Journal of Human Kinetics volume 85/2022, 75–85 DOI: 10.2478/hukin-2022-0111
Change of Direction Ability

Lower Limb Skeletal Robustness Determines the Change of Directional Speed Performance in Youth Ice Hockey

by

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The factors that influence the on-ice change of directional speed (COD) of ice hockey players remain unclear. Therefore, this study aimed to determine which off-ice and anthropometric variables determine hockey COD with and without a puck. Thirty-two elite ice hockey players (age: 17.64 ± 1.02 years, body height: 180 ± 7.5 cm, body mass: 76.4 ± 7.8 kg) performed squat jumps, broad jumps, countermovement jumps, and pull-ups and were assessed on agility off-ice and on-ice, with and without a puck. Anthropometric characteristics were determined according to the modified somatotype method. A moderate correlation (r = 0.59–0.6) was observed among all agility tests, between on-ice agility with a puck and lower limb skeletal robustness (r = 0.45), and between on-ice agility with a puck and sit-and-reach scores (r = -0.50). Agility without a puck correlated with squat jump height (r = -0.36). Multiple regression analysis indicated that off-ice agility (β = 0.51) and skeletal robustness of the lower limbs (β = 0.35) determined (R^2 = 0.41) on-ice agility with a puck. Players' COD was assessed by Illinois tests of agility off-ice and on-ice, with and without a puck; each of these tests moderately predicted the others, but differed in their physical constraints. Players with higher skeletal robustness used more strength and power to achieve COD performance, while players with lower skeletal robustness used techniques and skills to achieve COD, resulting in superior COD performance with a puck compared to stronger athletes. CODs with and without a puck are discrete skills requiring different abilities.

Key words: *agility, skeletal muscle, sports training, motor abilities, Illinois agility.*

Introduction

Factors influencing change of directional speed (COD) have been assessed in several sports disciplines, such as rugby (Gabbett, 2006; Meir et al., 2001), soccer (Maly et al., 2014; Sporis et al., 2010), and basketball (Horicka and Simonek, 2019; Horníková and Zemková, 2022; Šeparović and Nuhanović, 2008); however, factors influencing COD in ice hockey have not been assessed. In ice hockey, COD studies (Delisle-Houde et al., 2019; Gupta et al., 2022; Madden et al., 2019) have focused on the relationship between on-ice and off-ice scores (Novák et al., 2019; Perez et al., 2021; Secomb et al., 2021; Wagner et al., 2021), performance levels (Kokinda et al., 2012; Roczniok et al., 2016a; Vigh-Larsen et al., 2021; Vigh-Larsen et al., 2020), or relationships between COD and match performance (Daigle et al., 2022; Schwesig et al., 2021; Williams and Grau, 2020). Therefore, the structural basis of ice hockey COD, such as general off-ice conditions and anthropometric characteristics, remains unclear.

The original COD model (Sheppard et al., 2014; Sheppard and Young, 2006; Young and Montgomery, 2002) included the subfactors of technique, straight sprint speed, leg muscle qualities, and anthropometric variables. However, the hierarchy of these subfactors has not been verified by structural equation modeling (Hojka et al., 2016) or by the strength of the components. The determination of crucial components in ice hockey COD is complicated by the high requirements for movement control on ice as well as puck control (with a hockey stick). Therefore, hockey agility tests are often performed with and without a puck (Schwesig et al., 2021) since

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Authors submitted their contribution to the article to the editorial board.
Accepted for printing in the Journal of Human Kinetics vol. 85/2022 in December 2022.

players must master skating with a puck as well as adjusting their position and space without a puck. Thus, there is evidence that COD performance with and without a puck differs, distinguishing between playing performance (Schwesig et al., 2021) and basic anthropometric variables (Burr et al., 2008; Kutáč et al., 2017). Therefore, it is further necessary to distinguish the factors that differentiate between COD performance with and without a puck.

