INTERNATIONAL JOURNAL OF -EXERCISE SCIENCE-

Original Research

Validity and Reliability of a Radar Tracking Device in Ice Hockey Testing

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Abstract

International Journal of Exercise Science 19(7): 7004, 2026. This study investigated the reliability and validity of a radar tracking device (RTD) for assessing linear sprinting (sprint) and change-of-direction (CoD) performance in ice hockey. Twenty competitive male youth ice hockey players (age: 16.35 ± 0.67 years; body mass: 72.37 ± 10.06 kg; height: 177.48 ± 5.40 cm) performed three 30-m sprints and three 10-0-5-m CoD tests on ice. Sprint and CoD performance variables, including split times, position-based times, and maximal velocity, were assessed simultaneously using the RTD and a linear encoder (LE). Correlations between systems ranged from small to very high for sprint ($r = 0.49$ to 0.95, $p < .01$) and from moderate to very high for CoD ($r = 0.68$ to 0.90, $p < .01$), except for the $CoD_{0\text{-}5m}$ split ($r = 0.27$, $p > .05$). Coefficients of variation (CV) ranged from 4.41 to 6.68% for sprint and from 4.36 to 7.52% for CoD. Systematic bias for split times was trivial (−0.04 to 0.02 s), except for $sprint_{0\text{-}5m}$ and total sprint time (0.07 and 0.05 s, respectively), which likely reflected differences in system initiation methods. Intraclass correlation coefficients ranged from 0.67 to 0.94 ($p < .01$) for sprint and from 0.82 to 0.95 ($p < .01$) for CoD, with corresponding CV values of 1.10 to 3.06% and 1.45 to 3.01%, respectively. Overall, these findings indicate that the Ledsreact RTD demonstrates acceptable validity and moderate to very high within-session reliability for assessing sprint and change-of-direction performance variables in ice hockey.

Keywords: Sprint skating, change of direction, acceleration, sport science

Introduction

Skating performance in ice hockey involves a wide range of actions, including starts from a standstill, acceleration, deceleration, high-speed skating, and rapid changes of direction (CoD).[1-5] Among these actions, linear sprinting and CoD are considered key determinants of on-ice performance and are therefore commonly assessed in both applied and research settings.

Traditionally, sprint and CoD performance in ice hockey have been evaluated using total completion time, which provides limited insight into the mechanical and neuromuscular demands underlying these actions.[4,6,7] In linear sprinting, distinct phases such as the start, acceleration, and attainment of maximal skating velocity are characterized by specific changes in ice contact time, force production, muscle activation, and joint kinematics.[8-11] Assessing split times over short distances allows these phases to be examined more precisely than total sprint time alone and may better reflect the physical qualities targeted in training and performance monitoring.

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Similarly, commonly used on-ice CoD tests, such as the 5–10–5 m and 5–0–5 m, typically report only total time as the primary outcome. While these tests are practical and widely adopted, total time fails to characterize phase-specific velocity changes, including braking, re-acceleration, and exit speed. A more detailed assessment of these phases could provide valuable insight into a player's ability to decelerate and re-accelerate efficiently, which are critical components of CoD performance in ice hockey.[12-14]

To capture these phase-specific variables, various technologies have been employed to assess on-ice sprint performance , including radar device,[15,16] linear encoders (LE),[17] and camera-based systems.[6] LE are frequently used by professional ice-hockey organizations due to their ability to provide precise measures of displacement, velocity and split times. Importantly, LE quantify tether displacement over time, thereby providing a direct kinematic assessment of the athlete's horizontal center-of-mass (COM) motion independent of the locomotor modality (e.g., running vs. skating). For this reason, LE have been widely implemented as field-based reference systems in sport performance assessments. However, the practical implementation of LE systems requires substantial setup time, athlete instrumentation, and controlled testing conditions, which can limit their feasibility during routine on-ice assessments. These constraints are especially relevant when ice availability is limited and may further restrict the application of LE systems for on-ice CoD assessments.

In contrast, a radar tracking device (RTD) represents the only alternative technology capable of assessing both sprint and CoD performance on ice while providing continuous measures of position, velocity and split times. Importantly, RTDs are non-invasive, require minimal setup time, and do not interfere with skating mechanics, making them particularly suitable for applied ice-hockey environments. Despite these practical advantages and their increasing use in the field, the validity and reliability of RTDs for assessing on-ice sprint and CoD performance have not been fully established.

Accordingly, this study aimed to examine the within-session reliability and criterion validity of split times, position-based times, and velocity measures obtained with a RTD during on-ice sprint and CoD tasks, using a LE as the reference system. We hypothesized that the RTD would provide valid and reliable measurements of on-ice sprint and CoD performance in ice hockey players.

Methods

In this validation and reliability study, on-ice sprint and CoD data obtained with a radar tracking device (RTD; LedsReact Pro, 24 Hz, Courtai, Belgium/NY, USA) were compared with those obtained using a linear encoder (LE; 1080 Sprint, 1080 Motion, 333 Hz, Lidingö, Sweden), which has previously been validated for linear sprinting[18] and CoD.[19] Split times (s), position-based times (s), and maximal velocity ($m.s^{-1}$) were assessed simultaneously and served as the primary variables for the reliability and validity analyses.

