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Individual Puck Possessions Part I: Frequency, Duration, and Distance Travelled

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Abstract. In this paper we use puck and player tracking data from the 2023-24 NHL season to study individual player possessions (focusing on 5v5 situations). We study metrics such as possession count, average and total possession duration, average and total distance travelled with the puck, and examine relationships between these metrics and traditional measures of success (i.e., goals, assists and points). A key finding is that individual offensive zone possession is strongly correlated with points ($r = 0.70$) and is moderately correlated with goals ($r = 0.64$), assists ($r = 0.54$), and shots on goal ($r = 0.69$). We also observe differences in individual possessions based on position (forwards versus defence), zone of play, and strength and large and statistically significant differences between top ranked players and league averages (across most possession metrics). Finally, we examine the benefits of our individual possession metrics and find that they are highly stable (so they are useful for predictions), able to differentiate players, and provide information not captured by existing metrics.

1 Introduction

In the 2021-22 season, the National Hockey League (NHL) added puck and player tracking (PPT) technologies to all arenas, creating significant opportunities for advanced hockey analytics. The introduction of an individual player possession model into the "DISH" data stream in March 2023 added the ability to measure and understand teams' and players' abilities to control the puck.

In a previous study, we investigated the relationship between puck possession and team success in the NHL. We found that overall team possession had a modest correlation with team success; however, we introduced a new metric, average offensive zone possession time differential (Avg. OZPTD), which showed a strong correlation ($r = 0.77$) with team success, measured by average goal differential. This work advanced our understanding of team-level possession dynamics and highlighted the importance of controlling the puck in high-value areas of the ice. However, it also raised a series of questions about the role of individual possession in driving these team-level outcomes. Is team success simply a function of aggregate possession time, or do individual contributions matter? Which players dominate possession and carry the puck over the greatest distances? How do these metrics vary across positions and game situations, and how do they compare to possession metrics in other sports? These questions drive our present study, marking a natural progression from team-focused analyses to an investigation of individual player performance.

To address these questions, we introduce and compute novel metrics, including average possession duration and distance travelled per possession. Where appropriate, all metrics are normalized to eliminate the impact of differences in ice time. These metrics are analyzed across 5v5 situations unless otherwise noted as power plays, penalty kills, and other non-5v5 situations skew individual possession.

We report on the top players (we exclude goaltenders from our analysis) in several possession metrics categories and discover statistically significant differences between top players and the league average across several metrics. By identifying players who excel at possession related metrics this work offers valuable insights that could be used for talent evaluation, as well as line and roster construction. Most importantly, these metrics can identify players with skills beyond traditional metrics like goals and assists. In this work we make the following contributions:

- We define, compute and study several metrics related to individual possession including: total possession duration, average possession duration, average distance travelled per possession, and possession count. We find that, for most of these metrics, there are statistically significant differences among some of the top 10 players and that the top 10 players differ substantially from the league average.
- We examine correlations between individual possession metrics and other offensive metrics and find there is a strong correlation ($r = 0.70$) between offensive zone possession time and points. When examining the same relationship during power plays we find a much lower correlation ($r = 0.42$).
- We find that individual possession metrics are able to distinguish players from one another, stable throughout the season, and introduce new information not captured by existing metrics.

2 Related Work

Most research in soccer, basketball, and hockey has focused on team possession [1][2][8][15][10]. Relatively little research has examined individual possessions in those sports. We now describe studies that examine individual possession in soccer, basketball, and hockey. Below, we use μ and σ^2 when referencing a statistic to mean that the average is μ and the variance is σ^2. Additionally, we use the notation $m\!:\!ss$ to mean m minutes and ss seconds.

Using data from 60 soccer matches from the 2012-13 season of the German Soccer League (Bundesliga), and excluding player's who played less than 45 minutes in a match, Link *et al.* [7] found that the league average was 0:14 $\pm$ 0:13 of possession per 10 minutes of playing time. Note that they use a more restrictive definition than what we introduce for possession in hockey. They found that central midfielders and central defenders had the most instances of ball control with an average of 12.8 possessions per 10 minutes of playing time. They found that, on average, wingers and central forwards had fewer instances of controlled possessions but the differences were not statistically significant. The authors found a strong correlation ($r = 0.85$) between the time a player spent in control of the ball and a player's ball control count.

Next, we examine studies of basketball. To better understand variability, where possible (e.g., if the paper provides sample sizes), we convert standard deviations to 95%

mean confidence intervals (assuming a normal sampling distribution). We use the notation [L, H] to indicate that L is the low and H is the high of a 95% mean confidence interval. Sampaio *et al.* [12] used data from 1,230 games played in the 2013-14 NBA season, and found that players who were on the first, second, or third All-NBA team ($n = 15$) possessed the ball for [5.4 sec, 9.0 sec] per minute played on average. In contrast, non all-star players ($n = 324$), possessed the ball for an average of [4.4 sec, 5.2 sec] per minute played. The authors also found that all-stars averaged [1.94, 2.26] touches of the ball per minute as opposed to non all-stars, who averaged [1.65, 1.75].