COD has physical and motor control constraints (Jeffreys, 2011), which rapidly change in adolescents during growth and maturation (França et al., 2022; Živković et al., 2022). Anthropometric measurements of strength and power are considered physical constraints, whereas technical skills are considered motor control constraints. Therefore, this model can distinguish between players with better COD performance due to increased strength and power and players with better COD performance due to their skill level. This model is highly applicable in ice hockey, where technical skills have to be evaluated with and without a puck, and might provide specific training recommendations. To date, evidence suggests that off-ice strength and power are related to sprint and power abilities (Farlinger et al., 2007; Haukali and Tjelta, 2015), but their associations are lower during COD tests (Delisle-Houde et al., 2019; Farlinger et al., 2007; Haukali and Tjelta, 2015). Therefore, it is important to determine whether off-ice COD performance predicts on-ice skills and whether on-ice COD performance is influenced by physical constraints.

Numerous studies have examined the relationships of on-ice COD performance with other off- and on-ice conditional or anthropometric factors; however, these studies did not focus on possible determinants of COD with and without a puck. Therefore, this study aimed to identify off-ice and anthropometric variables that predict hockey COD performance with and without a puck.

Methods

Participants

Thirty-two junior ice hockey players (age: 17.64 ± 1.02 years, body height: 180 ± 7.5 cm, body mass: 76.4 ± 7.8 kg) from two academies in the highest Czech League were recruited at the beginning of the ice hockey season. These players included 17 defenders and 15 forwards without musculoskeletal injuries. Players were familiarized with all testing protocols before the study and during previous years in which similar periodical testing was conducted.

Design and procedures

Cross-sectional assessments were performed in two ice hockey academies at the beginning of the ice hockey season (September 2019). Testing consisted of anthropometric measurements, squat jumps, countermovement jumps, free-arm countermovement jumps, broad jumps, five jumps, sit-and-reach tests, pull-ups, and Illinois agility assessed off-ice (with a hockey stick and a ball) with a minimum 5 min of rest between consecutive tests. On-ice testing was administered after a minimum of 30 min of rest after off-ice testing and included Illinois tests of agility with and without a puck. The research design and informed consent forms were approved by the Institutional Ethics Committee of the Charles University Faculty of Physical Education and Sport (no. 245/2018), following the ethical standards of the Declaration of Helsinki in 2013. The parents of all participating players provided written informed consent.

Measures

Anthropometric variables

Body height was measured by a portable anthropometer A-213 (portable anthropometer A-213, Olomouc, Czechia) to the nearest 0.1 cm, body mass was determined using a calibrated medical scale TPLZ1T46CLNDBI300 (Columbus, OH, USA) to the nearest 0.1 kg, skinfolds were measured with the use of a Harpenden skinfold caliper (Baty International, West Sussex, UK) with accuracy of 0.2 mm, skeletal breadth was determined using a T520 thoracometer (Olomouc, Czechia) with a range of 0–40 cm, and circumferences were evaluated with measuring tape to the nearest 0.1 cm. All measurements were performed following the "Anthropometric Standardization Reference Manual" (Lohman et al., 1988) and “Somatotyping: Development and Application” (Carter et al., 1990) with standardized equipment.

In addition to the determination of body height and mass, measurements were collected of four skinfolds (triceps, subscapular, suprailiac, and calf), the maximal upper arm circumference (when contracted), the maximal circumference of the calf, and the epicondyle breadths of the humerus and femur; these variables were used to calculate frame indices of skeletal robustness. The upper and lower frame indices were calculated according to the Frisancho formulas (Frisancho, 1990):

Frame index from the upper limb =

$$\left[\left(\frac{\text{humerus epicondyle breadth in mm}}{\text{body height in cm}}\right)\right] * 100$$

Frame index from the lower limb =

$$\left[\left(\frac{\text{femur epicondyle breadth in mm}}{\text{body height in cm}}\right)\right] * 100$$

The somatotype of participants was identified according to Heath and Carter (1967) to determine mesomorph, endomorph, and ectomorph somatotypes.

