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Countermovement Jump Performance and Team Membership of Youth Male and Female Ice Hockey Players

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ABSTRACT

This study compared the countermovement jump (CMJ) performance of two teams of youth male ice hockey players and two teams of female ice hockey players of different levels of competition and examined whether a specific CMJ variable could predict team membership and thus be used as part of the talent identification process for ice hockey. A retrospective analysis of six CMJ variables collected via force platforms was conducted. Independent samples *t*-tests and effect sizes were used to compare the means of the six CMJ variables between the male teams and female teams respectively and a logistic regression analysis was performed to compare team membership to Prep or Varsity teams with the specific CMJ variables. Significant differences ($p \le 0.05$) were found between Prep and Varsity male players in three CMJ variables, all in favor of the Varsity group: Reactive Strength Index modified ($p = 0.016$, $ES = -0.860$), time to take-off ($p = 0.005$, $ES = 1.008$), and eccentric braking rate of force development scaled to body mass ($p = 0.013$, $ES = -0.889$). For the female players, only countermovement depth was significantly different ($p = 0.030$, $ES = 0.841$) between Prep and Varsity teams, in favor of the Varsity group. Following the logistic regression analysis, only countermovement depth (Wald's *p*-value = 0.020) could predict team membership to the Prep or Varsity group for the girls while no CMJ variables could significantly predict team membership to the Prep or Varsity teams for the boys. Results from this study suggest that other CMJ kinetic variables should be used when comparing CMJ performance between athletes rather than only using jump height. In addition, countermovement depth can be used by coaches of female ice hockey players as part of a team selection process.

Keywords: Countermovement jump, team membership, ice hockey, youth athletes

INTRODUCTION

Ice hockey is a fast and exciting sport to watch with players demonstrating great skill sets on the ice. In addition to the skating, shooting and puck handling skills required to play the game, ice hockey players need to possess well-rounded physical and physiological qualities such as upper- and lower-body muscular power, strength and endurance as well as anaerobic and aerobic fitness given the multidirectional, high-intensity intermittent efforts of the game (6, 10, 40). To assess these physical and physiological qualities, a variety of off-ice and on-ice tests have been proposed in the scientific literature to evaluate (a) playing potential (6, 28) and/or (b) player fitness (see (32) for a review of ice hockey testing protocols).

In many team sport settings, the countermovement jump (CMJ) is commonly used to assess athletic ability such as lower-body power, to track training adaptations following strength, plyometric, endurance and speed training and to monitor fatigue of the neuromuscular system (8, 12). For the purpose of talent identification, the CMJ is regarded as valid and as a strong predictor for on-ice skating performance and playing level (6, 14, 22). In fact, Bracko and George (4) suggest that "although jumping, running, and skating are biomechanically different, it is the power component of each movement that seems to be similar" (p.116). From a strength & conditioning perspective, Boucher and colleagues (3) suggest that the CMJ can be used as a starting point for players' physical preparation and selection especially when assessing numerous players at once and access to the ice is limited, although off-ice tests cannot replace on-ice tests to evaluate potential improvements associated with skating. Additionally, Janot and colleagues (22) suggested that off-ice tests are more economical compared to on-ice testing and that a generic test like the CMJ allows coaches to identify issues with skill (on-ice skating acceleration and speed) or conditioning (repeated sprint skate ability) that can be improved following strength & conditioning sessions.

In recent years, researchers and practitioners have been encouraged to move beyond only measuring jump height or 'jump outcome/output' and to also include variables that describe 'jump strategy' (2, 8, 15, 18, 37). When assessed via force plates, the force-time characteristics and additional kinetic variables obtained from the CMJ can provide insights into an athlete's neuromuscular performance (31). For example, Claudino and colleagues (8) reported many CMJ variables such as peak power, mean power, peak velocity, peak force, mean impulse, and power to be sensitive in tracking the supercompensation effects of training, which occurs after a period of acute fatigue according to Selye's General Adaptation Syndrome (11). From a training perspective, identifying deficits in neuromuscular performance in the 'eccentric yielding' and 'eccentric braking' subphases of the main eccentric phase of the CMJ and/or during its concentric phase can provide guidance to the strength & conditioning professional in selecting training exercises and methods such as unloaded or loaded plyometric exercises, general strength training exercises like a loaded squat or to implement velocity-based training to improve performance (20).

