# Exploring NS/EW Passing Strategy in Women's Hockey

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## Research Question

Passing strategy dictates the flow of a hockey game, a major factor in influencing in-game strategic coaching decisions. North-South and East-West (NS/EW) passing, referring to the direction of the pass, are two key strategies considered in this analysis. In this report, we explore the question: *Which passing strategy did teams employ under different game scenarios?* Using the Women's hockey: (2018 Women's Olympic Hockey Tournament sample and NCAA games) data set provided, we set out to uncover insights regarding usage of the two strategies. In this analysis, we explore the relationship between score difference and passing strategy through visualization, clustering, and in-depth game analysis.

## Background

### Description

North-South passing is when the possessing team passes the puck forwards or backwards, quickly moving the puck from one end to another and spreading the game out vertically. East-West passing is when the possessing team passes the puck side to side across the width of the ice, spreading out the game laterally.

### Implications of Passing Strategy

The significance of NS/EW passing strategy analytics is often overlooked. While each hockey team has an overall style to their gameplay, the application of passing strategies plays to the strengths and weaknesses of the overall strategy. Which means, it affects the type of passing the other team will want to utilize. A common strategy of very strong defensive teams is trapping the neutral zone, making it very hard for the opposing team to enter the offensive zone. In this case, the opposing team should be using north-south passing in order to quickly get from one end to the other before the defending team has time to set up their trap. North-south passing offers speedy entry times into the offensive zone, therefore creating more opportunity for fast breaks and odd-man rushes.

East-west passing is effective when the possessing team wants to settle things down, flip the pressure to the other side of the ice, and set up plays. If performed correctly, east-west passing creates time and space for the possessing team, two of the most important aspects in hockey. Time and space is extremely

important because it allows players to analyze their next move and create more scoring opportunities. Both passing strategies have their benefits and shortfalls, and the most effective strategy is learning how to use both and how to determine when to use each.

# Approach

### Passing Strategy Metric

This passing strategy metric uses a combination of the relative angle of the pass to the passer to the rink and the length of the pass. This allows us to determine if the pass is NS or EW respectively. Weighting for the length of the pass allows for the identification of short EW passes to setup a longer NS pass.

$$Passing\ Strategy\ Metric\ = \frac{\Delta x}{\Delta y}\sqrt{\Delta x^{\ 2}\Delta y^{\ 2}}$$

The range of this metric is a minimum of 0 (EW) to a maximum of 193 (NS) for all passes in the dataset.

### Passing Visualization and Exploration

To investigate the effectiveness of both passing strategies and to determine which one was most effective, we crafted a few visualizations and analyzed the passing strategies of the teams in the data set.

- Visualizing the relationship between pass direction and goal differential, provided insight into how teams change their strategy under pressure.
- Plotting passes and their angle on the rink for a subset of the data (e.g. game, team and period), allowed us to visualize important pieces of games.

After enhancing the dataset with the Passing Strategy Metric, we were able to create data visualizations over a range of team, period, and score differential combinations.

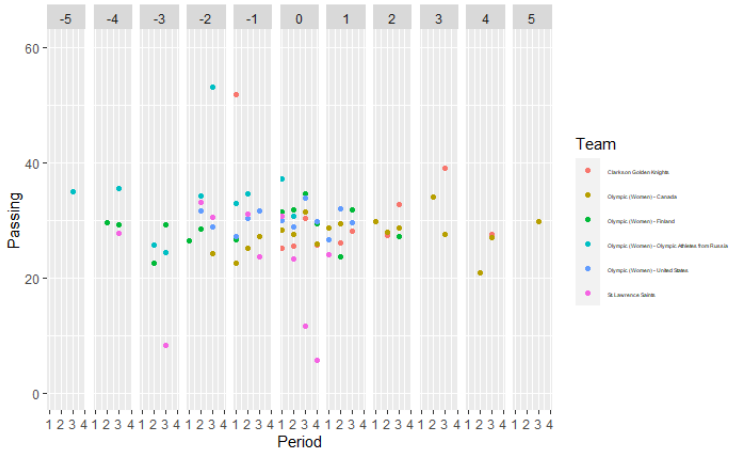



***Figure 1. Passing Strategy Metric per Period, Score Difference by Team***

Figure 1. above displays how relatively aggressive teams were passing the puck during certain game situations. Outliers are a result of limited game data with the NCAA Women's dataset. Figure 2.. on the next page, represents just the Canadian and United States Olympic women's hockey teams.