Off–ice tests

Vertical jumps (squat jumps, countermovement jumps, and free-arm countermovement jumps) were performed using the Optojump Next system (Microgate Italy, Bolzano, Italia). Jump height was calculated from the flight time, which has high reliability according to the intraclass correlation coefficient (ICC > 0.92) (Gupta et al., 2022). Each type of the jump was performed in two sets of three consecutive jumps separated by a 5-min rest interval, and the best jump height was used for statistical analyses.

The squat jump was performed from a starting position with 90° knee flexion held maximally for 2 s. During the squat jumps, participants were instructed to place their hands on their hips and bend at the knees, hips, and ankles. After participants stabilized in the starting position, the tester instructed them to jump as high as possible, keeping their hands on their hips and legs straight (Gupta et al., 2022).

For the countermovement jumps, assessed on mats, participants stood in a comfortable starting position with their hands on the hips. Participants bent at the knees, hips, and ankles when cued and then immediately jumped as high as possible (Burr et al., 2007). For free-arm countermovement jumps, participants stood with their hands along their trunk in a comfortable starting position. When cued, participants bent at the knees, hips, and ankles, with arms swung backwards, and immediately jumped as high as possible with arm elevation.

The broad jump was performed as a bilateral standing long jump, and countermovement was permitted. A maximum of three trials was recorded where players tried to jump as far as possible. This test has acceptable reliability, with an intertrial difference of 0.3 ± 12.9 cm (Ortega et al., 2008).

A five-step jump was performed indoors in two trials; in this jump, participants were allowed to take five consecutive strides from a split stance starting position before jumping. From the starting position, participants were not allowed to perform any backstep with any foot; instead, they had to directly move forwards with the leg of their choice. The last jump was performed from a bilateral landing position, where performance was evaluated with a tape measure from the front edge of the player's feet at the starting position to the rear edge of the feet at the final position. The reported reliability for horizontal jumps is high (ICC: 0.95, coefficient of variation: 1.9) (Maulder and Cronin, 2005).

Pull-ups were performed using a standard gymnastic bar 2.8 cm in diameter and 240 cm in length. This test has high reliability (ICC: 0.96–0.99 and smallest worthwhile change [SWC] of 3%) (Coyne, 2015). Players were instructed to use a pronated grip with hands placed at shoulder width or slightly wider. Each repetition began with a dead hang (elbows fully extended, shoulders fully flexed, and shoulder girdle elevated) with the player's hips in a neutral position and knees in a neutral position or self-selected flexion. After reaching the starting position, players performed the upward phase of the pull-up explosively, without swinging or kicking the legs or the trunk. The upward phase ended once the subject's chin passed the pull-up bar when maintaining a neutral head position, preventing the chin from being lifted to achieve a repetition. After the upward phase was completed, players performed the downward phase of lowering their body back to the starting position at a comfortable speed with a maximum pause of 2 s between repetitions.

During the sit-and-reach test, participants sat with their feet approximately hip-wide and with a hip flexion of 90°, placing their feet against the sliding board of the testing box. Players kept their knees extended and placed their hands to maintain 90° shoulder flexion while slowly reaching forward as far as possible, with their hands moving the sliding measuring board. The reliability of this test is high, with a reported ICC of 0.97 and a standard error of measurement (SEM) of 1.4 (López-Miñarro et al., 2009).

