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Comparing the Effects of an Off-Ice Sprint-Change of Direction Task on Trunk Kinematics and Gait Laterality in Collegiate Ice Hockey Players

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Abstract: Laterality preferences are intrinsic in most physical activities, and ice hockey is one domain wherein these preferences might influence performance. Biomechanical laterality between dominant and nondominant (or preferred and nonpreferred) limbs is believed to be an advantageous attribute that is linked with skilled performance. Yet little is known about the implications of motor asymmetries for skilled performers in dynamic, time-constrained, team-based activities in an off-ice environment. This can be extended to when player position is considered, notably for those playing in a defensive or an offensive position. In this study, fourteen semi-professional collegiate male ice hockey players (age: 21.87 ± 2.98 years; BMI: 25.26 ± 3.21 kg/m) performed a randomized repeated 15 m sprint-change of direction task. Assessments of lower limb laterality were carried out as participants commenced the 15 m sprint change of direction task in both a right and left foot rear setback position. Biomechanical laterality between right and left rear foot setback positions was inferred by an ActiGraph GTx3 triaxial accelerometer that was located on the participants' spinous process, representing the trunk centre of mass (CoM). Overall, ANOVA results indicated significant differences across all sprint split times between the right and left foot rear setback positions, with times significantly quicker when players commenced in a right rear foot setback position ($p < 0.001$). ANOVA revealed significant differences in trunk CoM acceleration between in a right and left rear setback position, specifically during the initial 0–10 m sprint split, with offensive players observed to have lesser trunk anteroposterior and vertical CoM acceleration ($p = 0.05$) and during the final 5 m sprint split ($p = 0.002$, $d = 0.7$), despite overall smaller effect sizes seen in the left foot rear setback position. It appears that starting with the foot in a right rear setback position results in quicker 15 m performance times and concurrent lower magnitudes of trunk CoM acceleration. Although we demonstrated that offensive players were quicker and displayed less trunk CoM acceleration, we recommend that future studies use a greater number of participants for inter-limb symmetry in these movement tests.

Keywords: gait speed; lateral balance control; trunk; ice hockey; centre of mass

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1. Introduction

Acceleration and rapid changes of direction are important determinants of ice hockey performance. Specifically, ice hockey demands a high level of metabolic, physical, and biomechanical fitness [1–5]. Skating agility—that is, rapid changes of direction—is an important skill that a competitive player must have to excel [6] and is significant in that players must encompass physical, technical, and cognitive constraints [7,8], which can be developed by off-ice training [9]. Given the importance of swift directional changes, ice hockey players advance these capacities to augment skating performance.

Ice hockey is an intermittent team sport that is characterized by different unilateral high-intensity actions including accelerations, changes of direction, sudden braking, and body contact with numerous transitions during play [9,10]. Subsequently, preplanned changes of direction combined with speed and nonplanned changes of direction (e.g., reactive agility) are determinants of successful performance.

Many athletes consistently use a preferred foot that is placed in the rear setback position when commencing a standing sprint start. These lateralized behaviours influence how athletes execute different motor skills, including sprinting and rapid changes of direction [6,7]. Laterality is defined as a behavioural manifestation of dominance resulting in a preferential use and superior functioning of either the left or the right side [11]. Change of direction indices can be developed off the ice—that is, by way of a structured strength and conditioning program. This information could be beneficial when athletes execute rapid off-ice performance tasks, which may contribute to improvements in sprint and change of direction movement patterns—the relevance being that a change of direction task may have motor transfer to on-ice performance [6,9].

The importance of "core" function for stabilization and force generation in ice hockey is being increasingly recognized. The "core", or trunk, has been labelled as a box with the abdominals in the front, paraspinals and gluteal muscles in the back, the diaphragm as the roof, and the pelvic floor and hip girdle musculature as the bottom [12,13]. While the term "core strength" can refer to the strength of these muscles, core stability is the ability to control the position and motion of the trunk over the pelvis and leg to allow optimum production. This allows transfer and control of force and motion to the terminal segment in integrated kinetic chain activities [14]. In ice hockey, additional factors such as endurance, strength, power, and coordination of the abdominal, hip, and spine musculature are important components. Despite the recognized importance of the core trunk muscular group, there are few studies examining trunk motion in an off-ice environment. Therefore, it may be beneficial to determine the magnitude that the trunk accelerates; for example, trunk motion that occurs in the anteroposterior, mediolateral, and vertical direction in off-ice sprinting and changes of direction. Notably, the relationship between trunk acceleration magnitude and laterality might vary depending on position the player's on-ice position (e.g., goalkeeper, defensive, offensive positional variations). In turn, this could have implications for off- and on-ice training.

