Individual Puck Possessions Part II: Speed Bursts and Possession Times within Teams

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Abstract. In ice hockey, handling and keeping control of the puck (possession) are valued skills. In this paper we study several metrics of individual player puck possessions from 2023-24 regular season NHL games. These metrics include players' speed while carrying the puck, and the distribution of puck possession times for players within their team (i.e., does a team have a few players who have a larger share of possession time or are times more equally distributed). Our goal in this paper is to examine and highlight different skills and roles related to puck possession and to design metrics that might be helpful in roster construction and/or creating line combinations.

1 Introduction

In ice hockey, being able to possess and handle the puck is a highly valued skill. Players with possession of the puck may advance the puck towards the opponent's end, set up plays, and prevent their opponents from making plays. We believe that understanding which players are able to obtain and maintain possession of the puck and what they do when they have the puck can provide critical information for valuing players and creating line combinations.

Using puck and player tracking data obtained from the National Hockey League, we utilize data from regular season games from the 2023-24 season and study individual player possessions. While puck handling skills are important for goaltenders, the types of metrics we consider are not designed to evaluate goaltenders. As a result, we do not include goaltenders in any of the analyses conducted in this paper, and henceforth, when the word "players" is used it is referring to skaters. We begin by examining the speeds with which skaters are able to carry the puck. Since many players are capable of reaching high top speeds we focus on which players are able to consistently reach high speeds while carrying the puck.

We later examine, on a per game basis, the distribution of the amount of time individual players possess the puck within their team. The objective it to understand the degree to which a smaller number of players dominate team possessions or whether possessions are distributed more equitably across players on the team. We believe that these new metrics provide insights into individual player's skills and/or roles and that these insights may be valuable when constructing rosters and/or line combinations.

From the analyses described above we make the following key contributions:

- We devise a methodology for preparing, cleaning and filtering games as well as (when appropriate) devising filters to exclude some players who may not have sufficient opportunities for us to obtain representative metrics.

- We find that, per 20 minutes, some players have significantly more bursts of 20 miles per hour (29.3 ft/s) or greater while carrying the puck (Bursts20), than others. For instance, Nathan MacKinnon averages more than 7 times as many 20+ MPH bursts per 20 minutes (3.35) than an average forward (0.44). We also find a large and significant difference between forwards and defencemen and believe that Bursts20 is a good indicator of players' roles.
- We evaluate individual contributions to team possessions by using Jain's Fairness Index to measure the distribution of possessions across all skaters within each team. For example, we find that the Florida Panthers have the most equitable distribution (index=0.85), while the Vancouver Canucks have the least equitable distribution (index=0.70). We observe significant differences between teams and believe this offers insight into roster structures and offensive styles.

2 Related Work

Much of the research studying possession in sports has focused on team possessions [1] [2][9][16][11]. Studies examining individual possessions have mainly concentrated on basketball [3][14][15] and football (soccer) [8]. These studies focus on how many times a player possesses the ball per game and how long they possess the ball.

One ice hockey study manually tracked the possession time of top players (e.g., Joe Sakic and Mike Modano) during the men's 2002 Olympic Ice Hockey games [4]. The results showed that the top players averaged one minute and seven seconds with the puck per game. Similarly they found that top players in the USA Tier 1 Youth National Championships averaged one minute and six seconds per game. They use these results to argue that youth hockey should place more emphasis on practice rather than games, to provide more opportunities for players to develop puck handling skills.

In Part I of this study, Iaboni *et al.* [5] examine the average time of each player's possession, the average time of possession per game and the average number of possessions (all in 5v5 situations). They normalized all metrics to 20 minutes of ice time because the metrics were strongly correlated with ice time. They found that the top player had possession for 1:37 (one minute and thirty seven seconds) per 20 minutes, with the league average being 0:43. They found that when considering players by position group (by grouping defencemen separately from forwards) there were only weak correlations between a player's possession time per 20 minutes and traditional measures of success per 20 minutes, measured by offensive production metrics (e.g., goals, assists, points and shots). They also examined the distance players travel with the puck during possession, finding that the top player averaged 36 feet per possession which is significantly greater than the league average of 20 feet.