Participants

To determine the minimum number of participants, a priori calculation was generated using a sample size calculator for reliability studies.[20] Based on data from Rakovic et al[18] and Eriksrud et al,[19] a minimum acceptable intraclass correlation coefficient (ICC) of 0.6, an expected ICC of 0.9, a power of 80%, and two replicates per participants (k = 2) yielded a required sample size of 16 accounting for an expected 10% dropout rate. Based on this a priori calculation we recruited

20 volunteers. There were no dropouts, therefore, the final analysis was completed on all 20 recruited individuals (n = 20).

Twenty male youth ice hockey players (age: 16.35 ± 0.67 years; body mass: 72.37 ± 10.06 kg; height: 177.48 ± 5.40 cm) competing across levels ranging from U18 Division 3 to major junior volunteered to participate in the study. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Research Committee of the University of Quebec in Montreal (approval number: 2025-7159). Prior to participation, all players and their legal guardians were informed of the study aims, procedures, and potential risks, and provided written informed consent. This research was conducted in full accordance with the ethical standards of the *International Journal of Exercise Science*.[21]

Inclusion criteria required participants to have at least five years of ice hockey experience, to be familiar with on-ice sprint and change-of-direction testing, and to be free from musculoskeletal or neurological injuries at the time of testing.

Protocol

Testing was conducted in an indoor ice rink with sufficient space for anthropometric assessment, dry-land warm-up, and on-ice testing. Height and body mass were measured using a standard measuring tape and a calibrated scale (Hawkin Dynamics, 4th Generation, model 1060; Westbrook, ME, USA), respectively, prior to a standardized warm-up lasting approximately 15 minutes. The warm-up consisted of three minutes of progressive-intensity jogging, lower-body mobility exercises (lunges and lateral squats), running drills (high knees, butt kicks, A-skips, side shuffles), plyometric exercises (bounds and vertical jumps), and four progressive 30-m sprints performed at 70, 80, 90, and 100% of maximal intensity.[22] Following the dry-land warm-up, athletes were given 15 minutes to put on their equipment, including their hockey stick, before stepping onto the ice.

The on-ice warm-up consisted of four progressive 30-m sprints and 10-0-5-m CoD trials performed at 70, 80, 90, and 100% of maximal intensity. Following the warm-up, each athlete completed three maximal 30-m sprints and three maximal 10-0-5-m CoD trials in a randomized order (i.e., half of the participants started with the sprint trials, while the other half began with the CoD trials), with four minutes of recovery between each trial.

The starting line (0 m) and finish line (30 m) for the sprint trials were marked on the ice, and a skating corridor was defined using cones placed every 2 m, resulting in a 30-m-long and 2-m-wide lane to guide the athletes.

The LE, serving as the reference system, was set in isotonic resistance mode using a 3-kg load to maintain constant tension in the cable during skating. As previously reported, this resistance does not affect inter-system comparisons (RTD vs. LE) for skating velocity and derived variables, as both systems measure the same skating action.[23] The auto-start function was used, with data acquisition initiated when velocity exceeded 0.2 $m.s^{-1}$.

The RTD was mounted on a tripod at 1.05 m above ice level, corresponding approximately to the height of the participants' center of mass while wearing skates. Both devices (RTD and LE) were positioned 3 m behind the starting line.

For the starting position, participants wore a waist-borne harness connected to the LE cable, placed their toes as close as possible to the starting line, and adopted a V-start position (hips facing forward) while holding their hockey stick with their dominant hand. After the fourth acoustic signal from the RTD, athletes initiated the sprint at their own initiative and were instructed to skate maximally until the finish line.

Based on the fastest completion times, the two best trials out of three 30-m sprints were retained for analysis to minimize the influence of submaximal efforts or execution errors.[24] This approach is consistent with previous sprint-mechanics studies using radar-based and tracking systems.[23]

For each trial and each system, split times ($sprint_{total}$, $sprint_{0–5m}$, $sprint_{5–10m}$, $sprint_{10–15m}$, $sprint_{15–20m}$, $sprint_{20–25m}$, $sprint_{25–30m}$, $sprint_{5–30m}$), position-based times ($sprint_{0–10m}$, $sprint_{0–15m}$, $sprint_{0–20m}$, and $sprint_{0–25m}$), as well as maximal velocity ($sprint_{max}$), were extracted for analysis.

For the CoD test, participants skated 10 m forward, stopped at the painted line, pivoted, and then skated 5 m in the opposite direction as fast as possible. As in the sprint trials, to ensure constant cable tension, the LE was positioned 3 m from the stopping line (i.e., 13 m from the starting line) and was set in isotonic resistance mode with 3 kg of assistance during the first 10 m and 3 kg of resistance during the second phase (5 m).[14] The RTD was mounted on a tripod at 1.05 m above ice level and positioned 3 m behind the starting line (Figure 1). Because ice hockey players perform skating actions more effectively with their hockey stick, and to avoid interference between the LE cable and waist harness, left-handed participants (stick in the right hand) started with the belt on the left hip and stopped with the left skate outside the line; the opposite configuration was used for right-handed participants.[19] Athletes initiated the CoD task at their own discretion following the fourth acoustic signal from the RTD. Based on the fastest completion times, the two best trials out of three were retained for statistical analysis.