Within sport expertise research, frequency-dependent theory has received much attention in explaining and conceptualizing laterality-based advantages. Frequency dependence depicts situations in which the probability of a result or event occurring is convincingly bound to how widespread a specific trait is. Similarly, conventional evolutionary theory contends that traits or strategies found to be advantageous will be selected over disadvantageous traits or strategies [15]. Taking this idea, the authors then proposed a direct selective cause of handedness through, among other factors, an examination of functional laterality among sports that reflect fighting or aggressive abilities. While aggressive behaviours are reasonably frequent in ice hockey, their relevance to off-ice laterality is unknown.

Laterality has been investigated in team sports including football [16], basketball [17], rugby [18] and volleyball [19]. However, to date, laterality research in ice hockey has mainly focused on on-ice interactions. This sole focus offers limited opportunities to examine training modalities, given the tendency of ice motion to alter typical biomechanics due to the constrained nature of movement due to skating on a low-friction surface whilst wearing an ice hockey boot. The off-ice environment provides a distinctive environment for the examination of laterality. Although the relationship between off-ice change of direction tests and linear skating is well reported [20,21] the importance of lateralized behaviour in a sprint, change of direction task, has not been widely investigated in an off-ice environment. Although minimizing functional differences between limbs is desirable for injury prevention [22], it is important to provide movement-specific and field-based reference data that can assist performance development. Given the importance of rapid changes of direction in ice hockey, a significant yet unanswered question is how a specific sprint and change of direction task influences the lateralized behaviour of collegiate players in an off-ice environment. This focus provides opportunities to examine lateralized differences in areas such as positional anticipations, promoting a more dynamic understanding of laterality interaction. Still, it is important to integrate exercises that transfer to on-ice speed rather than spending time on methods that will not transfer to the game [11]. In addition, both offensive and defensive players use a stick specifically developed for performance on either the left or right side, thus creating a highly lateralized environment [23]. Early lateralization is commonly understood to represent each hemisphere of the human brain that is responsible for different functions—that is, each function is localized to either the right or left hemisphere. This will, in turn, influence lateralized behaviour in young children but not adults.

Incorporating dynamic correspondence exercises off the ice rather than less transferable exercises is an important consideration. These factors are of significant interest to both the practical and theoretical understanding of laterality relative to off-ice biomechanics in ice hockey. In this study, we aimed to explore laterality and trunk acceleration differences between dominant and non-dominant limbs (rear foot position) in a 15 m off-ice sprint task. Furthermore, we explored potential differences in laterality and trunk acceleration between defensive and offensive players, as well as between goalkeepers. We hypothesised that laterality differences would occur between dominant and non-dominant limbs in collegiate ice hockey players in the 15 m sprint change of direction task. We also hypothesised that magnitudes of trunk motion and performance of the 15 m performance times would differ between offensive and defensive players.

2. Materials and Methods

2.1. Participants

Fourteen male collegiate athletes (age: 21.87 ± 2.98 years; BMI: 25.26 ± 3.21 kg/m) participated in this study. An a priori power analysis was conducted using G*Power version 3.1.9.7 [24] to determine the minimum sample size required to test the study hypothesis. Results indicated that the required sample size to achieve 80% power at a significance criterion of $\alpha = 0.05$ was $n = 12$. Thus, the obtained sample size was adequate to test the study hypothesis. Concerning the players' on-ice positions, the following players were assessed: two goalkeepers, six defenders (defensive), and six forwards (offensive) players. To be included in the study, the following criteria were fulfilled: active players at a collegiate sports level; aged 18–25 years; in good health throughout the last two months; and without injuries throughout the last 6 months prior to the start of the study. All participants were classified as university students (collegiate) based on their university enrolment status. All participants had been playing ice hockey since approximately the age of 6. At the time of this study, the players' average on- and off-ice training load ranged from four to eight hours per week. The participants were required to have had at least 24 h rest preceding the start of the study and were asked not to intake alcoholic beverages, caffeine, or perform intense physical activity 24 h prior to the start of the study. Participants supplied written informed consent and had no relevant history of back, lower limb pain or injury that impaired their function. This study was conducted according to the Helsinki Declaration and was approved by the Faculty of Health Ethics Committee (H21114).

2.2. Measures and Design

A crossover and repeated measurements design was selected so that each participant experienced both a right and left foot rear setback sprint start position. The design was based on systematically assessing the players based on their lateralized behaviour in what was their representative training environment. This may lead to more powerful performance predictions [25]. However, in this context, laterality refers not only to left–right preference [22] but also to how an athlete orients his body spatially. While the collegiate players were asked to self-select their dominant foot, this relied upon the players correctly identifying their specific perceptual or anticipatory skill relative to laterality [26] that related to managing spatial circumstances. In the current study, a more traditional approach was used to assess the players' laterality (i.e., motor skill) in isolation and did not directly assess if the player's self-selection was deemed correct. The dominant and non-dominant leg were set as the participants marked their preferred lower limb (i.e., right or left foot in a rear setback position for a staggered sprint-start position), which was confirmed by the team's coach and verified by the principal researcher.