A study conducted between 2015 and 2017 using 70 games with point differences of 20 points or less, involving 44 male players from Italy's Lega Basket Serie A and Serie A2 who had played at least 10 minutes in one game prior to the study period, found that, for guards, the mean percentage of playing time in possession of the ball was [9.4%, 14.4%] [3]. This is significantly higher than forwards and centres, who possessed the ball for [2.8%, 4.2%] and [2.1%, 3.7%] of their playing time respectively. Zhang *et al.* [14] used a sample of 699 games with a final score difference of less than or equal to 10 points from the 2015-16 NBA season found no significant difference between the amount of ball touches between players on teams that made the playoffs and players on teams that did not make the playoffs. Although not explained in these papers, we hypothesize that they exclude games with larger score differentials because they do not reflect typical game play.

In a study of the 2002 Olympic Winter men's ice hockey games, the author manually tracked individual possession for the top players, including Mike Modano and Joe Sakic [13]. The study found that these players averaged 1:07 with the puck per game. The study also looked at the top youth players in the USA hockey Tier 1 Youth National Championships and found that the top players averaged 01:06 of possession. The study highlights the extremely small amount of time players handle the puck during a game and emphasizes the benefits of team practices with more puck handling opportunities.

To compare previous findings with our own we normalize soccer results to 20 minutes of game time and find an average of 0:28 $\pm$ 0:26 in control of the ball per 20 minutes. For basketball, using the non-all star group, the same normalization yields [1:31, 1:49] of ball possession time and [33.2, 34.8] touches of the ball (both per 20 minutes of playing time). Our findings show slightly higher amounts of puck possession times for top players than the previous hockey study and that hockey falls somewhere between soccer and basketball, with an average possession duration of [0:39, 0:40] per 20 minutes and an average possession count of [33, 34]. In this paper, we examine the top 10 players across different metrics that capture data regarding individual possession. In addition, we compare forwards and defencemen, and examine the correlations between individual possession metrics and traditional metrics that are based on offensive production.

In Part II of this research [9] on individual puck possessions, we devise a metric to measure players that consistently carry the puck at high speeds (called Bursts20). This is a measure of the average number of times, per game, a player carries the puck for one second or longer where their speed reaches 20 mph or more during the possession. To avoid biases towards players who are given more ice time, we normalize the average to 20 minutes of ice time per game. Using data from the 2023-24 NHL regular season,

that work shows significant differences between forwards and defencemen. Forwards average [0.39, 0.48] Bursts20 while defencemen average [0.12, 0.15]. Nathan MacKinnon, the top ranked player, is significantly above average with [2.87, 3.83] bursts per 20 minutes of ice time. Cale Makar, the top ranked defencemen averages [0.50, 0.90] such bursts per 20 minutes. That paper also explores the distribution of individual player possessions during a game within a team. Jain's Fairness Index [6] is used to compute an equity score, which measures the degree to which possessions within a team are equal. The metric produces values between 0 and 1, with 1 being completely equal. The results show that despite there being a significant difference between teams with high equity scores (e.g., FLA with [0.84, 0.85]), medium equity scores (e.g., BOS with [0.80, 0.82]) and low equity scores (e.g., VAN with [0.68, 0.72]). All three of those teams were ranked in the top 4 teams in the league in terms of average 5v5 goal differential, indicating that different styles of individual puck possessions can be successful.

3 Background

3.1 Definition of Individual Puck Possession

We use the definition of individual puck possession deployed by the NHL in the model used to obtain the individual possession data we employ. There are two types of possessions. First, a player is considered to have possession and control of the puck when they have two or more consecutive touches of the puck. The possession starts with the first touch and is confirmed by a second touch. Individual possession ends when the player loses the puck or another player gains possession. The second type of possession includes specific one-touch actions, such as shot attempts, passes, or area plays (e.g., dump-ins), which are considered brief moments of possession [11].

3.2 Dataset Overview

Our study uses proprietary PPT data from the NHL which records x, y, and z coordinates at high frequencies (60 times per second for the puck and 12 times per second for each player on the ice). Players on the bench are updated once per second. In total, approximately 734,400 locations are recorded in a typical 60-minute game. Due to different data collection frequencies and lack of synchronization, all locations are interpolated to uniform one-hundredth of a second timestamps.