From a fatigue management perspective, in a study by Gathercole and colleagues (18) that examined the suitability of the CMJ to detect fatigue-induced declines in neuromuscular function and the usefulness of alternative CMJ variables for post-exercise fatigue detection and recovery, several CMJ variables showed interday coefficient of variations above 5% suggesting an altered movement strategy due to neuromuscular fatigue. In that study, the typical variables collected during CMJ testing that showed interday coefficient of variations above 5% were: maximum rate of power development (7.3 ± 3.7), time to peak power (5.4 ± 3.4), maximum rate of force development (16.2 ± 7.8), time to peak force (7.7 ± 4.0), minimum velocity (5.9 ± 3.3), and the ratio of flight time to contact time (5.2 ± 3.2). The alternative CMJ variables that showed an interday coefficient of variation above 5% were: the area under the force-velocity trace (7.4 ± 3.7), eccentric duration (8.0 ± 3.7), concentric duration (5.1 ± 3.4), total duration (6.1 ± 3.3) and mean centric and concentric power over time (7.9 ± 3.5). Interestingly, these variables were related to the eccentric phase of the CMJ and time, while 'outcome/output' variables such as peak power, flight time and jump height showed interday coefficients of variation of less than 5%. The findings thus demonstrated greater variability in the neuromuscular strategy that was required to maintain jump 'outcome/output', hence reinforcing the interest of examining this key phase of the CMJ.

Specifically to ice hockey, Gannon and colleagues (15) used the CMJ to quantify changes in neuromuscular function of professional ice hockey players over a full ice hockey season. To do so, they collected four variables (concentric mean velocity, concentric peak velocity, jump height, and countermovement depth) that represented (a) jump performance (jump height), (b) kinematics (mean velocity, peak velocity) and (c) movement or jump strategy (countermovement depth) and that were showed to be sensitive to changes in neuromuscular status. Significant decreases were found in concentric peak velocity, jump height, and countermovement depth at each of the four phases of the season, with the largest differences observed during the late-season relative to the pre-season, suggesting that players were in a compromised neuromuscular state for a significant period of time during the in-season, potentially due to the rigors of the competition calendar and extensive traveling, which impact recovery (15). Countermovement depth showed the largest decrement throughout the season and proved to be the most sensitive to changes in neuromuscular function over that period, with decrements in meters of -0.06 ± 0.03 in the early-season, -0.10 ± 0.04 in the midseason and -0.15 ± 0.04 in the late season compared to pre-season baseline testing.

However, given the number of kinetic variables that can be collected via force platform systems, it is important for practitioners to select the most appropriate metrics during the CMJ for the effective integration and use of vertical jump testing. In a brief commentary, Schuster and colleagues (37) summarized best-practice concepts for screening & profiling, programming & monitoring of training and for rehabilitation of professional basketball players that can be implemented through vertical jump testing. They described how several variables such as jump height, countermovement depth, eccentric deceleration, eccentric duration, eccentric peak velocity, force at zero velocity and concentric rate of power development can be extracted, analyzed, and interpreted to offer a global portrait of neuromuscular performance during the three phases of the CMJ. Similarly, Bishop and colleagues (2) proposed a framework aimed at researchers and practitioners to help guide metric selection for commonly used jump tests, including the CMJ. In this framework, it was suggested that both jump height and the Reactive Strength Index Modified (RSImod), which is calculated by dividing jump height by time to take-off, be considered outcome measures while time to take-off and countermovement depth be considered as jump strategy metrics. Taken together, the identification of both outcome and jump strategy variables during CMJ testing can provide coaches, researchers, and/or sport science professionals with metrics that possess different levels of sensitivity to training adaptations (both positive and negative) that complement each other in the analysis of the training process.