In addition, they also studied offensive zone (OZ) possession time per 20 minutes and found that when considering all players combined, OZ possession time correlates strongly with points per 20 minutes ($r = 0.70$). However, this correlation may be mainly capturing differences by position group as there were only weak correlations among forwards ($r = 0.45$) and among defencemen ($r = 0.49$). The top eight players in terms of OZ possession time were statistically similar with 95% mean confidence intervals ranging from [0:35, 0:41] for the top player to [0:30, 0:35] for the eighth highest ranked player. League averages were [0:14, 0:15]. So top players averaged more than twice the OZ possession time, in 5v5 situations, than the average player.

In this paper we build on and extend the complementary work in Part I by Iaboni *et al.* [5], described above. We examine an additional set of metrics that includes the speed at which players carry the puck and we study whether a team's time of possession is concentrated among a few players or is more evenly distributed across all players.

3 Background

3.1 Definition of Individual Puck Possession

The NHL defines two types of individual puck possession. The first occurs when a player touches the puck consecutive times, with at least one of those touches occurring when the puck is on the ice. For the second type, one-touch actions are also considered possession (e.g., one-touch passes and one-timers). Each possession is credited to an individual. The time between individual possessions, such as when the puck is travelling from one player to another during a pass, is not considered part of an individual's possession. Instead, an individual possession is deemed complete: at the end of the player's final touch (e.g., a shot, pass, or area-play), when another player establishes possession (e.g., a steal), or when the puck travels a substantial distance away from the possessing player (e.g., a puck loss). We utilize these types as the definition of individual puck possessions in this paper. In prior work we studied team possessions, defining team possession as the period of time players on the same team have consecutive possessions, including the time for a pass to reach another player [11]. See that work for a more precise description of how individual and team possessions are defined.

3.2 Dataset Overview

Our research is conducted using the NHL's proprietary puck and player tracking (PPT) data, which records puck and player locations at high frequencies (60 Hz and 12 Hz, respectively). Along with the PPT data, the NHL provides individual possession models, equipped with possession information using the definitions provided in the previous section. Moreover, these datasets also include automated event detection and labelling information. These event labels include but are not limited to: shots, passes, and area plays (e.g., dumps-ins and dump-outs), This data is interpolated by the Delayed Interpolated Smoothed Hundred-Hertz (DISH) stream to provide information about puck and player locations every one-hundredth of a second. Note that this data is considered unofficial by the NHL. We also use data from the NHL API for the games included in our analysis to get official player statistics, like goals, assists and points (which are used to examine correlations between our metrics and those statistics).

4 Dataset Cleaning and Filtering

4.1 Preparing, Cleaning, and Filtering Games

In previous work we devised techniques for analyzing puck possessions by individuals and teams and examined relationships between team possession and team success [12].

We utilize the data cleaning and filtering methods in our previous work on team possessions to conduct our analysis of individual possessions [12]. This includes merging individual possession data with game information to provide additional game context and details such as power play information, score differential, and puck and player locations. We then we address several issues with that data that include: adjusting the start and end times to account for time clock resets (e.g., plays where the clock is reset due to a video review like an offside), ensuring that possessions adhere to active game play intervals, removing duplicate possessions, fixing abnormal data entries (e.g., out of sequence data) and adjusting some possessions that contain excessive distance between the puck and the possessor.

After cleaning and filtering, we found a few issues that compromised game information and data accuracy. As a result, we removed games with erroneous data for more than 4% of the game duration, or 4% of a team's possession time. After this filtering (118 games) we were were left with 91% of the league's regular season games.

4.2 Filtering Individual Players

We apply filters to the remaining 1,194 games to exclude players for which there was insufficient data. From these 1,194 games, players are excluded if they played fewer than 10 games or had less than 10 minutes of 5v5 ice time per game. In the 1,194 games studied, 921 players participated in one or more games and 250 were excluded, leaving 671 players remaining. We believe these 671 players capture a representative sample of regularly participating players since the expected number of players (i.e., excluding goaltenders) given no roster changes throughout the entire season would yield 576 players (32 teams x 18 players per team).