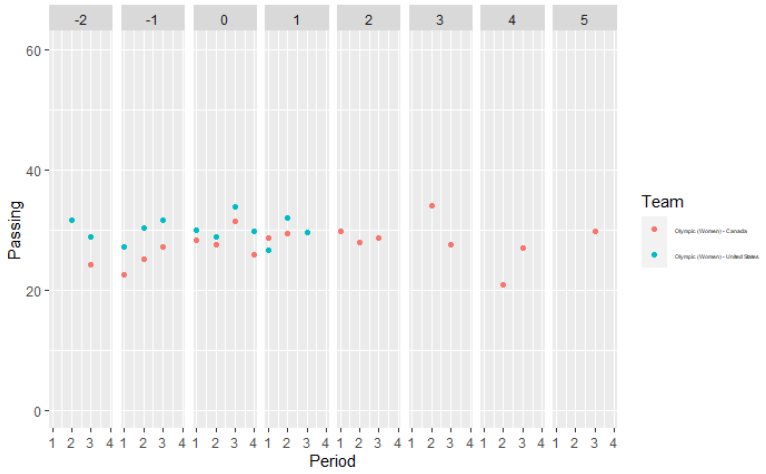



***Figure 2. Passing Strategy Metric per Period, Score Difference for Canadian and United States***

As the score difference between the two teams increases, the passing strategy metric variation increases. We would expect teams with large leads to kill time and pass more EW. This is not true for the Canadian team. With a three goal advantage in the second period, the Canadian team over this dataset plays it most aggressively with passing.

## Unsupervised Learning - K-Means Clustering

One example of our analysis is the use of K-means clustering. We use a combination of variables of score differential, number of home skaters, and number of away skaters and analyze the effect on the passing strategy metric. K-means clustering is an unsupervised machine learning method that allows for partitioning n observations into k clusters in which each observation belongs to the cluster with the nearest mean. Multiple numeric variables are used to determine the clusters. We then use descriptive statistics of our Passing Strategy Metric to gain insights. We limit the clustering to the variables of score differential, number of home skaters, and number of away skaters in this analysis. Additional variables such as line numbers and time on ice could also be considered.

| fit.cluster | N | Scoring_Diff | Home Skaters | Away Skaters | Mean Passing Hyp_Angle | Standard Dev Passing Hyp_Angle | Percent Intercepted |
|---|---|---|---|---|---|---|---|
| 1 | 1,888 | 0.58 | 5.00 | 4.88 | 28.97 | 24.09 | 4.8% |
| 2 | 767 | 0.67 | 3.94 | 4.82 | 25.68 | 22.69 | 2.2% |
| 3 | 1,525 | 1.29 | 5.01 | 4.87 | 28.38 | 24.68 | 4.7% |

| fit.cluster | N | Scoring_Diff | Home Skaters | Away Skaters | Mean Passing Hyp_Angle | Standard Dev Passing Hyp_Angle | Percent Intercepted |
|---|---|---|---|---|---|---|---|
| 1 | 1,560 | -0.05 | 5.00 | 4.85 | 30.04 | 25.23 | 4.9% |
| 2 | 447 | -0.12 | 3.93 | 4.34 | 29.47 | 24.17 | 3.1% |
| 3 | 1,214 | -0.87 | 5.03 | 4.82 | 30.55 | 26.52 | 6.3% |

***Table 1. Results of K-means clustering (k=3) for Olympic Canadian Women's Team on the left and United States Women's Team on the right***

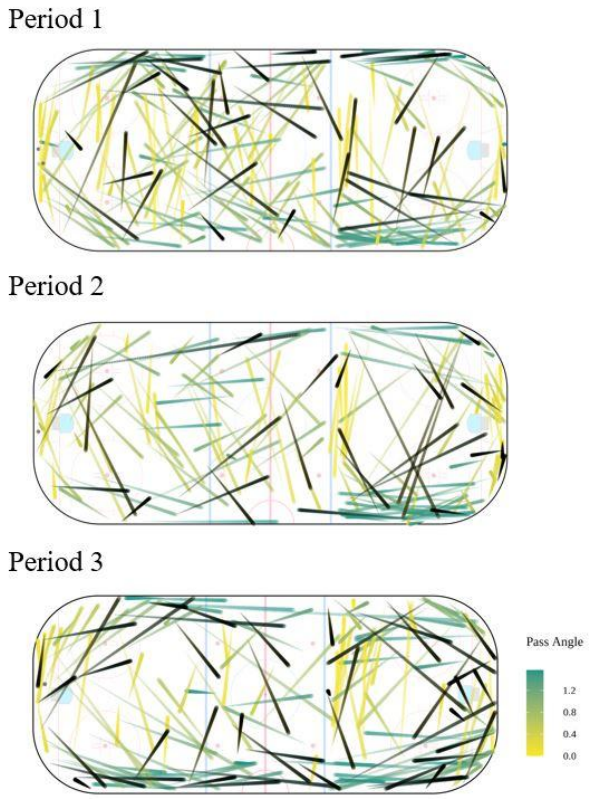
The results of the analysis displayed in Table 1. above also reinforce our earlier finding that the Canadian team passes aggressively even with a lead. Comparing the United States team with the Canadian team, we observe a slightly more aggressive passing strategy. Also, the United States is always playing from behind in this dataset. More United States passes with a large negative point difference are also being intercepted.