Considering the popularity of the CMJ for assessing lower-body power in various sporting contexts, its ease of use with large groups of athletes and its correlation to on-ice skating performance, the purpose of this research was two-fold. Firstly, it aimed to compare the CMJ performance of two teams of young male ice hockey players and two teams of female ice hockey players of different levels of competition using both outcome and jump strategy variables to which it was hypothesized that there would be significant differences in CMJ performance between the Prep and Varsity groups in both male and female teams considering that skating, which relies on lower body power, is a determining variable among the best players and that the CMJ is a valid and as a strong predictor for on-ice skating performance. Secondly, it aimed to examine whether a specific CMJ variable could predict Prep or Varsity team membership and thus be used as part of the talent identification process for ice hockey. However, skating ability is only one of many variables related to ice hockey performance and thus would not reflect the complexity of the talent identification process since other attributes such as leadership and personality need to be considered.

METHODS

Approach to the problem

A retrospective analysis of CMJ test data collected via a force platform system as part of the regular performance testing of four youth ice hockey teams was conducted. For both Varsity teams, data were collected during the pre-season testing in September 2021 before the start of their respective on-ice training activities. For both Prep teams, data were collected in November before the start of their on-ice training activities, following participation to another team sport during the Fall term as per school policies.

Subjects

A total of 65 young ice hockey players from the four different teams of the school took part in this research. Table 1 provides an overview of the main characteristics of the different teams. The data was gathered by the strength & conditioning coach as part of the teams' regular training activities. Therefore, approval of a university ethics committee was not required (42). Participants' personal information was coded in a database and information is presented in aggregate to ensure confidentiality. The study was conformed to the recommendations of the Declaration of Helsinki and verbal consent was obtained from each nominated individual player and from the director of the ice hockey program.

Procedures

For both varsity teams, the CMJ was performed as the third test included in their pre-season testing battery in September. After a standardized warm-up, participants completed two repetitions of the 10-meter sprint test from a stationary start and two repetitions of the modified 505 change of direction test before completing three maximal CMJ on portable dual force plates (Hawkin Dynamics, Westbrook, ME, USA) that sampled at 1000 Hz.

Table 1. Summary of participant information

Teams	Body mass in kg (mean ± SD)	Year of birth							Grade					
		2002	2003	2004	2005	2006	2007	2008	8	9	10	11	12	PG
Prep Girls (n = 13)	61.21 ± 7.22				1	4	5	3	4	4	5			
Varsity Girls (n = 17)	66.29 ± 6.56		4	8	3	2					3	5	8	1
Prep Boys (n = 17)	71.83 ± 11.65		1	3	10	3				2	5	8	2	
Varsity Boys (n = 18)	80.45 ± 12.38	1	5	5	5	2					3	4	11	

Legend: PG: Post-Graduate

Participants then completed further tests for upper body relative strength (chin-ups) and aerobic power (30-15 Intermittent Fitness Test). For both Prep teams, testing was performed in November after the conclusion of fall sports. Participants completed a standardized warm-up after which they completed two maximal CMJ on the same portable dual force plates before moving on with their regular off-ice training session.

For all teams, participants were instructed to keep their hands on their hips to eliminate any contribution of the upper extremities. Following a 3-2-1 countdown offered by the S&C coach, participants had to wait for an audio signal given by a tablet before rapidly performing the countermovement and jumping up as high as possible. Each attempt was interspersed with approximately 10 seconds of recovery due to time constraints. The mean of the three and two jumps was used for analysis for both varsity and prep teams, respectively (Haddad, Simpson, & Buchheit, 2015).

Based on their relevance in jump monitoring and neuromuscular assessment, the following six variables were selected to offer a global portrait of neuromuscular performance (2, 15, 37):

1. Measures of jump outcome
   a. Reactive Strength Index Modified: Ratio of CMJ height to time to take-off and considered a comprehensive indicator of jump performance or « explosiveness » in a variety of plyometric exercises (13).
   b. Jump height (m): Vertical displacement of an athlete's center of mass during the jump.
   c. Peak relative Propulsive Power (W/kg): Greatest power achieved during the concentric phase of the jump relative to body mass.