5 Speed with Possession

In this section we study player speeds during possessions with the goal of identifying players that carry the puck at high speeds. We focus exclusively on play during 5v5 situations because it is more indicative of regular play and avoids giving an advantage or disadvantage to players who spend more time in short-handed, power play, 4v4, 3v3, or empty net situations. We evaluate puck-carrying speeds using three metrics, inspired by the data available on the NHL EDGE website [10] that reports players top speeds and bursts of speed. Our metrics only consider player speeds when they have possession of the puck and we report all speeds in feet per second (ft/s) as we believe that this allows one to envision how much on-ice distance is being covered, given that NHL rinks are 200 feet in length and there are 50 feet between the two blue lines. Specifically, the metrics that we examine are the average number of 20+ MPH (i.e., 29.3+ ft/s) bursts reached by a player per 20 minutes (referred to as "Bursts20"), top speed across the entire season, and an average (across all games) of the top speed obtained in each game (Avg. Top Speed).

Note that Bursts20 is different from 20 MPH+ bursts reported on the NHL EDGE web site [10]. According to that site, "bursts measure the number of times a skater achieved a sustained speed above a given threshold". As noted, for Bursts20 a player must possess the puck for one second or more and we normalize the number of bursts to 20 minutes, to ensure that values are not skewed towards players with more ice time.

5.1 Data Cleaning

To capture possession speeds and draw fair comparisons, players must have enough opportunity within a possession to generate high speeds. Moreover, a player must have sufficient opportunity within a game and across the season to record high speeds. Therefore, we only consider possessions of one second or longer to capture "puck-carrying" possessions. Furthermore, we only consider games in which a player has five or more such possessions, and players with ten or more such games. Collectively, these filters exclude short possessions with insufficient puck-carrying time, and players that may not have had enough opportunites to reach high speeds in a game or over the season. After applying these filters, we are left with 663 players and an average of 53 games used per player. The PPT data provides speed computed using 12 readings per second and then "smoothed" to account for missed readings and the volatile movement possible with the tracking device over short time intervals [13]. Note that Bursts20 and average game top speed are calculated by game and then reported as an average. Also note that we record at most one burst per possession, thus if a player reaches 20+ MPH then their speed drops below and speeds up to 20 MPH (or more) during the same possession, we count this as a single burst.

5.2 Player Speeds

Table 1 shows the top 10 forwards and top 10 defencemen each sorted by Bursts20 during 5v5 situations. We sort by Bursts20 as this provides insights into which players carry the puck at high speeds more often. The ability to consistently carry the puck at high speeds (Bursts20) seems, to us, more valuable and more informative than top speed and average top game speed. When examining the data we notice that there are many well-known, highly-regarded players who average very few or zero puck carrying bursts of 20+ MPH. This is likely because those players have different roles and/or skill sets (e.g., play makers, goal scorers, or defensive-oriented players, to name a few). For example, Alex Ovechkin (WSH), Mitchell Marner (TOR), Rasmus Dahlin (BUF), Jason Robertson (DAL), and Adam Fox (NYR) have low Bursts20 averages but provide value to their respective teams in other ways. We believe that Bursts20 provides insights for teams and coaches looking to find and leverage players who can consistently carry the puck with speed when considering roster management and line combinations, however it is by no means a requirement for players to contribute to their teams (as different players may fill different roles). In addition to average Bursts20 and 95% confidence intervals for the average, Table 1 also shows the number of games used after filtering (GP$\star$: Games Played and not filtered), top speed, average per game top speed, as well as league and position averages (the bottom rows).