For each trial and each system, split times (CoD_{total}, CoD_{0-5m}, CoD_{5-10m}, CoD_{10-5m}) and maximal velocity (CoD_{max}) were extracted for analysis.

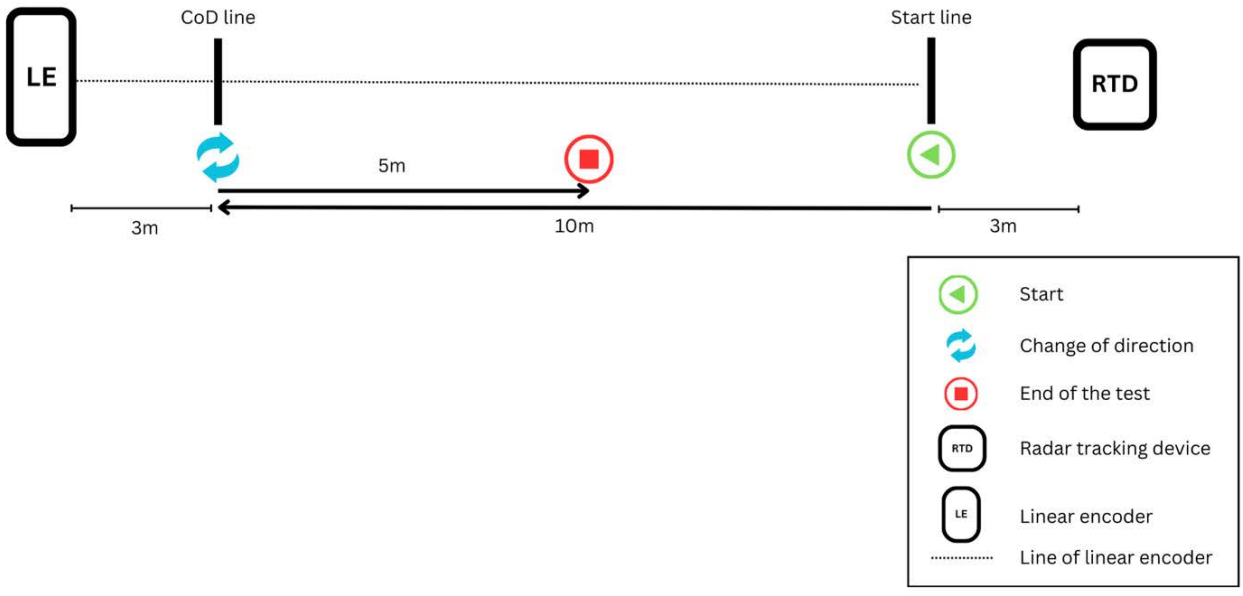

Figure 1. Testing setup illustrating the placement of the radar tracking device, linear encoder, starting line, change-of-direction line, and final position for the on-ice 10-0-5-m CoD test.

For the LE, raw velocity data derived from cable displacement were recorded at 333 Hz and processed using the device software (TrainitTest software, 1080 Motion). Raw data were exported in CSV format for further analysis in Excel (version 16.78.3; Microsoft Corp., Redmond, WA, USA).

For the RTD, raw velocity data were recorded at 24 Hz and filtered using the manufacturer's software (LedsReact Performance Hub, Courtai, Belgium/NY, USA), and then exported in CSV format for further analysis in Excel (version 16.78.3; Microsoft Corp., Redmond, WA, USA). Because the RTD and the LE relied on different start triggers, synchronization between systems was performed during post-processing. For both sprint and CoD trials, movement onset was defined as the first forward displacement detected in the RTD data stream and the first velocity value exceeding 0.2 $m.s^{-1}$ in the LE data stream (auto-start function). The two time series were then manually aligned based on these onset points to ensure that both systems referred to the same movement initiation event. No hardware-based synchronization was available between devices.

Statistical Analysis

Means and standard deviations (SD) were calculated for all split times, position-based times, and velocity variables using Excel (version 16.78.3; Microsoft Corp., Redmond, WA, USA). All other statistical analyses were performed using SPSS (version 29; IBM Corp., Armonk, NY, USA). Data normality was assessed using the Shapiro–Wilk test, with the significance level set at $\alpha = 0.05$.

Within-session reliability was evaluated using intraclass correlation coefficients (ICC), standard error of measurement (SEM), and coefficient of variation (CV) for all split times, position-based times, and velocity variables. ICC values were interpreted as follows: 0.50–0.75 = moderate, 0.75–0.90 = high, 0.90–0.99 = very high, and ≥ 0.99 = extremely high.[25]

Criterion validity was assessed using mean differences (Diff, s), CV, and Pearson correlation coefficients (r) or Spearman rank correlation coefficients (ρ) when data were not normally distributed. The strength of associations was classified as small (0.30–0.50), moderate (0.50–0.70), high (0.70–0.90), very high (0.90–0.99), and almost perfect (≥ 0.99).[26] Bland–Altman plots were generated in Excel (version 16.78.3; Microsoft Corp., Redmond, WA, USA) to examine agreement between systems for split times, position-based times, and velocity variables.