In March 2023, an individual player possession model was added to the "DISH" data stream, which features Delayed, Interpolated, Smoothed, and Hundred-Hertz enhancements. That possession model uses the (x,y) coordinates of the puck and players (i.e., their location on the ice). The changes between consecutive readings for all on-ice entities are combined with physics-based models to attempt to determine when a player is and is not in possession of the puck. The dataset we are provided contains information about when an individual possession starts and ends, including the unique identification number for the player. We applying cleaning and filtering techniques to the original data, described in Section 4, to obtain the data used in our analysis. This dataset is considered unofficial by the NHL and may differ from other datasets that track possession information (e.g., a hand-labelled dataset).

There were 1,312 games played in the 2023-24 NHL season. After finding 118 games with significant data issues, as detailed in Section 4.1, 1,194 games remained for our analysis.

4 Dataset Cleaning and Filtering

4.1 Preparing, Cleaning, and Filtering Games

Our dataset preparation, cleaning, and filtering methods are adapted from our previous work [10]. First, we merged the player possession data with a detailed game information file to provide broader game context, such as power play situations, goal differentials, and player locations. This enriched the player possession data with relevant context. Next, we cleaned the dataset by removing possessions that occurred during stoppages or clock resets, and those that were out of sequence, overlapping, or duplicated. Despite these efforts, some errors persisted, leading us to exclude games based on data corruption severity: if the data is compromised for either more than 4% of a games duration or more than 4% of a teams possession time, we exclude the game from our analysis. This resulted in the exclusion of 118 games, leaving 91% of the games for analysis. For more detailed information on the filter criteria, refer to our previous work [10].

4.2 Filtering Individual Players

After filtering down to 1,194 games, we also filtered out players for which there was insufficient data. We chose our filters in a way that ensured players had enough opportunity for our possession and production metrics to be reliably captured. We exclude players with less than 10 games played or less than 10 minutes of 5v5 ice time per game. In the 1,194 game sample, 921 players participated and 250 were excluded, leaving 671 players for our analysis (72.9% of the players who dressed for the included games). With 32 teams in the league and 18 skaters (forwards and defencemen) dressing per team, that equals 576 skaters (32×18). Since our dataset includes 671 players, we believe our analysis captures a representative sample of regularly participating players.

We applied additional filters when conducting power play and short-handed analysis. Players with less than 25 total minutes of ice time in these situations for the season were removed. This left 45.9% of players for power play analysis and 45.4% of players for short-handed analysis.

5 Individual Possession Analysis

We now analyze several metrics related to individual possession and their relationship with traditional player performance metrics such as points, goals, assists, and shots on goal. We found that possession duration is strongly correlated with time on ice ($r = 0.89$), so where appropriate, metrics are normalized to 20 minutes of ice time, providing for a fair comparison across all players (regardless of their ice time).

5.1 Possession Duration and Count

We use total possession duration (or possession time) to denote the average number of minutes that a player possesses the puck per game, normalized to 20 minutes of ice time. Similarly, possession count is the average number of times a player has possession of the puck per game, normalized to 20 minutes of ice time. The average possession duration is a player's total possession duration divided by their possession count (shown in seconds).

Total Possession Duration We start this section by examining the total possession duration. Table 1 shows the top 10 forwards (left) and defencemen (right), ranked by average total possession duration per 20 minutes (Possession Duration in the table). Note that times in the table are denoted as $m{:}ss$, to indicate minutes and seconds.

As described in the caption for Table 1, †† indicates that the player is ranked among the top 10 players for average possession duration, total possession duration, and possession count. We note that it should not be surprising that some players appear in all three tables since there is a strong correlation between total possession duration and both average possession duration ($r = 0.87$) and possession count ($r = 0.86$) and there is a moderate correlation between average possession duration and possession count ($r = 0.51$).

Rank	Name	Team	Possession Duration (m:ss)	Name	Team	Possession Duration (m:ss)
1	Mathew Barzal†	NYI	1:21 [1:16, 1:26]	Quinn Hughes††	VAN	1:37 [1:31, 1:43]
2	Jack Hughes††	NJD	1:15 [1:08, 1:19]	Cale Makar††	COL	1:25 [1:19, 1:31]
3	Jack Eichel††	VGK	1:14 [1:09, 1:20]	Jake Sanderson†	OTT	1:18 [1:13, 1:22]
4	Leon Draisaitl††	EDM	1:13 [1:07, 1:18]	Owen Power†	BUF	1:16 [1:11, 1:20]
5	Artemi Panarin†	NYR	1:06 [1:03, 1:09]	Erik Karlsson††	PIT	1:13 [1:08, 1:18]
6	Nikolaj Ehlers	WPG	1:05 [1:02, 1:08]	Scott Perunovich†	STL	1:13 [1:06, 1:19]
7	William Nylander†	TOR	1:05 [1:01, 1:08]	Mike Matheson†	MTL	1:13 [1:08, 1:18]
8	Clayton Keller†	ARI	1:04 [1:01, 1:08]	Cam Fowler†	ANA	1:11 [1:07, 1:18]
9	Connor McDavid†	EDM	1:03 [0:58, 1:08]	Drew Doughty†	LAK	1:11 [1:07, 1:16]
10	Troy Terry†	ANA	1:03 [0:58, 1:07]	Evan Bouchard	EDM	1:10 [1:04, 1:14]
+	Forwards Avg.		0:40 [0:39, 0:40]	Defencemen Avg.		0:49 [0:48, 0:50]