Illinois agility tests

Modified Illinois agility tests were administered, including off-ice tests (running with a ball) and on-ice tests (skating with and without a puck) since these tests provide satisfactory validity and reliability (SEM: 0.07, minimal detectable change at the 95% CI = 0.201) (Makhlouf et al., 2022). Players started from a steady high start position at the beginning of the Illinois agility track with the ice hockey stick across the photocell (TIMY3 timing device, ALGE-TIMING GmbH, Lustenau, Austria) line (0.20 m high) and with their feet behind the photocell line. Players ran with a ball using stickhandling (Figure 1 A, running with a ball), skated with a stick only (Figure 1 B), and skated with a puck using stickhandling (Figure 1 C, skating with a puck) throughout the 60-m Illinois agility track (Figure 1); the finish line was marked with a 1.2-m high photocell. Players had to pass the whole track with both feet in all variations. When running with a ball and skating with a puck, players had to control the ball or the puck throughout the entire track and finish with the ball or the puck under stick control. The ball used was 5.1 cm in diameter, and the puck was a standard ice hockey puck (7.6-cm diameter, 2.5-cm thick, weighing 170 g). Each player completed two successful trials in each Illinois agility test, and the best results were used for statistical analyses. The time differences/deficiencies between agility without a puck and other Illinois agility tests were calculated and expressed as percentage differences.

Statistical analyses

All statistical analyses were performed using NCSS2007 7.1.21 software (NCSS, LLC, Kaysville, UT, USA) with the statistical significance set at 0.05. Pearson correlation analyses were used to assess the relationships between variables. Multiple regression analysis was used to detect relationships between test results; in this analysis, on-ice scores were set as dependent variables and off-ice scores and anthropometric characteristics were set as predictors. First, we used backward stepwise regression with on-ice agility with and without a puck set as dependent variables and all off-ice tests and anthropometric traits set as independent variables. Second, backward stepwise regression was performed only for models with on-ice agility as the dependent variable, gradually removing independent variables based on observed correlations. Third, a combination of backward and forward stepwise regression analyses were applied to find the most suitable model to predict on-ice agility.

Results

The descriptive statistics are expressed as the mean, standard deviation, standard error and the 95% confidence interval (CI) (Table 1).

Regarding the somatotype, ice hockey players were categorized as mesomorphs due to their muscle-skeletal development component. The correlation analyses showed that several variables were collinear (e.g., all jump scores, Table 2). Furthermore, off-ice agility (running with a ball) was significantly associated with both on-ice agility scores (skating with and without a puck). Lower limb skeletal robustness and flexibility were significantly associated with on-ice agility with a puck (Table 2). Squat jump performance was significantly associated with on-ice agility without a puck (Table 2). The performance differences among the Illinois agility tests were negatively correlated; specifically, there was a negative correlation of the difference between on-ice agility with and without a puck with the difference between on-ice agility with a puck and off-ice agility with a ball ($r = -0.44$). There were positive correlations between on-ice agility with a puck and off-ice agility with a ball ($r = 0.68$) as well as between on-ice agility without a puck and off-ice agility with a ball ($r = 0.35$).

Backward stepwise regression revealed that the model with on-ice agility with a puck set as the dependent variable was statistically significant. All independent variables explained 65% of the variance in on-ice agility with a puck, but only nine of these predictors were significant (Table 3). The model with on-ice agility without a puck set as the dependent variable was not statistically significant; however, off-ice agility with a ball significantly predicted on-ice agility without a puck.

The backward stepwise regression for models with on-ice agility set as the dependent variable showed that body height, mass, the broad jump score, and the sit-and-reach score (flexibility) did not significantly predict on-ice agility with a puck.

The combined backward and forward stepwise regressions identified off-ice agility ($\beta = 0.51$; CI 95% 0.16–0.60) and skeletal robustness ($\beta = 0.35$; CI 95% 0.06–0.11) as the most stable significant predictors of on-ice agility with a puck (Table 4). This parsimonious model explained 41% of the variance in the dependent variable (on-ice agility with a puck) and was highly significant (Table 4). In this model, the player's somatotype had a relatively low predictive value (Table 4).