Results

Table 1 shows the main variables used to compare intra session reliability and inter system validity for both on-ice sprint and CoD. For reliability, CV ranged from 1.10 to 3.06 % for all variables and ICC ranged from moderate to very high (0.67 to 0.95). SEM ranged from 0.01 to 0.08 for time variables and from 0.09 to 0.12 for velocity variables.

Inter system validity showed significant correlations, as shown in Table 1, that ranged from small to very high (0.49 to 0.95), except for $CoD_{0\text{-}5m}$ that did not show a significant correlation. CV values ranged from 4.36 to 7.52%. Sprint biases (difference between the systems) were trivial (-0.02 to 0.02) for the split times ($sprint_{5\text{-}10m}$, $sprint_{10\text{-}15m}$, $sprint_{15\text{-}20m}$, $sprint_{20\text{-}25m}$, $sprint_{25\text{-}30m}$). Small differences were observed for $sprint_{0\text{-}5m}$ (0.07), $sprint_{0\text{-}30m}$ (0.05) and $sprint_{max}$ (0.14). Table 1 presents the main variables used to assess within-session reliability and inter-system validity for on-ice sprint and CoD performance. For reliability, CV values ranged from 1.10 to 3.06% across all variables, while

ICC values ranged from moderate to very high (0.67 to 0.95). SEM values ranged from 0.01 to 0.08 s for time-based variables and from 0.09 to 0.12 $m_{\bullet}s^{-1}$ for velocity variables.

Inter-system validity revealed significant correlations for most variables (Table 1), ranging from small to very high (r = 0.49 to 0.95), except for the $CoD_{0\text{-}5m}$ split, which did not show a significant correlation. CV values ranged from 4.36 to 7.52%. Sprint biases between systems were trivial (−0.02 to 0.02 s) for intermediate split distances ($sprint_{5\text{-}10m}$, $sprint_{10\text{-}15m}$, $sprint_{15\text{-}20m}$, $sprint_{20\text{-}25m}$, $sprint_{25\text{-}30m}$). Small differences were observed for $sprint_{0\text{-}5m}$ (0.07 s), $sprint_{0\text{-}30m}$ (0.05 s), and $sprint_{max}$ (0.14 $m_{\bullet}s^{-1}$).[27]

For CoD, biases were trivial for split times (−0.04 to 0.01 s) and small for maximal velocity (−0.11 $m_{\bullet}s^{-1}$). Bland–Altman plots illustrating agreement between systems for all sprint and CoD variables are presented in Figure 2.