2. Measures of jump strategy
   a. CMJ depth (m): The distance the athlete's center of mass travelled downwards during the jump.
   b. Time to take-off (s): Duration of time between the initiation of the countermovement and take-off i.e., how long the athlete is taking to complete the unloading, eccentric and concentric main phases of the CMJ.
   c. Eccentric braking rate of force development scaled to body mass (N/s/kg): Rate of force development (RFD) during the eccentric braking phase of the CMJ where higher is typically better for explosive athletes.

Statistical analysis

A database containing the identified metrics for each player was created in Excel (Microsoft Corp, Redmond, WA, USA) before being exported to JASP (version 0.16, Amsterdam, Netherlands) for analysis. Descriptive statistics are presented as means and standard deviations (means ± SD). To answer the research questions, independent samples t-tests were used to compare the means of the six variables between the prep and varsity male teams and the prep and varsity female teams. A logistic regression analysis was then performed to compare dichotomous variable (team membership to Prep or Varsity team) and the specific CMJ variables. As this technique requires a comparison of data using the same measurement scale for continuous variables, the collected data was converted into z-scores before analysis. Normality and homogeneity of variance were assessed using Shapiro-Wilk and Levene's tests. Statistical significance was set at $p \leq 0.05$ and effect size of < 0.2, < 0.6, <1.2 and > 1.2 were considered trivial, small, moderate, and large (21).

RESULTS

Significant differences ($p \leq 0.05$) were found between Prep and Varsity male players in 3 out of the following 6 CMJ variables, all in favor of the Varsity group: mRSI ($p = 0.016$, $ES = -0.860$), time to take-off ($p = 0.005$, $ES = 1.008$), and eccentric braking RFD scaled to body mass ($p = 0.013$, $ES = -0.889$). For the female players, only countermovement depth was found to be significantly different ($p = 0.030$, $ES = 0.841$) between Prep and Varsity teams, in favor of the Varsity group. Results of the independent samples *t*-tests between the Prep and Varsity teams are presented in table 2.

Following the logistic regression analysis, none of the six CMJ variables could significantly predict team membership to the Prep or Varsity teams for the boys. Even when first removing the CD variable and then both the CD and JH variables (since the p-values associated with these variables did not appear to be significant in the comparison of the means carried out previously using the independent samples *t*-tests), the results obtained were not conclusive. To summarize the results of the logistic regression analysis for boys, although the Varsity group differs significantly from the Prep group in terms of the results obtained for three of the six variables studied, none of them predicts more than another whether an athlete belongs to the either of these groups.

For the girls, the Wald's p-value associated with countermovement depth is the only one that was significant at $p \leq 0.05$. It should also be remembered that during the previous comparisons of means, countermovement depth was also the only one to be statistically significant. To sum up the situation for the girls, the results obtained for the countermovement depth of a CMJ could predict whether an athlete belongs to the Prep or Varsity group. The z-scores obtained between the Prep and Varsity groups for the six CMJ variables as well as the p-values associated with the Wald test for boys and girls are presented in table 3.

Table 2. Results to the comparison of the means

	Prep Boys (n = 17)	Varsity boys (n = 18)	*P*- value	Effect size	Prep Girls (n = 13)	Varsity Girls (n =17)	*P*- value	Effect size
JH	0.362 ± 0.044	0.382 ± 0.049	0.219	-0.424	0.259 ± 0.045	0.258 ± 0.029	0.942	0.027
mRSI	0.387 ± 0.086	0.453 ± 0.066	0.016*	-0.860	0.313 ± 0.084	0.314 ± 0.055	0.986	-0.007
PrPP	50.586 ± 4.567	52.666 ± 4.264	0.173	-0.471	40.885 ± 4.936	40.258 ± 3.951	0.702	0.143
CD	-0.388 ± 0.045	-0.385 ± 0.055	0.851	-0.064	-0.292 ± 0.054	-0.331 ± 0.137	0.030*	0.841
TTT	0.962 ± 0.128	0.854 ± 0.082	0.005*	1.008	0.855 ± 0.137	0.838 ± 0.086	0.710a	0.143 a
sBRFD	62.539 ± 28.590	86.459 ± 25.246	0.013*	-0.889	72.002 ± 30.509	68.150 ± 22.792	0.695	0.146