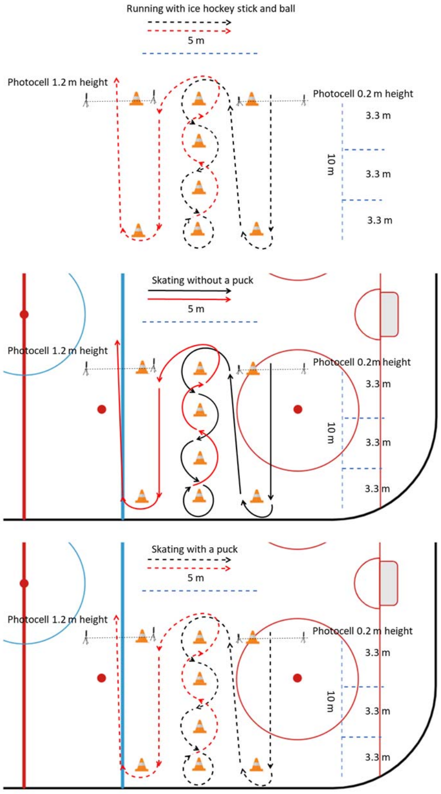

Figure 1. ***Illinois Agility test: running with a ball (off-ice) and skating with and without a puck (on-ice).***

Table 1. *Results of anthropometry, on-ice, and off-ice tests during cross-sectional measurements (n = 32).*

	Mean	SD	Standard error	± 95% CI
Body height (cm)	180.4	8.0	1.42	177.2–182.7
Body mass (kg)	76.5	7.8	1.38	73.8–79.2
Endomorphy	2.6	0.8	0.14	2.3–2.9
Mesomorphy	4.9	1.2	0.22	4.5–5.3
Ectomorphy	2.6	1.1	0.20	2.2–3.0
Frame index (skeletal robustness) in the lower limb	56.6	3.2	0.57	55.5–57.7
Frame index (skeletal robustness) in the upper limb	40.4	2.6	0.46	39.5–41.3
Squat jump height (cm)	36.2	3.6	0.60	34.8–37.3
Countermovement jump height (cm)	39.5	4.0	0.70	38.1–40.9
Free arm countermovement jump height (cm)	44.9	4.6	0.80	43.3–46.6
Broad jump distance (cm)	246.2	15.9	2.80	240.5–251.5
Five jump test distance (cm)	12.1	0.8	0.13	11.8–12.4
Sit and reach (cm)	34.7	6.8	1.2	32.3–37.1
Pull-ups (number of repetitions)	9.5	3.7	0.60	8.2–10.8
Off-ice Illinois agility with a ball (s)	16.8	0.8	0.14	16.5–17.1
On-ice Illinois agility with a puck (s)	15.61	0.6	0.10	15.4–15.8
On-ice Illinois agility without a puck (s)	14.90	0.5	0.08	14.7–15.1

Frame index in the upper limb = lower limb robustness index counted as femur epicondyle width (mm) */body height (m), Frame index in the lower limb = upper limb robustness index counted as humerus epicondyle width (mm) /body height (m). CI = confidence interval.*

Table 2. *Correlation matrix's across anthropometry and all fitness condition tests***.**

Test	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
1 Body height	-																
2 Body mass	**0.61**	-															
3 Endomorphy	-0.20	0.27	-														
4 Mezomorphy	**-0.66**	-0.04	**0.44**	-													
5 Ektomorphy	**0.64**	-0.22	**-0.51**	**-0.79**	-												
6 Frame index in the upper limb	0.07	-0.12	0.02	0.01	0.19	-											
7 Frame index in the lower limb	0.09	-0.06	0.06	0.01	0.16	**0.64**	-										
8 Squat jump height	-0,19	0.24	0.34	**0.38**	-0.49	-0.01	0.12	-									
9 CMJ height	-0.05	0.28	0.30	0.23	-0.35	-0.13	-0.01	**0.86**	-								
10 Free arm CMJ height	0.12	**0.40**	0.17	0.05	-0.23	**-0.35**	-0.12	**0.79**	**0.84**	-							
11 Broad jump	**0.36**	0.33	-0.11	-0.18	0.10	-0.22	0.02	**0.54**	**0.66**	**0.68**	-						
12 Five jump	0.28	**0.40**	-0.01	0.13	-0.05	-0.05	0.03	0.31	**0.45**	**0.34**	**0.66**	-					
13 Sit and reach test	-0.25	-0.16	0.24	0.04	-0.15	-0.14	**-0.35**	0.15	0.19	0.03	0.02	0.10	-				
14 Pull-ups	-0.14	-0.29	-0.34	-0.03	0.11	-0.26	-0.06	0.14	0.23	0.31	0.27	-0.06	-0.10	-			
15 Illinois agility with a ball	0.22	0.07	-0.03	-0.34	0.26	0.32	0.25	**-0.27**	-0.31	-0.24	-0.15	-0.30	**-0.50**	-0.12	-		
16 Illinois agility without a puck	0.23	0.15	0.29	-0.21	0.15	0.15	0,04	**-0.36**	-0.30	-0.21	-0.34	-0.30	-0.27	-0.30	**0.60**	-	
17 Illinois agility with a puck	0.24	0.05	0.11	-0.14	0.27	0.33	**0.45**	-0.15	-0.22	-0.16	-0.15	-0.30	**-0.50**	-0.12	**0.59**	**0.62**	-

