Goals Above Replacement

A Comprehensive Metric for Player Evaluation in the NHL

Andrews
University of Michigan
Stats 507 Final Project
Ann Arbor, USA
andrewsi@umich.edu

***Abstract*—This paper covers the needs and logistics behind developing a model for "Goals Above Replacement" (GAR), an advanced metric commonly used in the National Hockey League (NHL). GAR is a single numerical value assigned to each player that comes from weighing the different stats of an individual during a hockey game which allows efficient and informative player comparison.**

I. Introduction

The National Hockey League ranks as the fourth most-watched league in the United States, trailing only the National Football League, Major League Baseball, and National Basketball Association in popularity [3]. With such significant viewership and stakes, NHL teams' coaches and General Managers have been relying more and more on advanced analytics to make data driven decisions on all aspects of the game, including decisions related to player signings and roster building. However, comparing players based on a multitude of statistics, such as goals, assists, and defensive metrics, can be challenging. Conventional methods, such as evaluating players solely based on goals scored, often fail to capture how a player is able to contribute to the team in other aspects of the game.

For example, two players with similar goal totals may vary significantly in other critical aspects, such as their defensive impact or special teams' performance, two other phases of the game that are involved in the overall impact a player has on a game. To address this complexity, advanced metrics like Goals Above Replacement (GAR) have been developed. GAR attempts to find a player's overall contributions—offensive, defensive, and special teams— and present it in a single value. This allows teams to objectively compare players beyond traditional metrics like goals and assists.
In this paper, I propose and implement a model to calculate GAR using publicly available NHL skater data from hugging face [4].

II. Existing Literature

There is quite a bit of existing work on this topics as all 32 NHL teams have Data Analysts working behind the scenes on player evaluations, evaluating potential player trades, different team metrics, and in-game trends. With that being said, many of these teams keep the work that they are doing confidential and so this work is not available to the general public[6]. This comes up again in "Advanced Stats for Non-Stats People" as they explain that "Evolving Hockey" has created a fantastic Goals Above Replacement Model but users must pay to have access to it. An additional article that was published is "Evaluating NHL team performance: Metrics and Methods" [5] which talks the reader through a combination of different statistics, methods, and contextual analysis that can be found in the game.

III. Motivation

To demonstrate the need for a stat like GAR, I would like you to put yourself in the shoes of a General Manager in the National Hockey League. It's five days before the regular season starts and your first-line left winger that averages 42 goals per season is ruled out indefinitely with a lower body injury. Scoring is a huge part of the game and one might think your team is going to score 42 fewer goals this season. That is, of course, not true. The second line player can move to the first line, the third to the second, and so on until you fill the fourth line with a new player, likely not a 42 goals scorer, but he'll be able to make up some of the difference [1].
There are two talented players that are free agents that are willing to sign with you if given the chance, Player 1 and Player 2. They have scored a similar number of goals since entering the NHL, 267 and 261 respectively. With the season quickly approaching and being down a top player you are eager to find a replacement, and quick. Figure 1 displays the two players' career statistics.

In order to meet the Goal of creating a GAR model to help select the next NHLs superstar you hire a Data Analyst to summarize the contributions of each player in various game phases - full strength offense, full strength defense, power play, and penalty kill, in order to uncover which player has provided more overall value to their team.

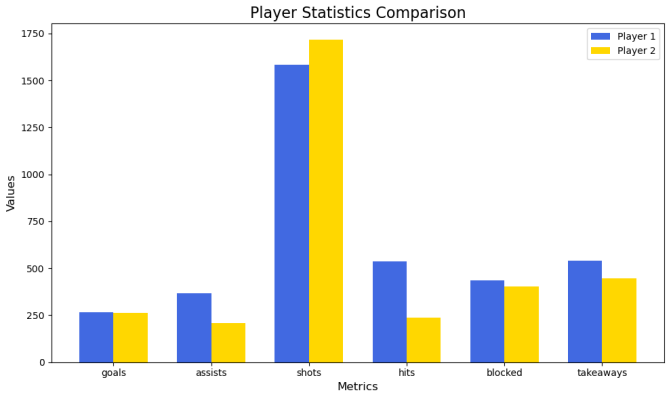

Fig. 1. Player Comparison

IV. Method

To create a model to calculate a player's Goals Above Replacement the data needs to be separated into different phases of the game - offense, defense, power play, and penalty kill. To do this, I provided a weight to each of the variables in each of the phases the model based on their importance according to my knowledge of hockey. The weights I assigned can be found in tables 1-4.