Table 1. Top 10 forwards (left) and defencemen (right) ranked by total possession duration in 5v5 situations. Numbers in square brackets are the low and high of the 95% confidence interval for the by-game mean. † indicates this player appears in another top 10 table in this section, and †† indicates they appear in two other tables (i.e., all three tables).

The player with the highest total possession duration per 20 minutes is Quinn Hughes (VAN) with 1:37 followed by Cale Makar (COL) with 1:25 and Mathew Barzal (NYI) with 1:21. The mean 95% confidence interval for total possession duration is [0:48, 0:50] among defencemen and [0:39, 0:41] among forwards. This suggests that

on average, players spend about 3.3% to 4.2% of their ice time with the puck. Moreover, since the confidence intervals do not overlap, there is a statistically significant difference [5] for mean total possession duration between defencemen and forwards.

In Table 2 we show correlations between total possession duration and individual offensive production metrics. Notice that there is a weak correlation with all offensive production metrics when separating forwards and defencemen, however the correlations vanish when combining all positions. It is important to consider forwards and defencemen separately since the nature of their possessions are different. Notably, only 19% of possession time by defencemen is in the offensive zone in contrast to 46% for forwards.

Offensive Production	Forwards r-value	Defencemen r-value	Combined r-value
Points per 20	0.39	0.35	-0.02
Goals per 20	0.24	0.20	-0.14
Assists per 20	0.36	0.31	0.12
SOG per 20	0.38	0.34	-0.02

Table 2. Correlations between 5v5 possession per 20 minutes and player offensive production.

Average Possession Duration Shifting our focus to average possession duration, Table 3 shows the top 10 forwards (left) and defencemen (right), ranked by average possession duration (Avg. Time (sec.) in the table) with 95% confidence intervals (shown in green).

Rank	Name	Team	Avg. Time (sec.)	Name	Team	Avg. Time (sec.)
1	Mathew Barzal†	NYI	2.03 [1.94, 2.11]	Quinn Hughes††	VAN	2.00 [1.93, 2.07]
2	William Nylander†	TOR	1.85 [1.77, 1.93]	Cam Fowler†	ANA	1.89 [1.80, 1.98]
3	Jack Eichel††	VGK	1.82 [1.74, 1.91]	Cale Makar††	COL	1.87 [1.79, 1.95]
4	Troy Terry†	ANA	1.78 [1.70, 1.86]	Scott Perunovich†	STL	1.80 [1.68, 1.93]
5	Evgeny Kuznetsov	CAR	1.78 [1.67, 1.88]	Mike Matheson†	MTL	1.78 [1.70, 1.86]
6	Jack Hughes††	NJD	1.76 [1.69, 1.84]	Owen Power†	BUF	1.78 [1.71, 1.84]
7	Connor Bedard	CHI	1.76 [1.68, 1.84]	Drew Doughty†	LAK	1.74 [1.67, 1.81]
8	Leon Draisaitl††	EDM	1.75 [1.68, 1.82]	John Klingberg	TOR	1.73 [1.55, 1.90]
9	Kent Johnson	CBJ	1.72 [1.59, 1.85]	Bowen Byram	COL	1.72 [1.64, 1.79]
10	Isac Lundestrom	ANA	1.67 [1.54, 1.81]	Erik Karlsson††	PIT	1.71 [1.64, 1.78]
+	Forwards Avg.		1.27 [1.25, 1.28]	Defencemen Avg.		1.32 [1.30, 1.34]

Table 3. Top 10 forwards (left) and defencemen (right) ranked by average possession duration in 5v5 situations. Numbers in square brackets are the low and high of the 95% confidence interval for the by-game mean. † indicates this player appears in another top 10 table in this section, and †† indicates they appear in two other tables (i.e., all three tables).