Top speed and average game top speed both suggest that defenders can carry the puck at fairly similar speeds to forwards (see the averages shown at the bottom of the table). We find that forwards average more Bursts20 than defencemen, with a statistically significant difference. We also observe overlapping confidence intervals among

Rank	Name	Team	Pos.	GP⋆	Bursts20 20+ MPH (29.3+ ft/s)	Top Speed (ft/s)	Avg. Top Speed (ft/s)
1	Nathan MacKinnon	COL	C	79	3.35 [2.87, 3.83]	35.1	31.7
2	Denis Gurianov	NSH	RW	11	2.53 [1.59, 3.48]	32.6	30.3
3	Julien Gauthier	NYI	RW	13	2.53 [1.59, 3.47]	34.6	30.0
4	Connor McDavid	EDM	C	68	2.18 [1.73, 2.62]	35.5	30.8
5	Noah Gregor	TOR	C	51	1.91 [1.44, 2.38]	33.5	29.8
6	Mathew Barzal	NYI	C	72	1.76 [1.32, 2.19]	34.5	30.2
7	Jack Eichel	VGK	C	58	1.71 [1.32, 2.10]	34.0	30.3
8	Martin Necas	CAR	C	68	1.61 [1.16, 2.05]	34.5	30.0
9	Andreas Athanasiou	CHI	C	24	1.58 [0.93, 2.24]	32.9	29.4
10	Ryan McLeod	EDM	C	70	1.55 [1.13, 1.97]	33.4	29.3
1	Cale Makar	COL	D	74	0.70 [0.50, 0.90]	33.1	28.6
2	Jake Sanderson	OTT	D	71	0.67 [0.44, 0.89]	33.9	28.6
3	Spencer Stastney	NSH	D	19	0.61 [0.28, 0.95]	31.8	28.4
4	Luke Hughes	NJD	D	74	0.61 [0.41, 0.81]	32.7	28.9
5	Nick Leddy	STL	D	73	0.59 [0.44, 0.74]	34.6	28.9
6	Sean Walker	PHI	D	77	0.59 [0.38, 0.79]	32.0	28.1
7	Quinn Hughes	VAN	D	69	0.58 [0.41, 0.76]	33.1	28.8
8	Colton Parayko	STL	D	73	0.58 [0.42, 0.74]	31.9	28.6
9	Jalen Chatfield	CAR	D	62	0.52 [0.31, 0.74]	32.1	27.1
10	Jamie Drysdale	ANA	D	32	0.49 [0.26, 0.72]	32.6	28.0
+	League Avg.			53	0.32 [0.29, 0.35]	31.2	26.8
+	Forwards Avg.			54	0.44 [0.39, 0.48]	31.5	27.3
+	Defensemen Avg.			53	0.14 [0.12, 0.15]	30.7	26.1

Table 1. Top 10 players ranked by average 5v5 20+ MPH Bursts per 20 minutes. GP⋆ denotes the number of games used (i.e., after applying filters).

the top 3 forwards, when comparing forwards ranked 2 to 10, and between the top 10 defencemen. This suggests that many of the top players in Table 1 are not significantly different from one another. However, we point out that the differences between all 20 players in the table and their respective position averages are statistically significant.

Notably, Nathan MacKinnon ranks 1st with 3.35 Bursts20 in comparison to the forward average of just 0.44 (7.6 times more). Cale Makar ranks first among defencemen with 0.70 Bursts20, compared to the defencemen average of 0.14 (5 times more). We note that a few players in Table 1 have had relatively low numbers of opportunities to obtain high speeds in possessions of one second or longer (GP⋆). As a result, these players typically have wider 95% confidence intervals than the rest of Table 1. This illustrates that Bursts20 may be useful for identifying players in smaller roles that have demonstrated an ability to consistently carry the puck at high speeds (although with a limited sample size).

Figure 1 plots, separately, the cumulative distribution function of Bursts20 for all forwards and all defencemen. This graph shows the clear and large difference between forwards and defencemen. Namely, it shows that nearly 19% of defencemen average zero Bursts20, compared to roughly just 7% of forwards, further illustrating that many defencemen may not be expected to carry the puck at high speeds. It also shows a large disparity between top forwards, like MacKinnon, with very high Bursts20 and other middle-ranked forwards. Players with an average of 1.0 or more bursts per 20 minutes represent fewer than 10% of all forwards and about one half of the forwards average fewer than about 0.3 bursts per 20 minutes.

