of the test. However, these latter tests vary in many aspects such as the distance covered (6 to 127m), time to complete (a few seconds to a few minutes), intensity (less than maximal to all-out sprinting), the number of sprint repetitions and may include other hockey related skills or agility movements. Using maximal on-ice sprint tests that are too long or include stops, turnarounds among other movements may not accurately reflect linear maximal sprinting ability and the ability to repeat this type of sprinting. As well, there is no single test that has emerged as the gold standard for repeated sprint performance of ice hockey players.

We chose 7 repetitions of 15m for the ROIST based on previous pilot research and our previous research that examined the frequency and duration of the different movement patterns that female players perform during competitive ice hockey games (21). It was observed in this latter study that maximal sprints lasted ~ 2-3s corresponding to a distance of approximately 15m and often occurred in a linear direction when sprinting out of the defensive end, through the neutral zone or during a fast back check by women in both positions. This occurred up to an average of 7 times during each period of a game (21). It is also well known that all-out, repeated explosive efforts of less than 5s primarily relies on the intramuscular concentrations of adenosine triphosphate (ATP) and phosphocreatine (PC) that comprise the ATP-PC energy system (2, 9, 14) which has been deemed important for the ice hockey player (11, 25). The fastest 15m time and mean time for the 7 repetitions in the present study were 2.96s (± 0.12) and 3.05s (± 0.14) which fit well within the rate of ATP-PC energy supply. As well, the total time for the on-ice test (mean = 21.35s) would stress the overall capacity of this latter energy system (2, 9, 14, 18). Furthermore, calculating total time as suggested by Girard et al., (17) and mean time across all 7 sprints should assist with evaluating the repeated sprint performance of female ice hockey players. It is difficult to directly compare our findings to previous research given the differences in test protocols; however, maximal sprint skating times have been published for 10m (1.96s) and 11 m (2.38s and 2.35s) in elite women ice hockey players (4, 22) which are somewhat similar to the 0-10m split time found in the present study (mean 0-10m time = 2.16s).

It has also been shown that the performance of ice hockey players of both genders and varying levels of competition may differ somewhat on repeated high intensity sprint skating tests depending on the player's position (12, 20, 21, 24, 27, 31). This is likely due to the selection of players with certain physical characteristics into the forward and defense positions and possibly any variation in training preparation for the different demands of each position (15, 21). In the present study, forwards had a faster mean 15m time across all 7 sprints and had a better total time. However, defensive players had a greater body mass compared to forwards (65.2 ± 7.5 versus 60.2 ± 7.4 kg, respectively) that may have influenced their sprint performance. Interestingly, the fastest 15m sprint time was not significantly different between forwards and defense in the present study. Although some differences between positions were expected and observed, this latter finding may suggest that sprinting is important for players in the defensive position at times during ice hockey games and should not be ignored (21).

In the present study, the 7×15m ROIST was designed to be reflective of the distances that occur when a player sprints all-out during a game and the ability to repeat these sprints that often occurs during shifts in a game. The test was relatively easy to set up, required minimal equipment and a small amount of space on the ice surface that allowed for moving equipment to ensure clean ice is available during testing or allow other activities to operate simultaneously on the ice surface. In the present study, split times over 5m segments were included to provide for further assessment of a player that may be of use to the coach or trainer. These split times can be easily converted to velocity and provide an additional evaluation of the player's sprint performance. For example, Figure 3 shows two players that present with different sprint velocity profiles on the 7×15m ROIST. Both players accelerated at a similar rate over the initial 5m and 10m, but Player A was unable to further increase skating velocity and reach the same peak velocity as Player B during the final 5m of the test. This may provide the coach and trainer with additional information that would aid in designing a specific training prescription or undertake modifications in skating mechanics to improve on-ice sprinting for certain players. As well, it could also be used to examine whether a player is ready to return to play after an injury. Using tests such as in the present study as a baseline evaluation and repeating testing at particular times of the season can be used to compare to test results after a player has recovered from injury can provide the coach and training staff with useful information to decide whether a player is ready to return to their sport. This test may also apply to ice hockey players of other competitive levels or elite groupings but further research would be necessary.

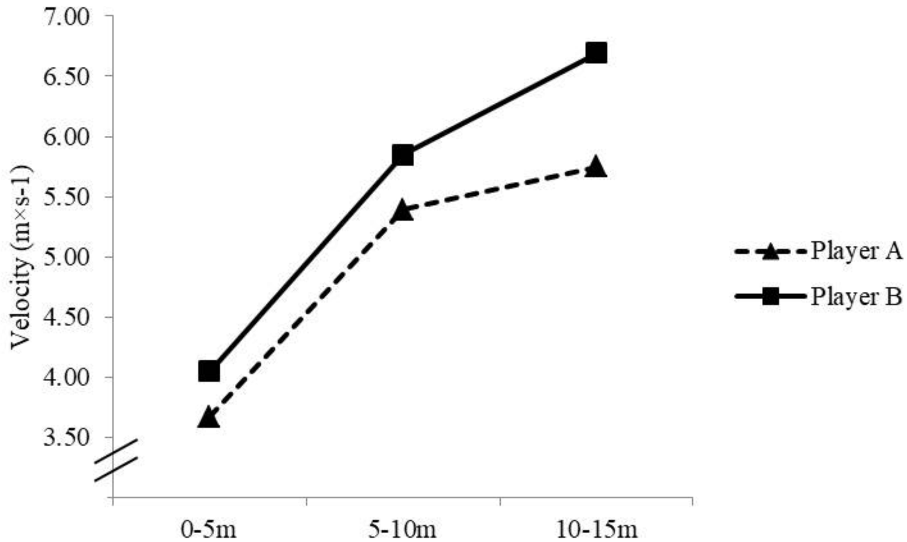

Figure 2. A comparison of 2 players that differ in their sprint skating velocity on the 7×15m ROIST. Note that both players accelerated at a similar rate over the initial 10m, but Player A did not achieve the same peak velocity as Player B during the final 5m. This may suggest that Player A would benefit from additional training or improvement in skating mechanics to enhance their sprinting ability. Velocity was calculated as $m \times s^{-1}$.

There were several limitations in the present study. First a convenience sample was used and the sample size was small especially for the comparison of player positions. However, the sample size was similar to other research that has published reliability analyses of different on ice testing of ice hockey players (6, 7, 8). The validity of the 7×15m ROIST was based on face validity and previously published observations (21). The present test was not intended to assess other aspects of player movements that occur during ice hockey game play in a single test and was specifically designed to assess repeated linear maximal sprint skating. It was difficult to completely ensure each player was performing maximally on each repeated sprint; however, the participants were highly skilled players with several years of training and competitive experience and were highly motivated to do their best during all testing. Finally, timing can be done with any system but photo cells, dual photo cells or video are recommended (6, 20, 23, 34).

In conclusion, the 7×15m ROIST was designed to assess the sprint performance of women varsity ice hockey players. The test was reflective of the distances that occur when a player sprints all-out during a game, as well as the ability to repeat these sprints that often occurs during shifts in a game. The 7×15m ROIST was found to be a reliable measure of peak and repeated maximal sprint skating ability in women ice hockey players. In addition, the 7×15m ROIST was also able to distinguish between player positions with regards to mean sprint time and total time.

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