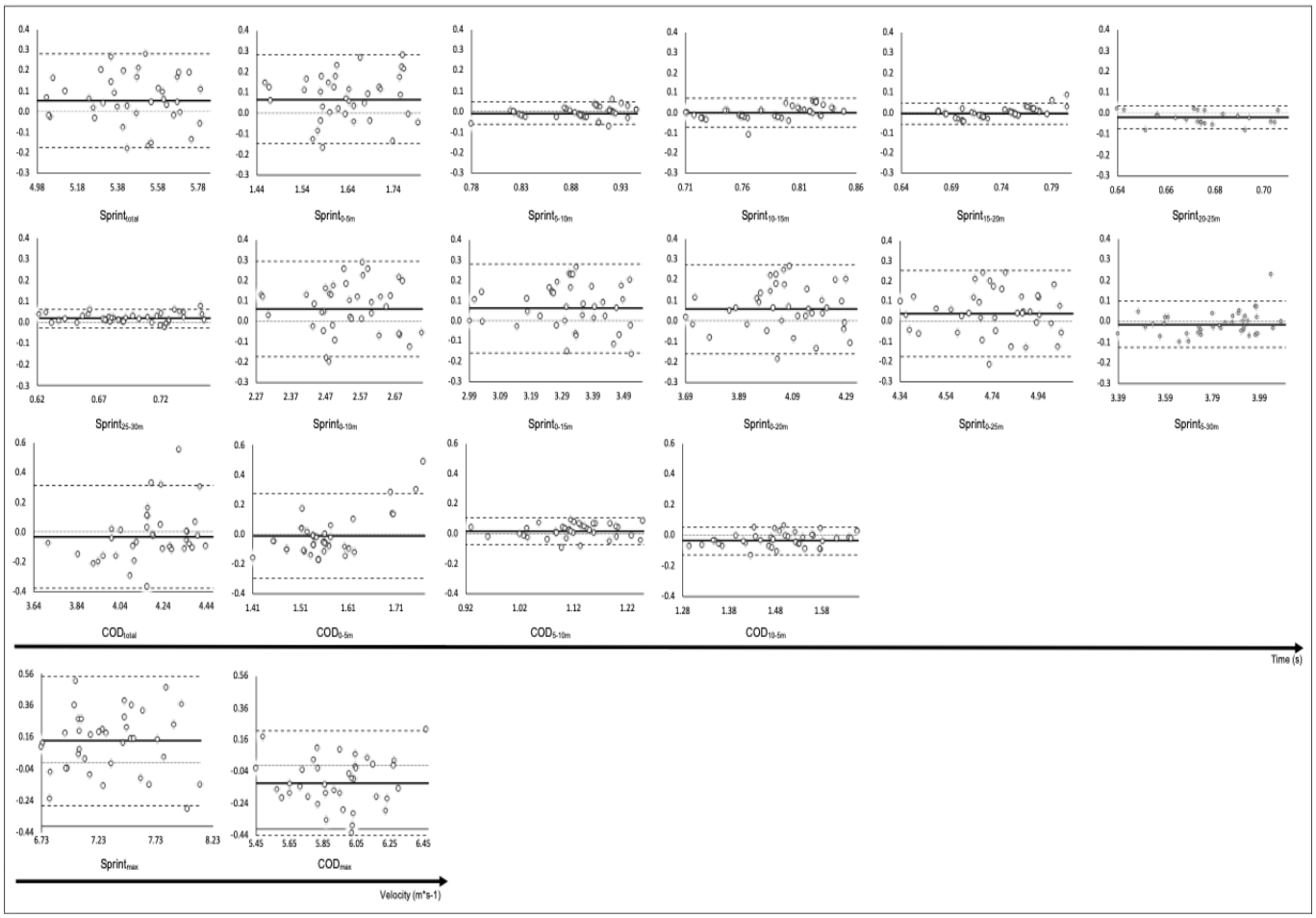

Figure 2. Bland–Altman analysis of 40 trials (on-ice 30-m sprint and 10-0-5-m CoD) comparing the two systems. The top three rows display time-based variables (y-axis: difference in time [s]; x-axis: time [s]), whereas the bottom row displays velocity-based variables (y-axis: difference in velocity [$m_{\bullet}s^{-1}$]; x-axis: velocity [$m_{\bullet}s^{-1}$]). The solid line represents the mean bias, the dashed lines indicate the 95% limits of agreement (LOA), and the dotted line represents the line of agreement.

Table 1. Within session reliability and criterion validity of the radar tracking device as function of the linear encoder.

	Time & Velocity (M ± SD)		Reliability			Criterion validity		
Variable	RTD (s)	LE (s)	CV%	SEM	ICC	Diff (s)	CV%	Corr
$sprint_{total}$	5.48 ± 0.24	5.43 ± 0.25	1.10	0.07	0.93**	0.05	4.43	0.86**
$sprint_{0-5m}$	1.67 ± 0.11	1.61 ± 0.11	3.06	0.04	0.79**	0.07	6.68	0.49**
$sprint_{5-10m}$	0.89 ± 0.05	0.89 ± 0.04	2.42	0.01	0.78**	-0.01	4.79	0.69**
$sprint_{10-15m}$	0.79 ± 0.05	0.79 ± 0.04	3.26	0.02	0.67**	0.00	5.62	0.70**
$sprint_{15-20m}$	0.73 ± 0.05	0.74 ± 0.03	2.40	0.02	0.86**	0.00	5.55	0.90**
$sprint_{20-25m}$	0.69 ± 0.04	0.71 ± 0.03	2.38	0.01	0.78**	-0.02	5.15	0.74**
$sprint_{25-30m}$	0.71 ± 0.04	0.69 ± 0.04	2.72	0.01	0.79**	0.02	5.66	0.85**
$sprint_{0-10m}$	2.56 ± 0.13	2.50 ± 0.13	2.36	0.04	0.81**	0.06	5.24	0.60**
$sprint_{0-15m}$	3.35 ± 0.15	3.29 ± 0.16	1.36	0.05	0.92**	0.06	4.63	0.74**
$sprint_{0-20m}$	4.09 ± 0.18	4.03 ± 0.19	1.12	0.06	0.94**	0.06	4.53	0.82**
$sprint_{0-25m}$	4.78 ± 0.20	4.74 ± 0.21	1.18	0.06	0.94**	0.04	4.41	0.86**
$sprint_{5-30m}$	3.81 ± 0.19	3.82 ± 0.17	1.29	0.06	0.94**	-0.01	4.78	0.95**
$sprint_{max}$ ($m.s^{-1}$)	7.39 ± 0.38	7.26 ± 0.38	2.18	0.12	0.84**	0.14	5.21	0.85**
CoD_{total}	4.16 ± 0.24	4.19 ± 0.18	1.45	0.08	0.95**	-0.03	5.06	0.68**
CoD_{0-5m}	1.57 ± 0.14	1.58 ± 0.06	1.75	0.05	0.95**	-0.01	6.46	0.27
CoD_{5-10m}	1.13 ± 0.09	1.11 ± 0.08	3.01	0.03	0.89**	0.01	7.52	0.86**
CoD_{10-5m}	1.47 ± 0.11	1.50 ± 0.09	2.77	0.03	0.86**	-0.04	6.63	0.90**
CoD_{max} ($m.s^{-1}$)	5.90 ± 0.27	6.01 ± 0.25	2.24	0.09	0.82**	-0.11	4.36	0.80**

Note: M, mean; SD, standard deviation; Sprint, 30-m linear sprint; CoD, change of direction 10-0-5-m; CV, coefficient of variation; SEM, standard error of measurement; ICC, intraclass coefficient of correlation; Diff, difference between the systems; Corr, Pearson correlation coefficient or Spearman rank-order correlation; **, p<0.01.

Discussion

The aim of this study was to validate and examine the within-session reliability of a RTD for on-ice sprint and CoD performance using split times, position-based times, and maximal velocity metrics. Inter-trial reliability demonstrated low to very low coefficients of variation, which are comparable to those reported for previously validated timing systems.[23] In addition, intraclass correlation coefficients were mostly high to very high and were similar to or higher than those reported in previous studies.[14,28] Overall, the RTD demonstrated satisfactory reliability for on-ice sprint and CoD assessment.