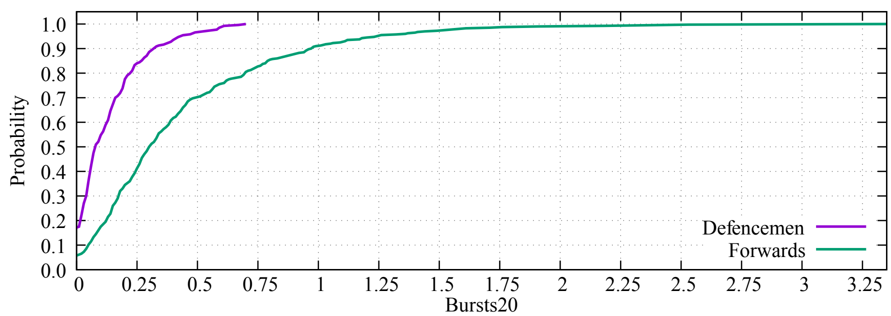

Fig. 1. CDF of Bursts20 for defencemen and forwards.

In future work, it would be interesting to consider possessions of shorter durations (e.g., half a second rather than one second) and examining the sensitivity of the results to that choice. It would also be interesting to consider bursts relative to each player's top speed. For example, studying bursts that are within p percent of a player's top speeds throughout the season. This could be useful in understanding a player's bursts relative their capability and how a player's speed changes over time. Such possibilities might include examining differences as a player ages, as their fitness level changes, or while they recover from an injury.

6 Individual Contributions to Team Possessions

In this section, we study the distribution of individual possession times across players on each team. The goal is to understand whether a team's possession time is concentrated among a few players or more evenly distributed across all players. While previous sections used individual possession data to gain insights into player roles and styles, this section focuses on how those possessions collectively shape each team's overall possession profile. However, we find a strong correlation between a player's possession time and their time on ice (TOI) ($r = 0.73$), thus our findings may also reflect underlying patterns in TOI distribution. While fairness has been used to study talent distribution in the NHL (in the context of strong-link and weak-link team structures [6]), to our knowledge, it has not previously been publicly used to study puck possession or TOI.

To examine how evenly teams share puck possession across their lineup, we compute an "equity score" based on ranked possession contributions. For each game, players on a team are sorted by their total possession duration (for 5v5 situations) and assigned a rank from 1 to 18. In this analysis, each player's possession duration is taken as-is, without normalizing for ice time. The filters described in Section 4.2 are not applied, so all players who appear in a game are included. This allows us to capture the full distribution of possession time across the entire lineup for each game.

For each team, we aggregate the possession durations across all games by rank. We sum the total time held by the top-ranked player across all games, then repeat this for ranks two through eighteen. This rank-based approach avoids bias from injuries or roster changes over the season. Each rank's total is divided by the team's overall possession time to obtain a share vector. This vector describes the proportion of total possession held by each rank from 1 to 18. We then compute Jain's Fairness Index on this vector to determine the team's equity score [7]. The equity scores range from 0 to 1 with higher values indicating a more even distribution. The Equity score (Jain's Fairness Index) is defined as:

$$E(t) = \frac{\left(\sum_{i=1}^{n} x_i\right)^2}{n \sum_{i=1}^{n} x_i^2} \tag{1}$$

Where t is the team, $E(t)$ is its equity score, x_i is the proportion of possession time held by rank i, and n is the number of ranks (18).

Table 2 ranks teams by their equity score with 95% confidence intervals computed by bootstrapping (resampling each team's games with replacement). Despite differences at the extremes, many teams have overlapping 95% confidence intervals, suggesting that possession distribution is similar across many teams.