2.3. Experimental Procedure

A standard 15 m change of direction test was used to assess laterality during the first week of the players' scheduled pre-season training. The test protocol was carried out according to Baechle and Earle [27]. Accordingly, two cones were placed at the 15 m mark to represent where the players had to change direction. The specific requirement for the change of direction was represented by only one change of direction (i.e., 180° turn to the right) and sprinting for 5 m toward the finish light gate. To assess sprinting speed, photocell timing gates (Witty System, Microgate, Bolzano, Italy) were positioned at the 0 m, 10 m, and 15 m mark to measure the performance speed split times between 0–10 m, 10–15 m, and 15–10 m (Figure 1).

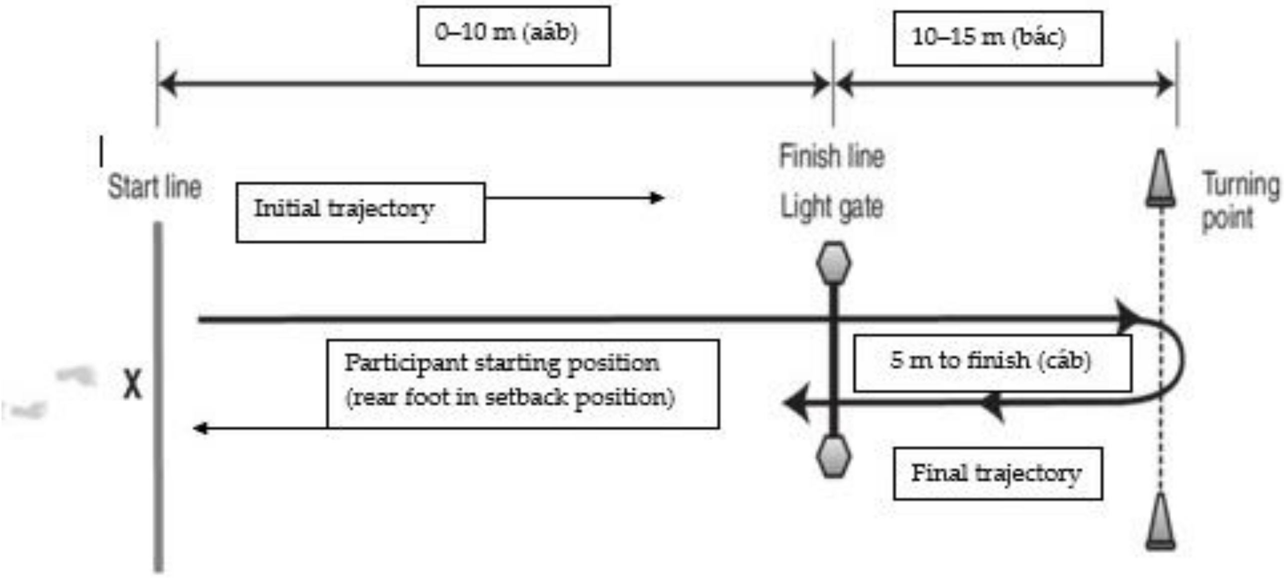

Figure 1. Schematic illustration of the right foot rear foot setback sprint-change of direction parameter.

To achieve the sprint, change of direction test, the participants had to commence from the start line in either a right rear foot setback start position, or a left rear foot setback start position. The participants then had to execute a 180° turn to the right and run as fast as possible to the arrival gate placed 5 m behind. When the finish line gate light turned red, the participant's time was recorded. The lights were composed of three balls of green colours modelled in three dimensions (3D). Each participant had to execute the test four times (i.e., two in a left foot rear setback position and two in a right foot rear setback position) in a randomized order. The leg stance was denoted by the trail leg (the leg in the rear setback position) in a standing staggered start position. The participants commenced the test with their shoulders positioned behind the start line with the selected rear leg also located just behind the start line. Before the test, each player performed a 20 min standardized warm-up and 90 s of recovery like that recommended by Janot et al. [28], with rest intervals selected based on the knowledge that ice hockey includes repeated bouts of maximal effort with a mean sprint time of 5 s [29,30]. After an initial familiarization session, the participants performed the test two times on two distinct days that were separated by at least 48 h.

The participants were verbally instructed to commence sprinting after an acoustic countdown ("3, 2, 1, go") by the principal author and were asked to run to maximum capacity. Rocking or leaning back prior to starting was not allowed. The cornering action that was performed at the 10 m mark required that participants rapidly adjust their trunk (i.e., around the designated cone) so that the lead foot was placed outside of the cone. The testing procedure and time of day were identical for all participants. The protocol occurred at an in-house gymnasium, located within the ice rink, that was familiar with the players. The gymnasium was fitted with high-grade polyurethane sled flooring (Iron Edge, St. Kilda, Australia). The participants were instructed to wear the same footwear for all sessions. The sprint-change of direction test occurred during the players' scheduled training time to eliminate effects owing to fatigue or everyday habits [31].