Correlations between RTD and LE measurements for split times, position-based times, and velocity variables were mostly high to very high and were comparable to those reported by Rakovic et al[18] for sprint performance (r = 0.48–0.95) and by Eriksrud et al[19] for CoD performance (r = 0.53–1.00). The largest sprint biases were observed for $sprint_{0-5m}$ and $sprint_{0-30m}$ (Table 1).

Bland–Altman analyses (Figure 2) demonstrated small mean biases between the RTD and the LE for sprint time variables, indicating minimal systematic disagreement between systems. $Sprint_{total}$ showed a bias of 0.05 s with limits of agreement (LOA) ranging from −0.18 to 0.28 s, while $sprint_{0-5m}$ exhibited a bias of 0.07 s (LOA: −0.15 to 0.28 s). Agreement progressively improved for intermediate and longer sprint split distances, with biases close to zero and narrower LOA.

For $sprint_{max}$, a bias of 0.14 $m.s^{-1}$ was observed with LOA ranging from −0.27 to 0.54 $m.s^{-1}$, indicating greater individual variability for velocity-based measures compared with time-based outcomes. This finding is not unexpected, as the two systems rely on different start-detection methods.[29,30] When examining the remainder of the sprint ($sprint_{5-30m}$), bias was negligible and correlations between systems were very high. This can be explained by the fact that the RTD

uses center-of-mass displacement to trigger movement onset, whereas the LE relies on an auto-start threshold when velocity exceeds 0.2 $m_{\cdot}s^{-1}$. When assessing sprint performance and force–velocity profiling, the initial rise in force production and the first displacement of the center of mass should ideally define the true start of movement.[31]

The non-significant correlation observed for the $CoD_{0\text{-}5m}$ split may also be explained by the methodological sensitivity of the start phase and by differences in measurement principles between technologies. Agreement between systems depends on the reference signal and the anatomical or mechanical point used to derive velocity. Previous studies have reported lower bias when linear encoder outputs are compared to mechanically linked signals, whereas greater bias occurs when compared to center-of-mass velocity derived from three-dimensional kinematics, particularly during phases involving rapid postural and directional changes.[19]

In the present study, differences in start alignment may also have contributed to reduced agreement for $CoD_{0\text{-}5m}$. To align the participant's center of mass with the RTD start signal, the pelvic attachment point of the linear encoder was positioned approximately 20 cm beyond the start line. Although this offset is unlikely to influence longer distances, it may disproportionately affect very short CoD segments. Similar start-related discrepancies between linear encoders and timing gates have been reported in sprint assessments.[18]

Notably, despite the reduced correlation observed for the $CoD_{0\text{-}5m}$ split, Bland–Altman analysis revealed a trivial mean bias (−0.01 s) with LOA ranging from −0.29 to 0.27 s, indicating minimal systematic disagreement between the RTD and the LE. However, the width of the limits of agreement highlights increased individual variability during this short segment. No proportional bias was observed, suggesting that disagreement reflects variability rather than systematic error. Collectively, these findings support the interpretation that reduced validity at $CoD_{0\text{-}5m}$ is likely phase-specific and influenced by start-related methodological factors, synchronization sensitivity, and the multidirectional nature of CoD movements.

The validity of radar-based measurements must be interpreted in the absence of a true field-based gold standard for on-ice sprint and CoD assessment. Systems such as LE, timing gates, global positioning system (GPS), and RTDs should therefore be considered as "silver standards," and inter-system differences are expected.[23] RTD validity is further influenced by sampling characteristics and by the short duration of early sprint and CoD phases, during which rapid velocity fluctuations and limited data points may increase relative measurement error.

Supporting this interpretation, previous GPS validation studies,[32,33] using lower sampling frequencies (e.g., 10 Hz and 18.18 Hz) have reported larger biases than those observed in the present study, particularly over short sprint distances. These findings indicate that limited sampling frequency disproportionately affects early acceleration phases and short split segments. In this context, moderate ICC values observed for short segments (e.g., $sprint_{10-15_m}$ ICC = 0.67) likely reflect methodological and sampling sensitivity rather than inadequate device consistency. From an applied perspective, these results support the use of RTDs for global sprint and CoD performance monitoring, while emphasizing that short split distances should be interpreted with caution.

Strengths and Limitations

A key strength of this study is the assessment of a RTD under ecologically valid on-ice conditions

using a commonly applied reference system. The inclusion of both sprint and CoD tasks, together with multiple performance variables (split times, position-based times, and velocity), provides a comprehensive assessment of the device's measurement capabilities across different skating phases.

Several limitations should be acknowledged. Although the LE has been primarily validated during running-based tasks, it quantifies horizontal tether displacement over time and therefore provides a kinematic estimate of the athlete's COM motion independent of the locomotor modality. Nevertheless, potential differences between running and skating mechanics should be acknowledged when interpreting the present findings. Differences in sampling frequency, signal processing, and in the measurement of COM velocity between systems may influence agreement, particularly during short split distances and early acceleration phases. The slight additional resistance applied to the LE cable, although necessary to prevent slack, should also be considered when comparing the present findings with studies using alternative configurations. Finally, the relatively small sample size consisted exclusively of male ice hockey players of similar age and competitive level, which may limit the generalizability of the findings to female athletes and other playing populations.