Rank	Team	Equity Score	Rank	Team	Equity Score
1	FLA	0.85 [0.84, 0.86]	17	MIN	0.80 [0.79, 0.82]
2	VGK	0.85 [0.84, 0.86]	18	TBL	0.80 [0.79, 0.81]
3	DAL	0.84 [0.83, 0.85]	19	STL	0.80 [0.78, 0.81]
4	NSH	0.83 [0.82, 0.85]	20	BUF	0.79 [0.77, 0.80]
5	DET	0.83 [0.82, 0.84]	21	CBJ	0.79 [0.78, 0.80]
6	SEA	0.83 [0.82, 0.84]	22	WSH	0.79 [0.78, 0.81]
7	CAR	0.83 [0.82, 0.84]	23	EDM	0.78 [0.77, 0.79]
8	ARI	0.83 [0.82, 0.84]	24	NYR	0.78 [0.77, 0.79]
9	PHI	0.83 [0.82, 0.84]	25	NJD	0.78 [0.77, 0.80]
10	LAK	0.82 [0.80, 0.83]	26	ANA	0.77 [0.75, 0.78]
11	WPG	0.82 [0.81, 0.83]	27	MTL	0.77 [0.76, 0.79]
12	TOR	0.82 [0.80, 0.83]	28	NYI	0.76 [0.74, 0.77]
13	SJS	0.82 [0.81, 0.83]	29	PIT	0.75 [0.73, 0.76]
14	CGY	0.81 [0.80, 0.82]	30	OTT	0.73 [0.71, 0.74]
15	BOS	0.81 [0.80, 0.82]	31	COL	0.72 [0.70, 0.73]
16	CHI	0.81 [0.80, 0.82]	32	VAN	0.70 [0.68, 0.72]

Table 2. Equity score (Jain's Fairness Index) in 5v5 situations for all teams in the NHL.

Figure 2 plots each team's equity score against their average 5v5 goal differential. We use goal differential as the primary measure of team success because it is adaptable across game situations (e.g., 5v5). Interestingly, the results show that both balanced and unbalanced possession strategies can lead to strong team performance. The Florida Panthers (FLA) rank first in equity score, while the Vancouver Canucks (VAN) rank last, yet both are among the top four teams in average goal differential. This lack of relationship is reflected in the near-zero correlation between equity scores and average goal differential ($r = 0.02$).

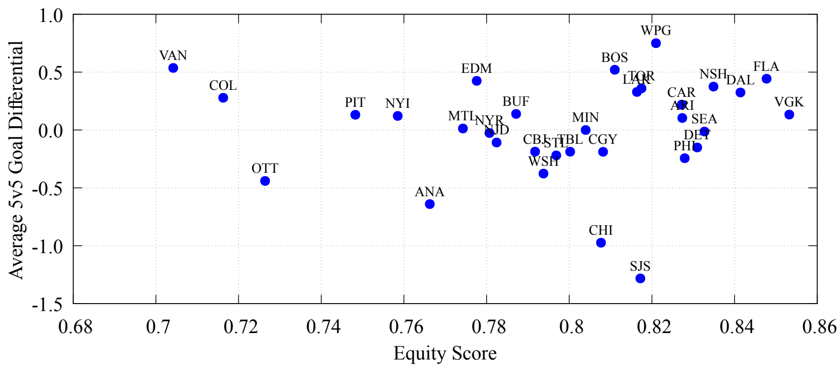

Fig. 2. Equity score versus average 5v5 goal differential ($r = 0.02$).

To illustrate how possession is distributed differently among successful teams, Figure 3 compares the Florida Panthers (FLA, 1st in fairness), Boston Bruins (BOS, 15th), and Vancouver Canucks (VAN, 32nd), who all rank in the top four in average goal differential but differ significantly in equity score. The figure shows that, on average, a smaller number of players account for a larger share of possession time on Vancouver compared to Florida and Boston (this can be seen by the steeper rise in Vancouver's curve over the first few players). This is primarily due to the top individual player on Vancouver averaging approximately 18% of the team's possession, while the top individuals for Florida and Boston each accounted for about 11%.

