THE RELATIONSHIP BETWEEN HORIZONTAL FORCE-VELOCITY PROFILE AND VERTICAL STRENGTH IN FEMALE ICE HOCKEY PLAYERS

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The primary purpose of this study was to evaluate the horizontal force-velocity (HFV) profiles of female collegiate ice hockey players and compare these to metrics of muscular strength. The secondary purpose of this study was to categorize strength metrics using reduction analyses to improve the interpretation and application of these results and that of future studies. Thirteen female ice hockey players (body mass = 66.7 ± 18.0 kg; height = 171.6 ± 6.2 cm) completed three 50-meter on-ice sprints. Instantaneous velocity was measured using a radar gun in which participant HFV profile metrics (maximal velocity, tau, force-velocity slope, maximum theoretical force, ratio decrease force) were derived. Forty-eight hours later, participants completed four strength tests (drop jump, countermovement jump, loaded countermovement jump, and isometric squat) measured using a dual force plate resulting in 64 metrics of strength. A stepwise regression was employed to assess the associations between strength and HFV profile metrics. All strength metrics were entered into a principal component analysis (PCA) to support interpretation of the results. There were no significant associations between strength and HFV profile metrics. The PCA identified four clusters of strength metrics that were considered distinct strength properties in this population. This study presents a robust method for evaluating skating HFV profiles and strength metrics in ice hockey players and should be used in future studies to contribute to this body of literature.

KEYWORDS: skating, performance, strength and conditioning

INTRODUCTION: Ice hockey is a highly complex team invasion sport that involves skating, stick and puck handling, and physical contact and collisions. Horizontal force, in addition to power, and acceleration during forward skating are key determinants of ice hockey performance (Samozino et al., 2016). Horizontal force-velocity (HFV) profiling estimates the horizontal force produced by an athlete while performing a linear sprint by combining kinematic metrics, providing valuable insight on athlete power expression which can subsequently be applied in training (Jimenez-Reyes et al., 2018). It is well accepted that muscular strength is important for ice hockey players (Hoff et al., 2005; Horwath et al., 2019), and strength training is a key component of training for this sport. Previous research has explored HFV profiling in ice hockey players (Perez et al., 2019, 2022; Stenroth et al., 2020) however, these studies may be using overly simplified methods and have yet to relate these profiles to strength metrics, which is crucial to inform training. Further, there is no empirically supported categorization strength properties in this population. Thus, the first aim of this study was to evaluate the HFV profiles of female collegiate ice hockey players and compare these profiles to strength metrics. The second, was to identify distinct strength properties from a series of vertical force-time metrics captured using a dual force plate system and use these categories to interpret the results.

METHODS: Thirteen female collegiate ice hockey players (body mass = 66.7 ± 18.0 kg; height = 171.6 ± 6.2 cm) were recruited for this study. Following a standardized warm up, participants completed three 50-meter skating sprints. The instantaneous velocity, collected using a radar gun (Stalker II, Texas US), was used to determine participant HFV metrics (maximal velocity, tau, force-velocity slope, maximum theoretical force, ratio decrease of force) using the method proposed by Samozino et al. (Samozino et al., 2016) within a custom Python script. Forty-eight hours later, participants completed a standardized lower body strength battery which included a 30 cm drop jump (DJ), countermovement jump (CMJ), loaded (75% body weight) CMJ (LCMJ), and isometric squat (IST) on portable dual force plate system (ForceDecks Lite, VALD Performance). Sixty-four strength metrics were derived from these tests and placed into a principal component analysis (PCA). All data were assessed for normality and stepwise multiple linear regressions were employed between each HFV and the strength metrics.

RESULTS: The PCA (Figure 1) revealed four main categories of strength metrics. These categories: Unloaded dynamic strength (i.e, concentric mean force during a CMJ), dynamic strength (i.e., braking impulse during LCMJ), maximal isometric strength (i.e., peak force during an isometric squat) and rate-dependent strength (i.e., force at 100ms in an IST) were used in subsequent data interpretations. This particular cohort of athletes were unable to achieve ground contact times of < 250 ms in the DJ, which means that the fast stretch shortening cycle was not utilized (Siff, 2001; Zatsiorsky, 2003) and reactive strength was not assessed. There were moderate to strong negative correlations (Hopkins, 2004) between HFV slope and braking, eccentric and concentric force, time, and impulse in the CMJ (*r* = -0.57 to -0.78) and LCMJ (*r* = -0.62 to –0.72) as well as peak force (*r* = -0.73) and early force (50-75 ms) (*r* = -0.55 to -0.62) in the IST. Eleven variables were then placed into a multiple regression model, where there were no significant relationships between vertical force metrics and skating HFV slope (adjusted r^2 = 0.80; p = 0.155).