Conclusion

This study demonstrated that the LedsReact radar tracking device provides acceptable criterion validity and moderate to very high within-session reliability for assessing on-ice sprint and change-of-direction performance in ice hockey players. Agreement between the RTD and the LE was generally high for split times, position-based times, and maximal velocity, with only short, start-dependent segments showing increased variability.

Collectively, these findings indicate that the RTD represents a robust and practical tool for on-ice performance assessment. Although caution is warranted when interpreting very short split distances, particularly during early acceleration and change-of-direction phases, the RTD offers a valid and reliable solution for global sprint and CoD monitoring under applied field conditions. Future studies should further examine its responsiveness to training-induced changes and its applicability across different competitive levels and age groups.

Practical Applications

From a practical perspective, the LedsReact RTD allows practitioners to monitor on-ice sprint and change-of-direction performance using a single, non-invasive device. Strength and conditioning coaches, hockey coaches, and sport scientists can efficiently assess split times, position-based times, and velocity in both individual and team settings without the need for athlete instrumentation or complex setup procedures.

The main practical advantages of this system include:
(a) simultaneous assessment of split times, position-based times, and velocity using one device;
(b) the absence of harnesses or physical attachments to the athlete; and
(c) the elimination of timing gates, wiring, and external computation systems.

These characteristics make the RTD particularly suitable for routine on-ice testing, longitudinal performance monitoring, and applied research in ice hockey environments where time efficiency and ecological validity are essential.

Acknowledgements

The authors would like to thank all participants for their time, commitment, and effort throughout the study. The authors also thank LedsReact BV, 1080 Motion AB, and Hawkin Dynamics Inc. for their availability and for providing technical explanations regarding their respective systems. The authors respectfully acknowledge that the International Journal of Exercise Science and Western Kentucky University are located on the ancestral land of the ᏩᎳᎫᏫᏏ Tsalaguwetiyi (Cherokee, East) people.

The authors declare no conflict of interest. No funding was received to conduct this research.

References

1. Buckeridge E, LeVangie MC, Stetter B, Nigg SR, Nigg BM. An on-ice measurement approach to analyse the biomechanics of ice hockey skating. *PLoS One.* 2015;10(5):e0127324. https://doi.org/10.1371/journal.pone.0127324

2. Budarick AR, Shell JR, Robbins SMK, Wu T, Renaud PJ, Pearsall DJ. Ice hockey skating sprints: run to glide mechanics of high calibre male and female athletes. *Sports Biomech.* 2020;19(5):601-617. https://doi.org/10.1080/14763141.2018.1503323

3. Cox MH, Miles DS, Verde TJ, Rhodes EC. Applied physiology of ice hockey. *Sports Med.* 1995;19(3):184-201. https://doi.org/10.2165/00007256-199519030-00004

4. Fortier A, Turcotte RA, Pearsall DJ. Skating mechanics of change-of-direction manoeuvres in ice hockey players. *Sports Biomech.* 2014;13(4):341-50. https://doi.org/10.1080/14763141.2014.981852

5. Pearsall D, Turcotte R, Murphy SD. Biomechanics of ice hockey. *Exercise and Sport Science.* 2000:675-692.

6. Bond CW, Younggren A, Crabtree M, Glasner E, Garry S, Noonan BC. Force-velocity profiling for short ice hockey skating sprints: effect of exponential function ISBS Proceedings Archive. 2021;39(1):180.

7. Stenroth L, Vartiainen P, Karjalainen PA. Force-velocity profiling in ice hockey skating: reliability and validity of a simple, low-cost field method. *Sports Biomech.* 2020:1-16. https://doi.org/10.1080/14763141.2020.1770321

8. Stidwill TJ, Turcotte RA, Dixon P, Pearsall DJ. Force transducer system for measurement of ice hockey skating force. *Sports Engineering.* 2010;12(2):63-68. https://doi.org/10.1007/s12283-009-0033-4

9. Stetter BJ, Buckeridge E, von Tscharner V, Nigg SR, Nigg BM. A Novel Approach to Determine Strides, Ice Contact, and Swing Phases During Ice Hockey Skating Using a Single Accelerometer. *J Appl Biomech.* 2016;32(1):101-6. https://doi.org/10.1123/jab.2014-0245

10. Renaud PJ, Robbins SMK, Dixon PC, Shell JR, Turcotte RA, Pearsall DJ. Ice hockey skate starts: a comparison of high and low calibre skaters. *Sports Engineering.* 2017;20(4):255-266. https://doi.org/10.1007/s12283-017-0227-0

11. Lafontaine D. Three-dimensional kinematics of the knee and ankle joints for three consecutive push-offs during ice hockey skating starts. *Sports Biomech.* 2007;6(3):391-406. https://doi.org/10.1080/14763140701491427

12. Harper DJ, Morin J-B, Carling C, Kiely J. Measuring maximal horizontal deceleration ability using radar technology: reliability and sensitivity of kinematic and kinetic variables. *Sports Biomechanics.* 2023;22(9):1192-1208. https://doi.org/10.1080/14763141.2020.1792968