For the forwards table, with the exception of two players, William Nylander (TOR) and Troy Terry (ANA), all of the top 10 players play centre (according to their listed position on the NHL website). Isolating the centres into their own group, their mean

average possession duration is 1.28 seconds (with a 95% confidence interval of [1.25 seconds, 1.31 seconds]). This means that there is no significant difference between the averages of all centres and all forwards (who, from Table 3, have a 95% mean confidence interval of [1.25 seconds, 1.28 seconds). With that being said, there is a small but statistically significant difference between forwards and defencemen (who have a 95% mean confidence interval of [1.30 seconds, 1.34 seconds]).

Table 4 shows the average possession duration by zone and position (in seconds with 95% confidence intervals). For all players (All Positions), the average possession duration is similar in the defensive and neutral zones, but lower in the offensive zone (the differences are statistically significant).

Position	All Zones	Defensive Zone	Neutral Zone	Offensive Zone
All Skaters	1.29 [1.27, 1.30]	1.43 [1.41, 1.45]	1.47 [1.45, 1.49]	1.05 [1.03, 1.06]
Forwards	1.27 [1.25, 1.28]	1.39 [1.36, 1.41]	1.56 [1.53, 1.59]	1.11 [1.09, 1.13]
Defence	1.32 [1.30, 1.34]	1.50 [1.47, 1.53]	1.33 [1.31, 1.35]	0.95 [0.94, 0.97]

Table 4. Avg. Possession Duration (seconds) by Zone for Different Positions in 5v5 Situations.

On average, players hold the puck for 1.29 seconds. In the defensive zone, this average increases to 1.43 seconds and again to 1.47 seconds in the neutral zone. However in the offensive zone, the mean average possession duration decreases to 1.05 seconds. On average, players hold the puck for significantly less time when in the offensive zone. Table 4, also shows that for all zones, defencemen have a slightly higher average possession duration. However, on average per possession, forwards hold the puck longer in the neutral and offensive zones than defencemen.

Possession Count Table 5 shows the top 10 forwards (left) and defencemen (right), ranked by possession count per 20 minutes (Possession Count in the table). Clayton Keller and Jack Hughes top the list for forwards, while Quinn Hughes and Jake Sanderson have the highest possession counts among defencemen. Comparing the two groups, the average possession count for defencemen is higher than the average possession count for forwards and since the 95% confidence intervals do not overlap ([36.6, 37.5] versus [30.9, 31.7]), this difference is statistically significant [5].

5.2 Distance Travelled Per Possession

We now introduce a new metric, average distance travelled per possession. The intent of this metric is to identify puck carriers, which in addition to indicating puck carrying skill, could be useful in constructing lines and defensive pairings. For this metric we only consider possessions longer than one second to capture "puck-carrying" possessions. Table 6 shows the top 10 forwards (left) and defencemen (right), ranked by average distance travelled per possession.

The 95% mean confidence interval for average distance travelled per possession is [37.9 feet, 38.9 feet] for forwards, and [32.5 feet, 33.5 feet] for defencemen. This

Rank	Name	Team	Possession Count	Name	Team	Possession Count
1	Clayton Keller†	ARI	43.4 [41.3, 45.2]	Quinn Hughes††	VAN	48.9 [47.0, 50.6]
2	Jack Hughes††	NJD	43.0 [40.1, 44.4]	Jake Sanderson†	OTT	46.9 [45.1, 48.5]
3	Artemi Panarin†	NYR	42.3 [40.6, 43.6]	Adam Fox	NYR	46.4 [44.8, 48.1]
4	Kevin Fiala	LAK	42.2 [40.3, 44.3]	Cale Makar††	COL	45.6 [44.0, 47.4]
5	Leon Draisaitl††	EDM	41.8 [39.8, 43.6]	Erik Gustafsson	NYR	45.5 [43.3, 47.1]
6	Jordan Kyrou	STL	41.6 [39.5, 43.4]	Zach Werenski	CBJ	44.8 [42.7, 46.7]
7	Nikita Kucherov	TBL	41.5 [39.4, 43.0]	Ryan Johnson	BUF	44.5 [42.0, 47.1]
8	Connor McDavid†	EDM	41.5 [39.4, 43.2]	Rasmus Dahlin	BUF	43.7 [41.9, 45.2]
9	Jack Eichel††	VGK	41.0 [39.3, 42.7]	MacKenzie Weegar	CGY	43.2 [41.2, 44.9]
10	Matt Boldy	MIN	40.9 [39.1, 42.6]	Erik Karlsson††	PIT	43.2 [41.4, 44.7]
+	Forwards Avg.		31.3 [30.9, 31.7]	Defencemen Avg.		37.1 [36.6, 37.5]

Table 5. Top 10 forwards (left) and defencemen (right) ranked by possession count in 5v5 situations. Numbers in square brackets are the low and high of the 95% confidence interval for the by-game mean. † indicates this player appears in another top 10 table in this section, and †† indicates they appear in two other tables (i.e., all three tables).