2.4. Data Collection

Data from an Inertial Measurement Unit (IMU) were collected instantaneously throughout all of the four sessions. The time between the signal appearance and the beginning of the participant movement was recorded, i.e., timing of the rear foot setback position to passing the start line. Here, the photocell light gate trigger signal was generated when participants passed the light gate. The participants sported a non-invasive ActiGraph GT9X+ accelerometer (ActiGraph, LLC, Pensacola, FL, USA). The IMU (3.5 × 3.5 × 1 cm, 14 g) was positioned to measure the magnitude of trunk CoM acceleration in three orthogonal planes across the vertical/longitudinal (y, upward–downward), anteroposterior (x, forward–backward) and mediolateral (z, side to side) axes. Prior to the start of the study, the devices were initialised by the primary investigator according to manufacturer instructions to record accelerations at a sampling frequency of 100 Hz. The device was secured to participants by double sided tape between the L5 and S1 spinous process as this position is the closest external point to the CoM [32] (Figure 2). Data were processed using the ActiLife software program (Version 6.13.4, ActiGraph, LLC). The raw accelerometery signals were converted from gt3x files to CSV format and saved and exported to Microsoft Excel (Microsoft Corporation Redmond, Washington, DC, USA version 4.90.4, build 6470.27615). The data analysis was performed in the time domain, with the mean of sprint change of direction splits of 0–10 m, 10–15 m and 15–10 m analysed.

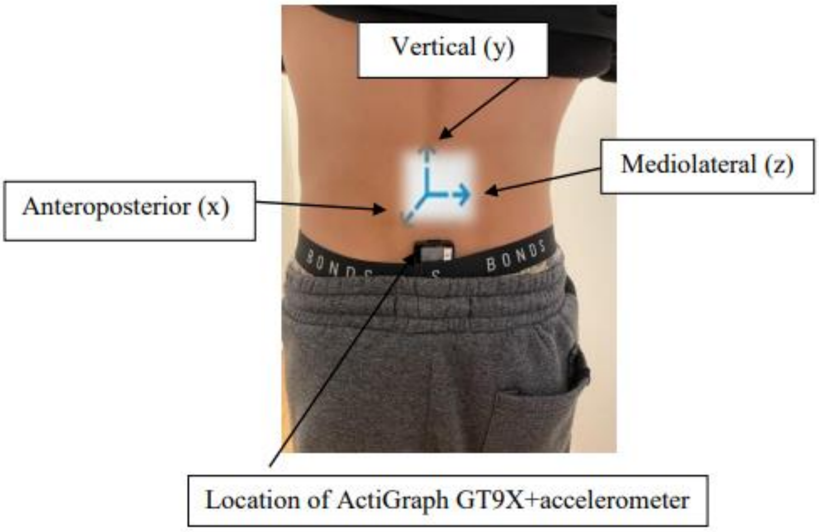

Figure 2. Depiction of orthogonal axes' orientation and sensor used in study.

No filtering was applied to the raw data. The magnitude of trunk acceleration, as observed at the spinous process, was a function of its local x, y, and z acceleration components. For repeatability, each participant was assigned an ActiGraph device that was subsequently used for all sessions. The signal vector of the x, y, and z CoM acceleration magnitude of each participant was calculated according to Equation (1):

$$\sqrt{(x^2 + y^2 + z^2)} \tag{1}$$

3. Statistical Analysis

Results are expressed as means ± standard deviations (SD). To ensure the assumptions were satisfied, independent variables were tested for linearity, normality, and variance using the Analyse-it statistical package (Leeds, United Kingdom, version 4.92). The measured data were not modified. A Shapiro–Wilk test was used for normality calculation, and data showed normal distribution. Descriptive statistics were then ascertained for sprint speed (in seconds, mm: ss) and the magnitude of trunk CoM triaxial acceleration (in gravitational acceleration, g). Then, a one-way ANOVA was used to compare laterality profiles of the left foot rear setback sprint start position and the right foot rear setback sprint start position in each 5 m sprint split time (in mm: ss). The coefficient of variation (CV) was also calculated to examine the level of dispersion in both the right and left foot rear starting positions. ANOVA was used for comparison between group factors (i.e., right-footed/left-footed) relative to the magnitude of triaxial acceleration of the trunk in the anteroposterior, mediolateral, and vertical axes between offensive and defensive players. A Cohen's d effect size [33] was used to assess the effect of both sprint performance time and magnitudes of trunk CoM acceleration using the measures; between <0.1 and 0.3 (small), greater than 0.3–0.5 (moderate), greater than 0.5–0.7 (large), greater than 0.7–0.9 (very large) and greater than 0.9 (extremely large) were considered. Significant differences were assumed when $p < 0.05$.