Legend: JH: Jump Height (m); mRSI: Reactive Strength Index Modified; PrPP: Peak relative Propulsive Power (W/kg); CD: Countermovement Depth (m); TTT: Time to Take-off (s); sBRFD: Eccentric Braking RFD scaled to body mass (N/s/kg)
** = Statistically significant (p ≤ 0.05)*
[a] = Levene's test was significant (F (1) = 4.759, p = 0.038) for the variable time to take-off when comparing the Prep and Varsity girls. As such, Welch's adjusted t-statistic is reported in Table 2 with its associated Cohen's d.

Table 3. Results of the logistic regression analysis

	Boys		Girls	
	z-score	***p*-value (Wald)**	**z-score**	***p*-value (Wald)**
JH	0.442	0.659	-0.027	0.978
mRSI	-1.367	0.172	-0.879	0.379
PrPP	1.193	0.233	0.877	0.380
CD	-1.419	0.156	-2.323	0.020*
TTT	-1.635	0.102	-1.383	0.167
sBRFD	1.628	0.104	1.119	0.263

Legend: JH: Jump Height (m); mRSI: Reactive Strength Index Modified; PrPP: Peak Relative Propulsive Power (W/kg); CD: Countermovement Depth (m); TTT: Time to Take-off (s); sBRFD: Eccentric Braking RFD scaled to body mass (N/s/kg)

** = Statistically significant (p ≤ 0.05)*

DISCUSSION

The purpose of the present research was to (a) to compare the CMJ performance of two teams of youth male ice hockey players and two teams of female ice hockey players of different levels of competition and (b) to examine whether a specific CMJ variable could predict Prep or Varsity team membership.

When comparing the CMJ performance of the different teams, the results of this study showed jump height to have a small, non-significant difference (p = 0.219, ES = -0.424) between male players from the Prep and Varsity teams and a trivial, non-significant difference (p = 0.942, ES = 0.027) between the female players from the Prep and Varsity teams. In light of these results, it seems that jump height alone may not be regarded as a valid and as a strong predictor for playing level in the context of this study (6, 14, 22). In fact, previous research by Burr and colleagues (7) examined the appropriateness of various vertical jump protocols to assess leg power and playing potential and found that the squat jump provided the highest correlation between lower body power and selection order of top players at the National Hockey League Entry Draft, although there were no significant difference between the squat jump and CMJ. However, adequate performance of the squat jump needs to emphasize the propulsive phase by avoiding any countermovement (34), hence the recent interest and preference for the CMJ to assess neuromuscular function (17, 18). Despite the fact that forward skating mechanics in ice hockey rely more on concentric muscle actions and that eccentric muscle actions are somewhat limited during performance of this skill compared to other athletic tasks such as jumping and sprinting (1), efficient use and thus assessment of the stretch-shortening cycle found in the CMJ can be relevant for changes of directions and quick accelerations during each shift. Altogether, this reinforces the need to examine via force plates the force-time characteristics and additional kinetic variables obtained during the phases of the CMJ (31).