Rank	Name	Team	Distance Travelled per Possession (ft.)	Name	Team	Distance Travelled per Possession (ft.)
1	Mathew Barzal	NYI	53.8 [51.5, 56.0]	Samuel Girard	COL	43.2 [41.0, 45.4]
2	Denis Gurianov	NSH	53.2 [45.3, 61.2]	Quinn Hughes	VAN	42.9 [41.4, 44.3]
3	William Nylander	TOR	51.4 [49.1, 53.7]	Cam Fowler	ANA	42.0 [40.2, 43.8]
4	Jack Hughes	NJD	51.4 [49.1, 53.6]	John Klingberg	TOR	41.6 [37.7, 45.6]
5	Paul Cotter	VGK	51.3 [48.2, 54.5]	Nikita Zadorov	CGY	41.6 [39.1, 44.1]
6	Jack Eichel	VGK	50.9 [48.5, 53.4]	Cale Makar	COL	41.5 [39.9, 43.1]
7	Noah Gregor	TOR	50.3 [46.7, 53.8]	Wyatt Kaiser	CHI	41.3 [37.9, 44.8]
8	Julien Gauthier	NYI	50.0 [42.8, 57.2]	Mike Matheson	MTL	41.3 [39.6, 43.0]
9	Connor Bedard	CHI	49.8 [47.4, 52.1]	Michael Kesselring	ARI	40.8 [38.5, 43.1]
10	Adam Fantilli	CBJ	49.8 [46.3, 53.2]	Charlie McAvoy	BOS	40.6 [38.8, 42.3]
+	Forwards Avg.		38.4 [37.9, 38.9]	Defencemen Avg.		33.0 [32.5, 33.5]

Table 6. Top 10 players ranked by Distance Travelled per Possession. The numbers in square brackets are the low and high of the mean 95% confidence interval.

is a statistically significant difference since the confidence intervals do not overlap. It indicates that, on average, forwards tend to travel further with the puck per possession.

All the top 10 players in both tables have overlapping confidence intervals, indicating little difference in average distance travelled per possession among them. However, it is noteworthy that the top 10 defencemen have significantly higher average distance travelled than the league mean among defencemen of 33.0 feet. Likewise, the top 10 forwards greatly exceed the league mean among forwards of 38.4 feet. The very top player, Mathew Barzal, averages 15.4 feet more than the league average among forwards.

5.3 Offensive Zone Possession

In Table 7, we list the top 10 players (all forwards) ranked by offensive zone (oZone) possession time per 20 minutes (oZone Pos20 in the table). We are particularly interested in forwards here so we choose to not include separate table for defencemen. We also include columns for offensive production metrics, (normalized per 20 minutes of 5v5 ice time) including points (P20), goals (G20), assists (A20) and shots on goal (SOG per 20). Additionally, we include GP$*$, which refers to the number of games used for that player after filters were applied. Notice that the 95% confidence intervals for the mean overlap for the top 8 players. This indicates that there may not be a statistically significant difference in offensive zone possession time between the top players. Interestingly, several top players in terms of offensive zone possession rank fairly low in term of points (per 20 minutes of 5v5 ice time). So, we can infer that more goes into accruing points than just offensive zone possession.

Rank	**Name**	**Team**	**Pos.**	**GP$*$**	**oZone Pos20 (min.:sec.)**	**P20**	**P20 Rank**	**G20**	**A20**	**SOG per 20**
1	Connor McDavid	EDM	C	68	0:38 [0:35, 0:41]	1.20	1	0.31	0.89	4.4
2	Leon Draisaitl	EDM	C	72	0:37 [0:34, 0:41]	0.89	14	0.25	0.64	3.5
3	Nathan MacKinnon	COL	C	79	0:36 [0:33, 0:38]	1.10	2	0.52	0.58	5.8
4	Jack Eichel	VGK	C	58	0:36 [0:32, 0:39]	0.80	32	0.36	0.44	6.7
5	Mathew Barzal	NYI	C	72	0:35 [0:32, 0:39]	0.66	110	0.23	0.44	3.8
6	Clayton Keller	ARI	R	73	0:34 [0:31, 0:38]	0.66	113	0.33	0.33	4.0
7	Artemi Panarin	NYR	L	77	0:34 [0:31, 0:36]	0.99	5	0.54	0.45	5.0
8	William Nylander	TOR	R	75	0:33 [0:30, 0:35]	0.81	27	0.41	0.40	5.6
9	Luke Evangelista	NSH	R	71	0:31 [0:28, 0:33]	0.59	171	0.30	0.30	3.7
10	Matt Duchene	DAL	C	73	0:31 [0:28, 0:34]	0.67	107	0.24	0.43	3.2
+	League Avg.			58	0:15 [0:14, 0:15]	0.45		0.17	0.28	2.5
+	Forwards Avg.			60	0:18 [0:18, 0:19]	0.56		0.24	0.32	3.1
+	Defencemen Avg.			54	0:09 [0:09, 0:09]	0.28		0.06	0.22	1.6

Table 7. Top 10 Players ranked by 5v5 oZone Pos20 (metrics are normalized to 20 minutes of 5v5 ice time). The numbers in square brackets are the low and high of the 95% confidence interval for the per game mean.