4. Results

4.1. Participants' Laterality

Descriptive data of laterality profiles can be found in Table 1. Significant differences were observed in all sprint split times between the right and left foot rear setback positions. It can be observed that the quickest sprint split was in the right foot rear setback position in the 10–15 m split. While the lowest variation was observed in the right foot rear setback position (9.92%), higher overall coefficient of variations were observed in the left foot rear setback position when averaged across the total distance. The slowest sprint times were identified in the initial sprint split of 0–10 m.

Table 1. Mean (±SD) magnitudes of acceleration across three different splits in the 15 m agility test in the right and left rear setback positions. CV = Coefficient of variation. Significant * $p \leq 0.05$.

Distance (meters)	Right Rear Foot Mean (mm: ss)	CV (%)	Left Foot Rear Mean (mm: ss)	CV (%)	Effect Size (d)	t	p
Sprint Split 0–10 m (a to b)	03.94 ± 0.38	9.92	03.96 ± 0.13	29.07	0.7 (large)	−4.39	0.004 *
Sprint split 10–15 m (b to c)	02.80 ± 0.25	19.00	02.81 ± 0.15	11.45	0.7 (large)	−4.89	0.001 *
Sprint split 15–10 m (c to Finish line)	02.96 ± 0.34	25.9	02.99 ± 0.36	19.08	0.5 (moderate)	−4.59	0.003 *

4.2. Athletes' Trunk Acceleration

As shown in Table 2, among right and left foot rear setback positions, the smaller magnitudes of trunk acceleration were seen when the participants started in a right foot rear setback position. Moreover, significant differences were observed in the anteroposterior direction during all sprint splits. Conversely, no significant differences were seen in the 0–10 m sprint split in both vertical and mediolateral directions. Regarding effect sizes, mediolateral trunk motion was perceived to have the largest combined effects.

Figure 3 shows the group mean magnitudes of trunk CoM acceleration across the three sprint split conditions in both right (top-most) and left foot rear (bottom-most) starting positions for the goalkeepers, offensive and defensive participants. Lower magnitudes of trunk CoM acceleration were seen in those whose position was offensive. In contrast, higher magnitudes of acceleration were consistently seen in the goalkeeper positions.