A. Even Strength Contributions (Offense and Defense)

The majority of hockey games are spent playing 5 skaters against 5 skaters; therefore a large weight of the calculated time will be on offense and defense of even strength. See below for the variables that are included in this portion of the model.

Metric	Weight
Goals	1.0
Assists	0.75
Shots	0.20
Giveaways	-0.15

TABLE I
Even Strength Offense - 5v5

Even Strength offense variable definitions:

Goals – The number of times a player successfully directs the puck into the opponent's goal

Assist – Awarded to a player who contributes to a goal by passing the puck to the scorer (primary assist) or to the player who makes a pass to the primary assister (secondary assist)

Shot – Recorded when a player shoots the puck on net. This included when the puck goes into the goal or the goalie makes a save.

Giveaways- Situation where a player loses the puck to the opposing team.

Metric	Weight
Hits	0.1
Blocked Shots	0.2
Takeaways	0.15

TABLE II
Even Strength Defense - 5v5

Even Strength defense variable definitions:

Hits – When a defensive player deliberately checks an opponent that has the puck.

Blocked Shots – When a defensive player blocks an offensive players shot with their body or stick

Takeaways – Situation where a defender successfully takes the puck from an offensive player.

B. Special Teams Contributions (Power Play and Penalty Kill)

Unlike other sports, when a player commits a penalty, they are required to leave the ice for an amount of time, often 2 minutes. In this case, the team plays down a man in a 5 on 4 situation. This is known as a power play for the offense and a penalty kill for the defense. See below for the variables that are included in this portion of the model.

Metric	Weight
Power Play Goals	0.9
Power Play Assists	0.7

TABLE III
Power Play Offense - 5v4

Power Play Offense Variable Definitions:

Power Play Goals: Goals scored while the offensive team has a numerical advantage due to a penalty by the other team.

Power Play Assits: Assists (both primary and secondary) that happen when the offensive team has a numerical advantage.

Metric	Weight
Short-Handed Goals	1.0
Short-Handed Assists	0.8
Penalty Minutes	-0.5

TABLE IV
Power Play Defense - 4v5

Penalty Kill Variable Definitions:

Short-Handed Goals: Goals scored while the offensive team has a numerical disadvantage due to a penalty by their team

Short-Handed Assists: Assists (both primary and secondary) that happen when the defensive team has a numerical disadvantage.

Penalty Minutes (PIM): The total numer of minutes a player spends in the penalty box due to penalties.

Going along with the idea of a power play, this is a very hard time for the defense to kill off these two minutes, and so it is desirable to NOT take penalties. Players that do spend many minutes in the penalty box and a liability for their team. This negative impact will be taken into account by having a negative weight on Penalty Minutes.

C. Replacement-Level

In this Goals Against Replacement model, it is required to create a "replacement level." The goal of this is to find a baseline level of play where a player isn't drastically adding or subtracting value to the team [2]. If a player has a positive GAR they play above the level of a replacement player and if they have a negative value they play below the level of a replacement player. For my model, I have chosen to determine this value by identifying the performance of a player that has a statistic in the 30th percentile of the statistic for all athletes in the dataset. See Figure 2 to see how the replacement level player matches up against the league average player and an elite level player (90th percentile) in both goals and assists.

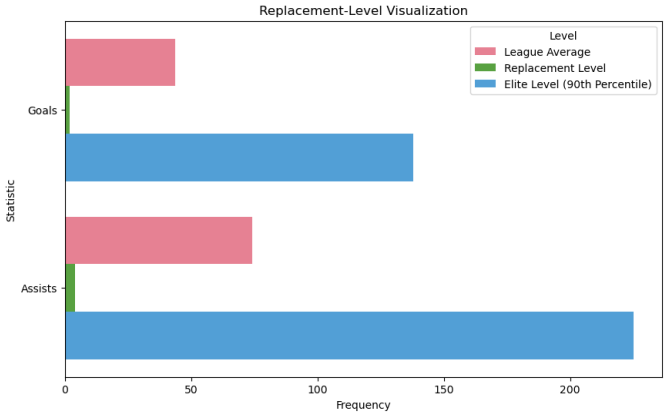

Fig. 2. Replacement-Level Visualization

V. Creating the Model

For each of the 4 phases of the game, I created a model similar to the one found below:

powerPlayContribution = $0.9\times$ powerPlayGoals(pergame) + $0.7\times$ powerPlayAssists(pergame)