Frame index in the upper limb = lower limb robustness index counted as femur epicondyle width (mm) /body height (m), Frame index in the lower limb = upper limb robustness index counted as humerus epicondyle width (mm) /body height (m). Bold numbers show statistical significance (p < 0.05). CMJ = countermovement jump.

Table 3. *Significant backward regression models between on-ice agility and off-ice performance.*

Model	**Significant predictors**	**F-ratio**	***p*-Value**	**Adjusted R^2**
On-ice agility with a puck	Body height, mass, ectomorphy, mesomorphy, Frame index in the lower limb, broad jump, sit and reach, off-ice Illinois with a ball, five jump tests.	4.87	0.0016	0.69
On-ice agility without a puck	off-ice Illinois with a ball	2.09	0.08	0.34

Frame index in the lower limb = upper limb robustness index counted as humerus epicondyle width (mm) /body height (m).

Table 4. *Multiple regression model: dependent variable on-ice Illinois agility with a puck***.**

Model	**Significant predictors**	**F-ratio**	***p*-Value**	**Adjusted R^2**
On-ice agility with a puck	ectomorphy, mesomorphy, skeletal robustness in lower limb, off-ice Illinois with a ball	6.77	< 0.001	0.43
On-ice agility with a puck	off-ice Illinois with a ball, skeletal robustness in the lower limb	11.9	< 0.001	0.41

Frame index in the lower limb = upper limb robustness index counted as humerus epicondyle width (mm) /body height (m).

Discussion

The main findings were that skeletal robustness in the lower limbs and off-ice agility with a ball predicted on-ice agility with a puck and that scores on all three Illinois tests were moderately related. This finding is in agreement with previous studies providing evidence of transfer between off-ice and on-ice agility (Novák et al., 2019) and a general approach to testing on-ice agility with and without a puck (Schulze et al., 2021; Schwesig et al., 2018, 2021). Moreover, the present study found that on-ice agility with and without a puck differed in physical constraints given differences in the predictors. This finding emphasizes that COD with and without a puck are discrete skills with different underlying abilities, as expected for differences between forwards and defenders (Schulze et al., 2021). Moreover, weave agility with (R^2 = 0.39) and without (R^2 = 0.24) a puck (part of the Illinois test) is one of eight variables able to explain 20% of game performance (Schwesig et al., 2017).