# Key Action Points in Analysis

As seen above, within our study we used a variety of visualizations to portray information. The k-means cluster and other graphical representations showed the passing strategies broken down by the goal differential each team was facing. The k-means clustering results would provide a coach with a robust technical interpretation of passing strategy and specific statistics to evaluate. Passes plotted on the rink offer a much more realistic and applicable visual of how the teams are actively using the passing strategies.

The results indicate that losing teams tend to become more aggressive with their passing strategy, especially in the third periods. Those passing strategies would be categorized as a mostly north-south passing strategy. We also found that the neutral zone is where most incomplete passes occur. In many of the games, the teams tend to veer away from the middle of the neutral zone and use the boards as a catalyst in their passing strategy. Now, the overall idea that teams will become aggressive when losing and the use of boards is prominent in the neutral zone are expected observations. However, this information is valuable to a coach. Our study took a look at each team and each game to find patterns.

What this study will help coaches do is create a **defensive strategy** to counter the passing strategy used by each team, or to deploy an offensive passing strategy that was most effective, in this study. It also provides key areas where passing the puck was most successful and most intercepted, giving coaches a sense of where to and not to pass on the ice. Again, it would all depend on the team that you're facing because even though there are similar patterns by every team, each team has their own strategy and set plays that you have to account for. Now, we didn't have a lot of games and data to work with, so we decided to focus on Canada and the United States for this report. In the game between Canada and the United States on 2/21/2018, there was a clear change in passing strategy by the United States. The image below shows all the passes made by team USA broken down by periods.




**Period 1**: In this visualization, it shows how the United States was very calculated with their passing. The zone on the left hand side of this picture is their defensive zone. In that, we can see that they took their time setting up plays and regrouping by the amount of east-west passing they did. This is meant to create time and space, to again, set up clean transition plays. As we discussed earlier, the score of the game plays a huge role in which strategy a team will use. In this game, it was a tie game at zero for the entire period, except for a very late USA goal with 27 seconds left, which is why they took a very conservative EW style. They also took chances through the middle of the ice due to the nature of the score.

***Figure 3. Team US Passing Strategy: US vs Canada 2/21/2018***

**Period 2**: Team Canada tied the game at one very quickly into the second period, and then they took a 2-1 lead a couple minutes later. This led to the United States to be trailer for over half of this period. This is why they begin taking chances with long stretch passes across the ice (EW) and down the ice (NS). Looking at the offensive zone (right hand side zone), you can see that there were not many passes attempted through the middle of the zone, and the ones that were ended up being incomplete or intercepted (denoted by the black lines). This indicates that Canada was covering the center of the ice very well, pushing everything to the outside.

**Period 3**: The United States did not tie the game at two until very late in the period, 6:23 remaining. What this period shows is that the United States moved to a very heavy north-south strategy, mainly along the boards. This is due to the fact that they were trailing and needed a goal in this period. They also kept most of their passes out of the center of the ice in their defensive zone and the neutral zone, meaning they did not want to put the puck in a high turnover area. However, this clearly shows that when they did pass it into the center of the ice, it was almost always incomplete. They were obviously trying to tie the game, so

using the center of the ice would be very dangerous for them because it could easily lead to more scoring opportunities against them, creating a larger deficit.

In this specific game, each period exemplifies a change in passing strategy made by the United States. What this does for the coach of the opposing team is show them how the United States reacted to the score. So when they were losing, in periods two and three, they moved to more NS passing strategy and stayed along the boards. Now that the opposing coach has this intel, they can set up a defensive strategy to counter it. A popular one throughout this data set was keeping the puck to the outside, along the boards. That is exactly what team Canada did in this example. You can tell by the majority of passes made by the United States moving away from the middle of the ice. Along with defensive strategy, this gives the coaches insight on which passing strategy, and location of the passes, are most successful to enter the offensive zone and create scoring opportunities. The main coaching insight this analysis provides is defensive strategizing, it provides the information on how your opponent will react to losing and helps create a plan for your team to hold a lead.

## Summary

Passing the puck is a fundamental trait of hockey, it is the cornerstone of movement on the ice. The strategy surrounding how a team passes is crucial to their success. The passing strategy a team chooses to use in a given period is entirely situational as it has the ability to change multiple times in a game. This is why it is important for coaches to know what passing strategy an opposing team is conducting. Is it a north-south passing strategy or an east-west strategy, and at what point in the game are they utilizing each? Recognizing passing strategies and puck movement is a crucial element to creating both offensive and defensive in-game strategies, and it could mean the difference between an incredible win and a crushing loss.