Not all players play the same amount of games because of inevitable injuries, trades, roster decisions, and experience of the player. Using stats per game allows me to normalize the metric, creating a better comparison between players with different total games. It is rare for players to be available for all 82 games, and looking at it by game is a great way to take this into account.

After creating models for each phase of the game, I added them together, weighing again on importance and regularity, to take all phases of the game into account when evaluating the player to have a metric that can compare athletes.

GAR = $0.4\times$ offenseContribution + $0.3\times$ defenseContribution + $0.15\times$ powerPlayContribution + $0.15\times$ penaltyKillContribution

VI. Results

Now that the model has been created it will be significantly easier to decide who to fill the hole that was created when the star left winger got injured. Here are the calculations for the two players brought up before:

Player1 = 0.474172
Player2 = 0.674754

Originally it was hard to decide which player to sign, now, looking at the calculated Goals Above Replacement values, it appears that choosing player2 is likely to be more help to the team. Although player1 had more goals and assists, they do not seem to be as well rounded of a player as player2 and are lacking on defense and special teams. This was not clear prior to the creating of this model.

VII. Limitations

As with all models, there are some limitations. A couple that come to mind from the model I created are the following:
Perhaps your team is really lacking a specific feature of the game that is weighted low in the model such as a 4th line player that's role is to be an enforcer. This model wouldn't be helpful as it is assisting in finding a well rounded player and puts a low weight on hits which you may want to be really high for the type of player your team is missing.
My model doesn't account for the player's Time On Ice (TOI). Using TOI to normalize the model could be a direction this model could go in.
My model also doesn't take into account who the hockey player is playing with (which teammates) or who they're playing against on any given day.
One final topic I can think of that my model doesn't take into account is a way to recognize younger or less experienced players that are likely to still be growing in strength. The same can be said for older players that are likely on a downward trend.

VIII. Conclusion

As mentioned above, there are limitations to this idea. This is a model that can continuously evolve as new variables are recorded and new methods are discovered. According to "Advanced Stats for Non-Stats People: Article One - Goals Above Replacement", the best model to calculate Goals Above Replacement was created through Evolving Hockey. Unfortunately, this model is found on a site that fans need to pay for in order to access[2].

GAR is an extremely practical way to compare models by observing one number instead of trying to boggle a bunch of them down. It is quite common for teams to have injuries or have players request a trade, in this case it is critical to find a replacement, at times quickly. Having a readily available metric like GAR can make the scouting and roster decisions more efficiently and with more confidence.

REFERENCES

[1] "goals ABOVE REPLACEMENT," STATS AND STUFF, 2018. https://hockeyandstuff.weebly.com/chaces-blog/goals-above-replacement (accessed Dec. 09, 2024).

[2] "Advanced Stats for Non-Stats People: Article One - Goals Above Replacement," Winging It In Motown, Jul. 14, 2021. https://www.wingingitinmotown.com/advanced-stats-for-non-stats-people-article-one-goals-above-replacement/ (accessed Dec. 09, 2024).

[3] C. Brighton, "The Most Popular Sports in the United States," WorldAtlas, Aug. 27, 2024. https://www.worldatlas.com/sports/the-most-popular-sports-in-the-united-states.html

[4] Recordly/nhl-skaters-dataset from HugginFace

[5] Reporter, "Evaluating NHL team performance: Metrics and Methods — British Ice Hockey," Britishicehockey.co.uk, Jun. 07, 2024. https://www.britishicehockey.co.uk/post/evaluating-nhl-team-performance-metrics-and-methods/

[6] S. Shapiro, "Trying to explain how NHL teams use analytics," Shapshotshockey.com, Jul. 12, 2023. https://www.shapshotshockey.com/p/trying-to-explain-how-nhl-teams-use (accessed Dec. 09, 2024).