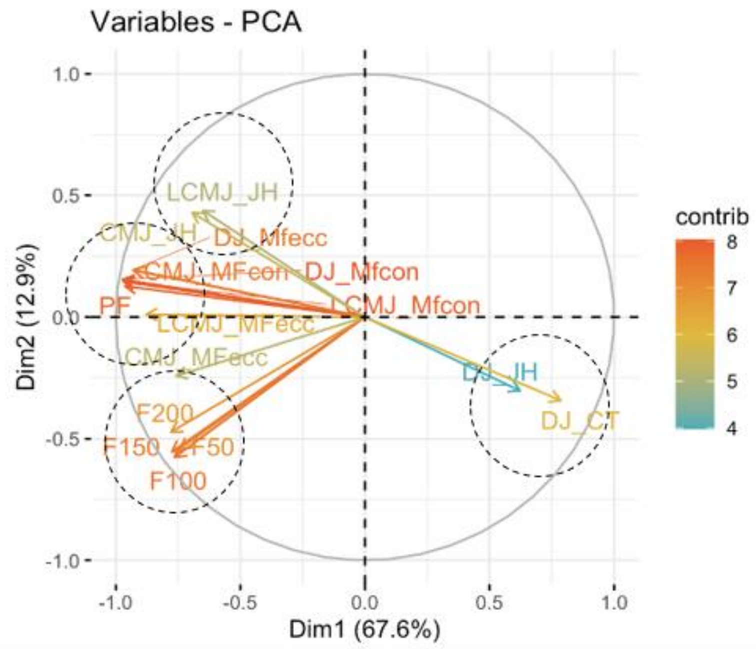

Figure 1: Principal component analysis demonstrating the interrelationships of strength variables derived from the strength battery. The variables within the model that explain the most variance to each dimension are represented as arrows. The strongest contributors are orange and the weakest contributors are blue.

DISCUSSION: There were three main findings from this study. First, female ice hockey players were unable to achieve a ground contact time of < 250 ms during a 30 cm DJ, which has implications when deriving a reactive strength index measure from that test. This may in part be due to the longer contact times in skating, making reactive strength irrelevant to this sport

(Behm et al., 2005). Second, this study is the first to empirically define strength properties using reduction analyses in ice hockey athletes. From these data, we identified four distinct clusters of force-time metrics which represent different properties of strength. These categorizations can be used in training and testing by pairing metrics with the appropriate training modalities and improving the interpretability of results. Lastly, although some metrics are strongly correlated, vertical strength and horizontal force-velocity metrics can be considered independent from one another in elite female ice hockey cohort. Similar results have been reported between vertical force velocity profiles and sprinting HFV profiles in a variety of athletes (Jimenez-Reyes et al., 2018). The r^2 of 0.80 is quite high yet does not reach a level of significance in this study (p = 0.155). This may be due to the large variability (CV % = 7-45%) of metrics and/or low power (n = 13) of this sample, and research expanding on this work is recommended. Overall, these results suggest that both off-ice vertical and on-ice horizontal assessments be conducted when evaluating physical properties of elite female ice hockey players.

CONCLUSION: These results greatly contribute to the current understanding of strength properties and HFV profiles of elite female ice hockey athletes. Since strength and HFV profiles are distinct, strength and sport science practitioners should include both in player evaluations. When assessing strength, the practitioner should include the four identified categories of strength in analyses to capture all strength properties in this population. Lastly, the methods used in this study are robust, and can be used in future studies to contribute to this growing body of literature.

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ACKNOWLEDGEMENTS: Thank you to the University of British Columbia's Women's Ice Hockey staff and athletes who made this collection possible.