Figure 1 plots the relationship between offensive zone possession and points, split by position. Defencemen are largely clustered in the bottom left of the plot. However, there are defencemen who have offensive zone possession and points numbers competitive with forwards. The top defenceman in terms of offensive zone possession, Quinn Hughes, has 0:29 of offensive zone possession time and 0.54 points (per 20 minutes of 5v5 ice time). Table 8 shows more details examining correlations between offensive zone possession time and some traditional measures of player success (Offensive Production). We see that offensive zone possession has a strong correlation with points when players of all positions are considered ($r = 0.70$). We note that when considering all strengths (i.e., not just 5v5 situations) the correlation is even stronger ($r = 0.78$).

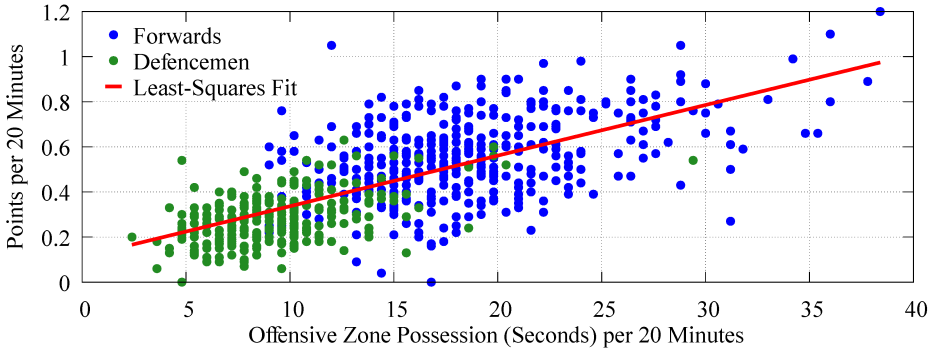

Fig. 1. Offensive Zone Possession vs Points (r = 0.70).

Offensive Production Metric	Forwards r-value	Defencemen r-value	Combined r-value
Points per 20	0.45	0.49	0.70
Goals per 20	0.30	0.30	0.64
Assists per 20	0.40	0.42	0.54
SOG per 20	0.42	0.55	0.69

Table 8. Correlations between 5v5 oZone possession per 20 minutes and offensive production.

5.4 Possession in Different Game Situations

We now turn our attention to special teams situations. Figure 2 plots CDF's of player possession time per 20 minutes for shorthanded, even strength, and power play situations, separated by position. Note that even strength differs from 5v5 as it includes 3v3, 4v4, and empty net situations. We can see that, as expected, players have less possession when shorthanded than during even strength situations, and much more possession time when on the power play. We can also see that possession time on power plays is dominated by a small number of players and that there is a larger difference among players playing the power play than in short handed or even strength situations.

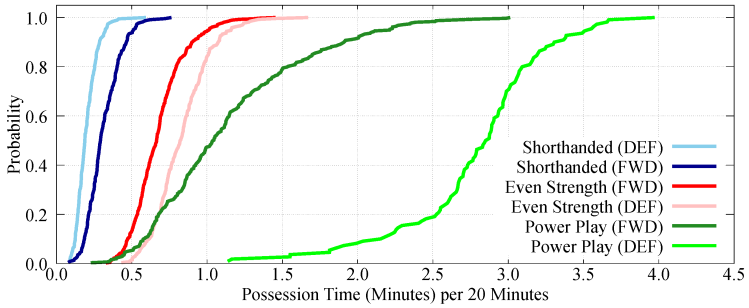

Fig. 2. Possession by strength CDF (DEF refers to defencemen and FWD refers to forwards).

Table 9 shows the correlations between offensive zone possession per 20 minutes and player offensive production metrics in both even strength and power play situations.

Offensive Production Metric	Even Strength r-value	Power Play r-value
Points per 20	0.72	0.42
Goals per 20	0.66	-0.09
Assists per 20	0.57	0.57
SOG per 20	0.61	0.14

Table 9. Correlations between oZone possession per 20 and offensive production by strength.