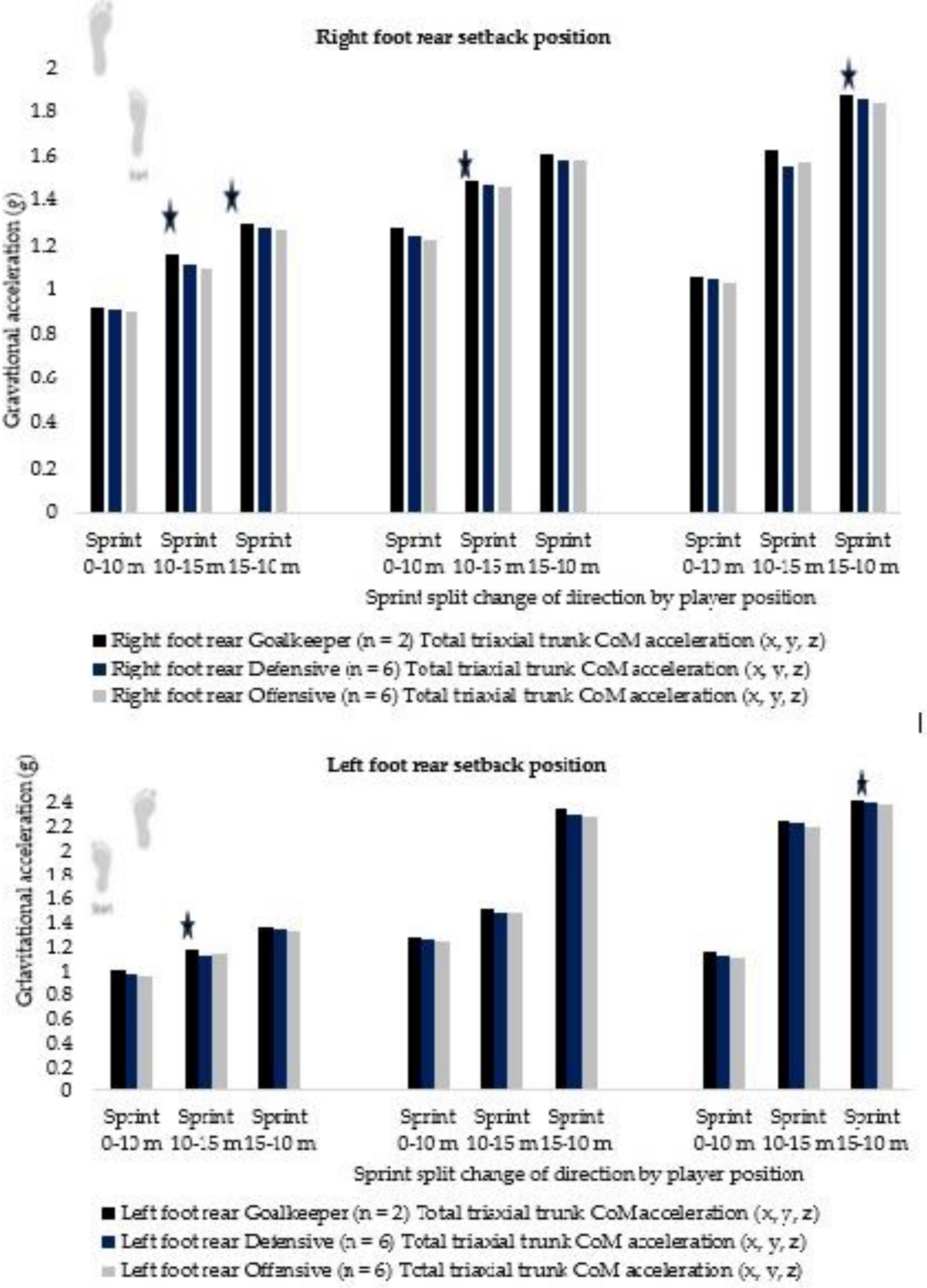

Figure 3. Group mean (±SD) magnitudes of acceleration across three different splits in a left rear start setback position (top-most) for goalkeepers, defensive and offensive players, and a right rear start setback position (bottom-most). x = anteroposterior, y = vertical, z = mediolateral acceleration in *g*. Significant $p \leq 0.05$.

Table 2. Mean (±SD) magnitudes of acceleration across three different splits in the 15 m agility test in a right and left rear start setback positions. acc = acceleration, x = a, anteroposterior, y = vertical, z = mediolateral acceleration in g. Significant * $p \leq 0.05$.

Distance (meters)	**Right Rear Foot Mean (*g*)**	**Left Foot Rear Mean (*g*)**	**Effect Size (*d*)**	***t***	***p***
	x	**x**			
Sprint split 0–10 m (a to b)	0.90 ± 0.1	0.98 ± 0.1	0.5 (moderate)	2.63	<0.001 *
Sprint split 10–15 m (b to c)	1.13 ± 0.1	1.15 ± 0.2	0.9 (very large)	2.67	<0.001 *
Sprint split 15–10 m (c to Finish line)	1.28 ± 0.2	1.34 ± 0.2	0.7 (large)	4.21	0.006 *
	y	**y**			
Sprint split 0–10 m (a to b)	1.25 ± 0.3	1.25 ± 0.2	0.5 (moderate)	2.19	0.367
Sprint split 10–15 m (b to c)	1.48 ± 0.2	1.51 ± 0.2	0.5 (moderate)	5.05	0.002 *
Sprint split 15–10 m (c to Finish line)	1.59 ± 0.2	2.31 ± 0.2	0.9 (very large)	4.75	<0.001 *
	z	**z**			
Sprint split 0–10 m (a to b)	1.05 ± 0.3	1.13 ± 0.3	0.7 (large)	3.81	0.250
Sprint split 10–15 m (b to c)	1.59 ± 0.2	2.23 ± 0.5	0.9 (very large)	4.41	<0.001 *
Sprint split 15–10 m (c to Finish line)	1.85 ± 0.3	2.39 ± 0.2	0.9 (very large)	5.01	<0.001 *

Player positional differences in the defensive and offensive positions in both right and left foot rear setback positions pertaining to the magnitude of trunk CoM acceleration were compared using ANOVA. According to the results, offensive players recorded less trunk acceleration in the right foot rear position in all acceleration channels. Yet, significance was observed only in the anteroposterior and mediolateral channels. On average, the defensive players also displayed greater magnitudes of trunk CoM acceleration in the left foot rear setback position, despite no significant differences being identified (Table 3).

Table 3. Mean (±SD) magnitudes of acceleration across three different splits in the 15 m agility test in right and left rear start setback positions between defensive and offensive players. acc = acceleration, x = a, anteroposterior, y = vertical, z = mediolateral acceleration in *g*. Significant * $p \leq 0.05$.