13. Nimphius S, Callaghan SJ, Bezodis NE, Lockie RG. Change of Direction and Agility Tests: Challenging Our Current Measures of Performance. *Strength & Conditioning Journal.* 2018;40(1):26-38. https://doi.org/10.1519/SSC.0000000000000309

14. Westheim F, Gløersen Ø, Harper D, Laugsand H, Eriksrud O. Reliability of phase-specific outcome measurements in change-of-direction tests using a motorized resistance device. *Frontiers in Sports and Active Living*. 2023;5 https://doi.org/10.3389/fspor.2023.1212414

15. Perez J, Guilhem G, Brocherie F. Reliability of the force-velocity-power variables during ice hockey sprint acceleration. *Sports Biomech.* 2022;21(1):56-70. https://doi.org/10.1080/14763141.2019.1648541

16. Perez J, Guilhem G, Hager R, Brocherie F. Mechanical determinants of forward skating sprint inferred from off- and on-ice force-velocity evaluations in elite female ice hockey players. *Eur J Sport Sci.* 2021;21(2):192-203. https://doi.org/10.1080/17461391.2020.17513044

17. Perez J, Guilhem G, Brocherie F. Ice Hockey Forward Skating Force-Velocity Profiling Using Single Unloaded vs. Multiple Loaded Methods. *J Strength Cond Res*. 2022;36(11):3229-3233. https://doi.org/10.1519/JSC.0000000000004078

18. Rakovic E, Paulsen G, Helland C, Eriksrud O, Haugen T. Validity and reliability of a motorized sprint resistance device. *Journal of Strength and Conditioning Research*. 2022;36(8):2335-2338. https://doi.org/10.1519/JSC.0000000000003830

19. Eriksrud O, Ahlbeck F, Harper D, Gloersen O. Validity of Velocity Measurements of a Motorized Resistance Device During Change of Direction. *Front Physiol.* 2022;13:824606. https://doi.org/10.3389/fphys.2022.824606

20. Arifin WN. Sample Size Calculator (Online). 2017. https://wnarifin.github.io/ssc/ssicc.html

21. Navalta JW, Stone WJ, Lyons TS. Ethical Issues Relating to Scientific Discovery in Exercise Science. *Int J Exerc Sci.* 2019;12(1):1-8. https://doi.org/10.70252/EYCD6235

22. Rakovic E, Paulsen G, Helland C, Eriksrud O, Haugen T. The effect of individualised sprint training in elite female team sport athletes: A pilot study. *J Sports Sci.* 2018;36(24):2802-2808. https://doi.org/10.1080/02640414.2018.1474536

23. Fornasier-Santos C, Arnould A, Jusseaume J, et al. Sprint Acceleration Mechanical Outputs Derived from Position- or Velocity-Time Data: A Multi-System Comparison Study. *Sensors (Basel).* 2022;22(22) https://doi.org/10.3390/s22228610

24. Hopkins WG. Measures of reliability in sports medicine and science. *Sports Med.* 2000;30(1):1-15. https://doi.org/10.2165/00007256-200030010-00001

25. Hopkins WG. A new view of statistics (Online). 2011. http://www.sportsci.org/resource/stats/valid.html

26. Hopkins W, Marshall S, Batterham A, Hanin J. Progressive statistics for studies in sports medicine and exercise science. *Medicine and science in sports and exercise.* 2009;41(1):3-13. https://doi.org/10.1249/MSS.0b013e31818cb278

27. Hopkins W. Spreadsheets for Analysis of Validity and Reliability. *Sportscience* 19, 36-42. 2015;

28. Zukowski M, Herzog W, Jordan MJ. Single Leg Lateral and Horizontal Loaded Jump Testing: Reliability and Correlation With Long Track Sprint Speed Skating Performance. *J Strength Cond Res*. 2023;37(11):2251-2259. https://doi.org/10.1519/JSC.0000000000004533

29. Haugen T, Tonnessen E, Seiler SK. The difference is in the start: impact of timing and start procedure on sprint running performance. *J Strength Cond Res.* 2012;26(2):473-9. https://doi.org/10.1519/JSC.0b013e318226030b

30. Haugen T, Buchheit M. Sprint Running Performance Monitoring: Methodological and Practical Considerations. *Sports Med.* 2016;46(5):641-56. https://doi.org/10.1007/s40279-015-0446-0

31. Haugen T, Breitschadel F, Samozino P. Power-Force-Velocity Profiling of Sprinting Athletes: Methodological

and Practical Considerations When Using Timing Gates. *J Strength Cond Res*. 2020;34(6):1769-1773. https://doi.org/10.1519/JSC.0000000000002890

32. Komino P, Le Mat Y, Zadro I, Osgnach C, Morin J-B. Sprint acceleration mechanical outputs: direct comparison between GPEXE Pro2 and 1080 Sprint devices. 04/13 2022;

33. Clavel P, Leduc C, Morin JB, et al. Concurrent Validity and Reliability of Sprinting Force-Velocity Profile Assessed With GPS Devices in Elite Athletes. *Int J Sports Physiol Perform*. 2022;17(10):1527-1531. https://doi.org/10.1123/ijspp.2021-0339