Although overall off-ice agility and on-ice agility (with and without a puck) were closely related ($r \approx 0.60$), the strength of these correlations was lower than that among jump scores ($r \approx 0.80$). Moreover, there was a negative correlation between the difference in on-ice agility (skating with vs. without a puck) and the difference between on-ice and off-ice agility (skating without a puck vs. running with a ball). This correlation suggests that players with low on-ice puck control (a high on-ice performance difference) did not differ greatly in their control of a puck or a ball (a low on-ice puck to off-ice ball performance difference). Consequently, there was a positive correlation of the difference between skating with a puck and running with a ball with the difference between skating without a puck and running with a ball. This finding indicates that players with high ball and puck control (low performance differences) do not lose performance when skating with or without a puck. Observing this phenomenon across three types of agility (off-ice, on-ice with and without a puck) is unique since few studies have reported associations between on-ice and off-ice agility. Previous research has described a more direct transfer of physical abilities; for example, performance on a 36.6-m off-ice sprint predicted forward skating performance (explaining 65.4% of variability) better than crossover or tuning performance (Krause et al., 2012). However, studies have reported associations of COD performance with and without a puck with game performance, where sprints with and without a puck were moderately ($r \approx 0.8$) correlated with match goal assistance (Schwesig et al., 2021), total points, and the plus-minus score, but sprints without a puck were correlated only with shots on the goal ($r > 0.6$) (Schwesig et al., 2021). Therefore, future research needs to investigate the relationships between (structure of) on-ice agility with and without a puck.

The finding that skeletal robustness in the lower limb determined on-ice agility with a puck was based on a positive correlation (r = 0.45), indicating that players with higher skeletal robustness in the lower limbs had lower performance (higher test duration). This anthropometric relationship might be explained by particular physical constraints, where more robust players relied on strength rather than skills to achieve the best COD without a puck, a strategy less effective for achieving a higher COD with a puck. Additionally, on-ice agility without a puck was negatively correlated with the squat jump score (-0.36), meaning that players with higher power achieved better COD without a puck. However, COD with a puck is considered superior to that without a puck. Previous research found that agility relates to the body-fat percentage (r = 0.55), with a higher body-fat percentage slowing down players (Czeck et al., 2022). In this case, our endomorphic component showed only a weak and nonsignificant relationship, which might be explained by the generally high performance of players.

The primary limitation of the present study is that COD does not reflect complex agility performance (Henry et al., 2011; Serpell et al., 2010; Sheppard et al., 2006). However, standard COD tests (the Illinois, L-Run, T test, Pro-Agility, and 505 agility) are highly reliable and valid measures of COD in invasive game athletes, explaining 89.5% of the variance in COD. Although this study did not compare different COD tests, the three aspects of the Illinois test include key movement strategies (starts, turns, acceleration after turns, weave agility and forward skating speed on the 60-m track), and these test aspects provide satisfactory validity and reliability with and without equipment (Makhlouf et al., 2022). One of the missing conditions in our experiment was backward movement agility, which is typically included in ice hockey testing (Allisse et al., 2019; Haukali and Lief, 2016; Novak et al., 2020; Roczniok et al., 2016b). As sprinting (backward and forward running) has greater factorial validity for COD than a slalom test, a 4 × 5 m sprint, or a T test in elite soccer players, backward agility in ice hockey players should be investigated.

The practical implication of these findings is that off-ice COD predicts on-ice COD. This association might be used during the preparatory period for off-ice training of ice hockey players, during which little time is spent on the ice. Thus, reduced COD while using a stick (i.e., running with a ball) can be identified and improved before the preseason on-ice period. However, ice hockey coaches should recognize that the three aspects of COD (off-ice agility with a ball, on-ice agility without a puck, and on-ice agility with a puck) have different physical bases. Specifically, players with high skeletal robustness have high COD off-ice and on-ice without a puck, but a significant performance drop regarding on-ice agility with a puck. These players should focus on the development and automatization of stickhandling. In contrast, players with high ball and puck control will have a good motor learning transfer between off-ice and on-ice COD.

Conclusion

Agility was assessed with Illinois tests, both off-ice and on-ice and with and without a puck (or a ball), to determine the COD of ice hockey players; scores on each of these tests moderately predicted scores on the others, but differed in their physical constraints. Players with higher skeletal robustness relied on strength and power to achieve better COD performance, while players with lower skeletal robustness used more techniques and skills to achieve better COD performance; less robust athletes thus had superior COD performance with a puck compared to stronger athletes.

Acknowledgements

This study was supported by Charles University, project Cooperation Sport Science, Biomedical and Rehabilitation Medicine, and by UNCE/HUM/032.

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