	Right Foot Rear Setback				**Left Foot Rear Setback**			
	Defensive (*n* = 6)	**Offensive (*n* = 6)**	***p***	**Effect Size (*d*)**	**Defensive (*n* = 6)**	**Offensive (*n* = 6)**	***p***	**Effect Size (*d*)**
	x				**x**			
Sprint split 0–10 m (a to b)	0.93 ± 0.1	0.91 ± 0.1	0.003 *	0.7 (large)	0.97 ± 0.1	0.96 ± 0.1	0.6667	0.1 (small)
Sprint split 10–15 m (b to c)	1.12 ± 0.1	1.11 ± 0.1	0.235	0.2 (small)	1.13 ± 0.2	1.14 ± 0.1	0.777	0.1 (small)
Sprint split 15–10 m (c to Finish line)	1.28 ± 0.1	1.27 ± 0.2	0.523	0.2 (small)	1.34 ± 0.1	1.33 ± 0.2	0.878	0.1 (small)
	y				**y**			
Sprint split 0–10 m (a to b)	1.25 ± 0.2	1.23 ± 0.2	0.024 *	0.3 (moderate)	1.25 ± 0.1	1.24 ± 0.2	0.259	0.1 (small)
Sprint split 10–15 m (b to c)	1.47 ± 0.1	1.46 ± 0.1	0.528	0.2 (small)	1.48 ± 0.1	1.47 ± 0.1	0.422	0.1 (small)
Sprint split 15–10 m (c to Finish line)	1.59 ± 0.1	1.59 ± 0.1	0.183	0.2 (small)	1.60 ± 0.1	1.60 ± 0.1	0.0572	0.4 (moderate)
	z				**z**			
Sprint split 0–10 m (a to b)	1.05 ± 0.2	1.03 ± 0.1	0.092	0.3 (moderate)	1.06 ± 0.1	1.06 ± 0.1	0.689	0.1 (small)
Sprint split 10–15 m (b to c)	1.58 ± 0.2	1.57 ± 0.2	0.259	0.2 (small)	1.60 ± 0.2	1.58 ± 0.2	0.003 *	0.7 (large)
Sprint split 15–10 m (c to Finish line)	1.86 ± 0.2	1.84 ± 0.2	0.002 *	0.7 (large)	1.87 ± 0.1	1.85 ± 0.2	0.1181	0.9 (very large)

5. Discussion

To the best of our knowledge, the present study was the first to examine off-ice laterality in collegiate ice hockey players and its effects during a 15 m sprint change of direction task. The influence of laterality on overall sprint performance time, with reference to the magnitude of trunk CoM acceleration magnitude, was studied with the performance times compared between goalkeeper, defensive and offensive players. Overall, we identified significant differences in laterality and the magnitude of trunk CoM acceleration. More specifically, our analysis revealed two meaningful results: (a) starting a sprint, change of direction task with the right foot in a rear setback position exhibited faster performance times when compared to the left foot rear setback position, and (b) the magnitude of trunk acceleration is significantly reduced when a right foot rear setback position is adopted. When magnitudes of trunk acceleration pertaining to player position were analysed, those participants who played in an offensive position displayed lower magnitudes of trunk acceleration when compared to their defensive counterparts.

5.1. Athlete Laterality

At the conclusion of the sprint change of direction task (i.e., 10–15 m), significant variances in laterality between both right and left foot rear setback positions were observed. For all tests, better—that is, faster—results were obtained in a right foot rear setback position. Our data appear to be consistent with the literature (i.e., [34]). Unlike common sprint tests that are used for off-ice testing, the change of direction test used in the current study required participants maintain a sprint technique that combined centrifugal or centripetal force (outward and inward radial force). Therefore, even though an increase in speed was observed from 0 to 10 m, the abrupt change in direction required that the participants decelerated and applied a braking force. And coherently with this, we found that this laterality was reduced in the right foot rear setback condition combined with quicker performance times. Yet, a reason for the improved performance could be due to well-orchestrated neuromuscular control that is required to maintain spine stability [35]. In turn, biomechanical effort increases in terms of augmented muscle coactivation and higher ground reaction forces [36]. Proportionately, our results may not be entirely surprising given that disparate physiological, biomechanical, and motor control factors appear to influence performance laterality. Though all sprint splits were observed to be slower in the left foot rear setback position, the between-player variation was marginally greater when the players commenced in a right rear setback position (e.g., a greater coefficient of variation). But it is important to consider that collegiate ice hockey players may also be skilled with their non-preferred foot, and thus consideration is needed as some of the players in the current study may not have known if they were more skilled—that is, faster—with their dominant limb or non-dominant limb. Nonetheless, it remains controversial which rear leg one should adopt when commencing a standing sprint change of direction task. This was matched by Eikenberry and colleagues [34] in that sprinters are encouraged to select a specific leg based on preference, rather than performance. Thus, more studies are needed to demonstrate if off-ice sprints and changes of direction allow specific laterality profiles for performing at a collegiate level.

5.2. Athlete Trunk Acceleration

The main findings showed the participants exhibited reduced magnitudes of trunk acceleration in a right rear foot setback position. Moreover, significant effects were observed in all but two instances, of which the non-significant results appeared in the 0–10 m sprint in the vertical and mediolateral directions. The reasons for this variation are unknown, although we speculate that while trunk acceleration varied depending on the rear foot start position, a decrease in the combined acceleration movement—for instance, the resultant vector of x, y, and z—may have somewhat reduced laterality with no detriment observed to overall performance. This is also because significant differences are common in sport-specific demands, such as unilateral actions [17,19]. In ice hockey, unilateral demands include constant changes of direction and trajectory, asymmetric displacement due to the stick grip and the technical passing/shooting action [9]. This may support the proposition that excessive laterality negatively affects movement efficiency. However, further research is needed to support this.