While fairness is computed per game and the specific top ranked player may vary, Vancouver's curve reflects a pattern of consistently high concentration at the top rank. In 64 of Vancouver's 69 games included in our dataset (92.8%), Quinn Hughes led the team in possession time. He had one minute and thirty-seven seconds of possession time per 20 minutes in 5v5 situations (the top ranked player in the league in that category [5]). The remaining five games were led by Filip Hronek (4) and Tyler Myers (1). Notably, no players from Boston or Florida rank among the top 15 in that category. Florida's top player, Mike Reilly, had 1 minute and 7 seconds of possession per 20 minutes, while Boston's top player, David Pastrnak, had 56 seconds of possession per 20 minutes.

After the top player, the rate of possession accumulation across subsequent ranks is comparable across all three teams, and in fact, the jump from the first to second player is slightly smaller on Vancouver than on Florida. This confirms that Vancouver's lower fairness score is mainly driven by Quinn Hughes high possession time in most games.

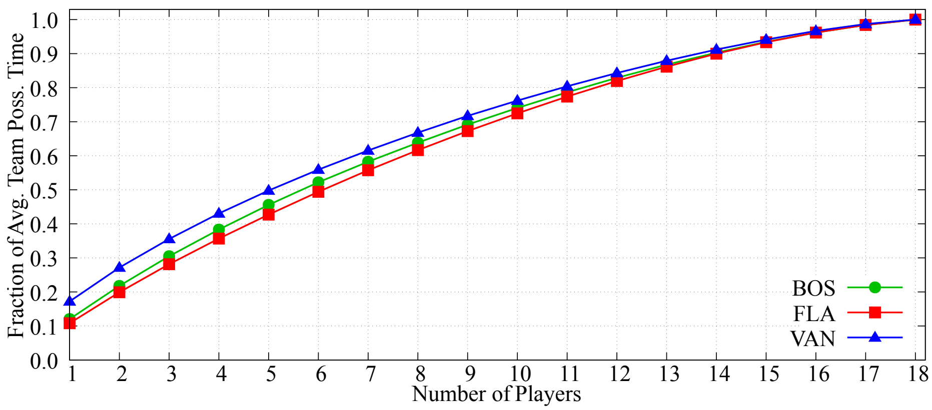

Fig. 3. Cumulative share of team possession held by players ranked 1-18 in 5v5 situations, aggregated across all games. Florida (1st in equity), Boston (15th), and Vancouver (32nd) all rank top-4 in goal differential but significantly differ in how evenly possession is distributed among team members.

7 Conclusions

In this paper we utilize unofficial NHL puck and player tracking data to introduce and analyze metrics related to player speed while in possession of the puck. We determine the number of times per game a player carries the puck for one second or more at a speed of 20+ MPH, normalize that value to 20 minutes of ice time and compute each player's per game average. We call this metric Bursts20 and find that top ranked players significantly outperform their position group averages. We believe this metric can be useful for studying and identifying players with different skills, playing styles, or roles, and that they may be useful for constructing line combinations and rosters.

We also devise a method for analyzing possession distributions within a team using Jain's Fairness Index to compute an "Equity Score". This measures how equally puck possessions are spread among players on the same team in each game. We believe that this metric provides information about team structures and playing styles and that it offers value in team analysis and scouting. We find no evidence that equitable distribution of possessions within a team influences average goal differentials.

An interesting direction for future work would be to investigate which players create or begin new possessions for their team. Additionally, we plan to examine the outcomes of individual possessions. For example, possessions that end in a pass, dump-in, shot on net, or whistle, how the outcomes vary across players, as well as the success rate of a player's possessions. Finally, we hope to examine relationships between Bursts20 and other metrics. Some examples include: zone entries, zone exits, drawn penalties, expected goals (since goals may somewhat depend on luck) and other possession outcomes. For some of these metrics it requires access to individual game data from alternative sources (i.e., data that is not available in the PPT data or via the NHL API). This is needed to ensure that only the same set of games used to compute Bursts20 are included (due to the cleaning and filtering process).

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