By including variables that also describe jump strategy, comparison of the CMJ performance between the male Prep and Varsity teams showed three CMJ kinetic variables to be significantly different ($p \leq 0.05$) between the teams, all in favor of the varsity group. A single outcome variable, mRSI, showed moderate differences (ES = -0.860) between both groups while two jump strategy variables, time to take-off and eccentric braking RFD scaled to body mass, also showed moderate differences (ES = 1.008; ES = -0.889). The mRSI, as a ratio of CMJ height to time to take-off, has been developed as a measure of explosive power (13) that can be used to assess an athlete's ability to use the stretch-shortening cycle in a vertical plyometric exercise (13, 38). As a simple performance index, the mRSI captures two conceptual factors of the performance of the CMJ: (a) a force factor and (b) a speed factor (23). In the present study, the moderate differences in mRSI as an outcome variable between both male groups was influenced by the jump strategy variable time to take-off, a speed factor, which suggests that male players from the Varsity team not only achieved higher jump heights in general, but that they completed the unloading, eccentric and concentric main phases of the CMJ more rapidly than the Prep team. According to Bishop and colleagues (2), a reduction in time to take-off could be explained by (a) a reduction in countermovement depth, which will likely result in a reduced jump height and thus be considered a negative training adaptation or (b) improved ballistic qualities of the lower extremities as a positive adaptation to training. Thus, given the time available to produce force in various sporting movements during training and competition, the assessment and monitoring of time to take-off would be of value from both a performance and fatigue monitoring perspective (16). In this regard, eccentric braking RFD scaled to an athlete's body mass also seems to be a useful variable when comparing athletes, which is showed by the moderate differences (*ES* = -0.889) between the Prep and Varsity groups in the present study. According to Schuster and colleagues (37), this variable can also be used to track the athletes' progress throughout training programs and ensure positive adaptations of the neuromuscular system are obtained from training. In fact, studies by Laffaye and colleagues (25, 26) demonstrated eccentric RFD to be an accurate predictor of vertical jump height that summarizes the ability of the muscle-tendon unit to stretch and store elastic energy as well as activate the stretch-reflex, two important components of the stretch-shortening cycle (24). Cormie and colleagues (9) also demonstrated that the most significant changes in the shape of the power-time, force-time, and velocity-time curves of the CMJ occurred primarily during the eccentric phase of the CMJ following 12 weeks of lower-body power training in jumpers and non-jumpers. They explained that participants increased the magnitude of their countermovement (ie. countermovement depth) as well as increased eccentric RFD, which helps generate additional force at the beginning of the concentric phase. Considering that many movements in ice hockey, both on-ice and off-ice as part of strength & conditioning practices, involve the stretch-shortening cycle, optimization of the eccentric phase of muscle action is deemed important and should thus be assessed and monitored via force plate testing. Overall, examination of the CMJ kinetic variables obtained from CMJ testing suggest that the players from the Varsity group possess better ballistic qualities of the lower extremities than the Prep group especially during the eccentric main phase of the CMJ, which could potentially transfer to better on-ice skating performance.

For the female players, only countermovement depth showed a significant moderate difference between the groups, in favor of the Varsity group ($p = 0.030$, *ES* = 0.841). This result could thus reflect a difference in jumping technique between the Prep and Varsity teams possibly resulting from differences in training experience and strength levels where stronger athletes, in a group of relatively homogenous skill, who possess more experience in resistance training would perform better in comparison to weaker athletes (9, 38). These results also support the findings of Gannon and colleagues (15) that countermovement depth, as a jump strategy variable, can be used to monitor changes in neuromuscular status because changes in the eccentric function of the muscle could potentially alter the skating efficiency and acceleration ability of ice hockey players. These changes in countermovement depth can also help contextualize changes in time to take-off (2).