Agility is a performance factor in ice hockey when players are on the ice. From a mechanical perspective, it is important to orientate the body so that the mean location of the trunk CoM is as forward as possible to allow continued forward acceleration [37]. In our study, the forward lean of the players was represented by anteroposterior acceleration of the trunk. Here, we observed significant differences in anteroposterior acceleration between right and left foot positions, with the largest effect seen during the final 5 m or post change of direction. In a performance context, the horizontal braking force matched with the horizontal distance between the body CoM at the turning point should be small to avoid a significant loss of speed prior to participants accelerating rapidly in the final 5 m. These capacities have previously been associated with better running and skating sprint performance [32]. Yet sprint performance can be characterized through the CoM velocity over time [38]. Here, the position of the foot prior to cornering (i.e., change of direction) that is preferred for everyday activities, or the dominant foot, may offer answers regarding the mechanism that underpins the lower CoM acceleration in the right foot rear position, but does not explain why one would adopt these stances in the first place. Still, while Eikenberry and colleagues [35] noted that a forward lean of the body optimizes the striking angle of the foot, it could be that those with greater experience in performing a similar test were able to control their forward lean. Notwithstanding this, enhanced biomechanical effort can lead to the development of muscle fatigue [39] and that fatigue reduces neuromuscular trunk control [40]. However, current evidence cannot provide a clear link between trunk fatigue, trunk acceleration and laterality.

With respect to player positions (goalkeepers, defensive and offensive players), a significant difference in lateralization relative to the magnitude of trunk CoM acceleration was found between positions. Among the defensive players, there was a trend for an increase in the proportion of trunk acceleration in all directions in both the right and left foot rear setback positions. Since significant differences in overall trunk acceleration between defensive and offensive players were found, a potential explanation for these positional differences might be strategic or environmental advantages relating to the demands of the position. However, according to Raymond et al. [15], the increased frequency of a particular lateralization strategy is not due to lateralization itself, but rather a strategic mechanism driven by the specific constraints of the performance environment. It is possible that offensive players have a strategic advantage in sprinting and rapid changing of directions, but these advantages could differ with maturation and experience.

Among goaltenders, results indicate that greater levels of trunk acceleration were observed compared to the outfield defensive and offensive players. Goaltending requires the skilful coordination of catching with one hand and manipulating a hockey stick and blocker with the other [23]. As these authors note, the goaltender must decide to either use his preferred or non-preferred hand when it comes to on-ice catching of a puck. Therefore, lateral foot dominance might be predisposed to an a priori selection bias.

Although this study reveals new information regarding off-ice laterality distributions, it has several limitations. Firstly, it is acknowledged that our study featured collegiate players and, therefore, the results cannot be applied to elite players or those found in the upper echelons of competition. Moreover, our sample size was relatively small and could form a disproportional representation if directly compared to other collegiate players. Due to insufficient evidence linking off-ice laterality in sprinting and changes of direction to on-ice performance, we cannot infer as to how these results may influence performance. Rather, laterality was conceptualized as a perceptual trait that relates to experientially based differences rather than innate differences. In the current study, players were required to execute a 180° turn to the right at the turning point. As the players were not required to perform a 180° turn to the left, this additional laterality consideration could be important for overall performance. This may affect the findings in that each player may have had a weaker side and a stronger side when he performed a 180° rotation.

In fact, additional research may need to be performed on off-ice to on-ice performance in collegiate players to more comprehensively identify why performance times were quicker when the right foot was in a rear setback position and why the magnitude of trunk CoM acceleration was reduced in the offensive players. Despite this, the results presented here provide new information in off-ice laterality and performance. Here, off-ice laterality could be inferred using field-based, low-cost, unobtrusive wearable technology. Longitudinal studies into the effects of off-ice laterality in sprint change of direction tasks combined with a strength and condition intervention would help further this body of literature. Exploring biomechanical interventions as a strength and conditioning coach or sports specialist may also provide insight.

5.3. Practical Applications

The present analysis adds to a very limited body of knowledge regarding the implications of laterality for off-ice sprint and change of direction tasks in collegiate ice hockey players. Off-ice training techniques—that is, sprint and change of direction tasks—are known to be important factors for off-ice training that can assist with on-ice performance in ice hockey players, and laterality seems to influence both sprinting and changes of direction. The findings, in our opinion, suggest that head coaches, fitness coaches and staff members working with collegiate ice hockey players may need to consider the impact of laterality more carefully in off-ice sprint-based tasks. Further research should consider more detailed performance variables, such as shooting strategies, and more detailed positional data. It is unclear, for instance, how the differences found between left and right rear foot position influence shooting and puck control. These measures would provide greater insight into the relationships found in this study.

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