The correlation with shots on goal and goals goes from a moderate correlation in even strength to no correlation on the power play. However, the correlation with assists is moderate in both even strength and on the power play. Perhaps average player possession lengths is less important for scoring goals on the power play than in even strength situations. For even strength offensive zone possessions, we found that the average duration was 1.15 seconds for all possessions and 0.99 seconds for those that resulted in a goal. In contrast, power play offensive zone possessions averaged 1.32 seconds for all possessions and 0.84 seconds for possessions that resulted in a goal. This indicates a greater difference in duration, for the power play, between all possessions and possessions resulting in a goal, which may explain why there is no correlation between total offensive zone possession time and goals on the power play.

6 Metric Evaluation

We now evaluate the possession metrics using the "Meta-Analytics" framework introduced by Franks *et al.* [4], which can be used to determine the usefulness of the metrics in terms of their discriminatory power, stability over time, and independence from existing metrics. Unless otherwise stated, all metrics are for 5v5 situations and normalized per 20 minutes of ice time.

Discrimination: The discriminatory power of a metric tells us how well that metric is able to differentiate between players. We calculate discriminatory power using the method introduced by Franks *et al.* [4]:

$$\mathcal{D} = 1 - \frac{\text{Average Intrinsic Variation}}{\text{Total Between Player Variation}} \tag{1}$$

Stability: The stability of a metric tells us how stable a metric is over a period of time. We study stability by examining the correlation between the first and second halves of the season. This method differs from that proposed by Franks *et al.* [4] but maintains the philosophy of the metric.

Independence: The independence score of a metric tells us how much new information is provided by the metric compared to the others existing metrics. We compute independence scores for our metrics using the method proposed by Franks *et al.* [4]. Note that possession metrics are only included if they are the metric of interest. For example, we do not include possession metrics when calculating the independence score for points and other preexisting metrics. In addition, when computing the independence score for each possession metric we do not include any other possession metrics.

Table 10 shows the discriminatory power, stability, and independence scores for our and several other metrics. All of the possession metrics have very high discriminatory

power, roughly equal to the discriminatory power of time on ice. This indicates that the possession metrics are very good at differentiating between individual players. There is a strong correlation for all possession metrics between the first half and second halves of the season. These metrics are therefore stable and could be used for predictions. Table 10 also shows that possession metrics provide quite good independence scores. For example, possession duration has a score of 0.60 indicating that only 40% of the variation in possession duration can be explained by the other metrics. This indicates that possession metrics provide information not available from the other metrics examined.

Metric	Disc.	Stab.	Ind.	Metric	Disc.	Stab.	Ind.
Possession Duration	0.97	0.92	0.60	Giveaways	0.73	0.55	0.80
Possession Count	0.96	0.90	0.50	Missed Shots	0.87	0.79	0.48
oZone Possession	0.98	0.93	0.44	Shot Attempts Blocked	0.89	0.79	0.56
nZone Possession	0.95	0.87	0.60	Takeaways	0.81	0.64	0.66
dZone Possession	0.99	0.97	0.53	Plus Minus	0.48	0.33	0.77
Hits	0.97	0.90	0.70	Time On Ice	0.97	0.61	0.39
Corsi Against	0.79	0.65	0.17	Points	0.73	0.55	0.07
Corsi For	0.86	0.68	0.14	Goals	0.72	0.55	0.18
Fenwick For	0.85	0.68	0.15	Assists	0.53	0.30	0.15
Fenwick Against	0.74	0.56	0.19	Shots on Goal	0.95	0.89	0.36
Blocked Shots	0.92	0.82	0.62	Penalty Minutes	0.73	0.57	0.46

Table 10. 5v5 Discrimination, stability, and independence score of the metrics in our metric set. Time On Ice and Plus Minus are not normalized. Notice that points, goals, and assists all have very low independence scores. This is expected as they are all dependent on one another. Points has an independence score of 0.50 if we exclude goals and assists from the metric set.

7 Conclusions

In this paper we introduce and analyze individual possession metrics across different zones and game situations. We find a statistically significant difference between forwards and defencemen in regard to possession time per zone, average possession length, and total possession duration. Additionally, we find that offensive zone possession time is strongly correlated with points ($r = 0.70$) and that the correlation with goals is moderate in even-strength situations ($r = 0.67$) but disappears on the power-play ($r = -0.09$). Finally, we find that all of these possession metrics are able to effectively discriminate between players, are stable across the season, and introduce new information not captured by existing metrics.

In the future we hope to study outcomes of individual possessions (e.g., success rates) and to determine which players begin or create new possessions for their team. Additionally, we hope to examine relationships between our possession metrics and other metrics not already considered in this paper. Examples include drawn penalties, expected goals (since goals may depend somewhat on luck), zone entries, and zone exits. Computing some of these metrics requires access to per player game data that may not be available in the PPT data or via the NHL API. This data is needed to ensure that same subset of games are used when computing all metrics (due to our data cleaning and filtering process).

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