When examining whether a specific CMJ variable could predict Prep or Varsity team membership, none of the CMJ variables of this study could predict more than another whether an athlete belongs to the male Prep or Varsity teams. For the boys, the McFadden R^2 obtained for the logistic regression model was 0.304, suggesting the results to be a weak representation since it would only explain 30% of the variance in team membership. This result somehow corroborates the findings of Lemoyne and colleagues (28) who found that off-ice fitness tests, which included the vertical jump, could not discriminate between selected and non-selected Under-15 elite male ice hockey players during summer evaluation camps. For the girls, the McFadden R^2 obtained for the logistic regression model was 0.380, which was better than for boys but cannot be considered very representative since it would only explain 38% of the variance in team membership. However, despite the lack of data used in our sample, but since these data still represent practically the entire population related to our sample, it was interesting to observe an acceptable z-score for all CMJ variables except countermovement depth, with a value of 2.323. In other words, the distribution of the data around this variable showed a standard deviation of 2.323 from the mean, which is beyond what is generally accepted. We also noted Wald's p-value associated with countermovement depth this variable to be the only one that was significant at $p \leq 0.05$. Thus, the results obtained for the countermovement depth of a CMJ could predict on their own whether a female athlete would belong to the Varsity or Prep group. The inclusion of countermovement depth as a potential predictor of team membership in female athletes but not for the male athletes may be reflective of the sex differences in CMJ performance. In fact, McMahon and colleagues (30) attributed the greater concentric impulse and velocity and thus greater jump height in men mainly to greater countermovement depth compared to women, despite similar movement times. Female athletes with greater countermovement depth than their other female counterparts would thus demonstrate a more compliant (less stiff) leg strategy. From a biomechanical perspective, this greater countermovement depth could potentially be associated with on-ice skating performance where high-caliber skaters typically demonstrate greater hip extension and hip abduction ranges of motion in both acceleration and steady-state skating compared to lower-caliber skaters (5). Skating speed, like sprinting speed, is an interaction between stride length and stride frequency where high-caliber skaters show a greater range and rate of joint motion in both the sagittal and frontal planes which contributes to greater stride length (41). Altogether, the results of this study further highlight the multifactorial aspect of ice hockey where players need to possess well-rounded physical qualities such as speed, muscular strength and power, anaerobic and aerobic fitness, mobility, and stability to perform multidirectional, high-intensity intermittent efforts alongside the ability to execute technical skills such as skating, shooting and passing of the puck and tactical understanding (6, 10, 32, 35, 40). Team membership and talent identification is thus a complex process that requires that a comprehensive, holistic evaluation protocol be developed to assess physical attributes, technical-tactical skills as well as psychological assets via off-ice and on-ice testing as well as observation of game performance (28, 39).

It is important to highlight the limitations of this study. Firstly, participants were selected from the four youth ice hockey teams from the same local boarding school, with data collection for the varsity teams taking place as part of their pre-season testing battery in September while for the Prep teams, testing was performed after the conclusion of fall sport season in November. Secondly, goaltenders from both varsity teams were not available in September at time of testing and therefore, all goaltenders were excluded from this study. Thirdly, CMJ performance was not compared to other off-ice and on-ice performance indicators for ice hockey, thus rending any associations to game performance difficult to make. Finally, only six variables were selected for the purpose of this study while other CMJ kinetic variables obtained via force plate testing can offer potential insights in CMJ performance (both outcome and jump strategy variables) and could thus be explored. Overall, the data presented herein is specific to the context of these four ice hockey teams at the beginning of their respective seasons and changes in CMJ performance were not monitored. The findings of this study may thus be difficult to generalize to other ice hockey teams at similar levels of competition.

CONCLUSION AND PRACTICAL APPLICATIONS

The effective integration and use of vertical jump testing using force platforms for ice hockey can prove valuable for talent identification and for strength & conditioning purposes. The results of this study demonstrated no significant differences in jump height between Prep and Varsity teams for both males and females, thus supporting recent suggestions to move beyond only assessing jump height and to consider other CMJ kinetic variables during pre-season fitness testing and over the course of an ice hockey season. In terms of talent identification, no CMJ variable could predict team membership for the boys while for the girls, only countermovement depth proved to be significant between the Prep and Varsity groups and can therefore be used as part of a team selection process. Overall, limiting team membership selection to a few number of variables from CMJ testing seems incomplete, except for the addition of a single variable in female players, hence why ice hockey testing protocols typically include a variety of both on-ice and off-ice tests (3, 6, 22, 27, 29, 32, 36).

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