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Analysis of pulling the goalie strategy in Finnish Junior Elite Leagues

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Bachelor's Thesis
Degree Programme in Sports and Leisure Management
2018

Haaga-Helia
University of Applied Sciences

Abstract

Date

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Degree programme in Sports and Leisure management. DP14

Report/thesis title	**Number of pages and appendix pages**
Analysis of pulling the goalie strategy in Finnish Junior Elite Leagues	**32+0**

The aim of the study is to produce data and data analysis of use of the pulling the goalie strategy in Finnish junior leagues. Selected leagues for the study are Finnish elite junior league of A-& B-juniors (U20 & U18).

This thesis focuses on analysing the effectiveness of the strategy and how it relates to the previous data and research about the subject.

Teams and coaches pull the goalie in almost every game when the game is close and the game clock is heading to the final minutes. The strategy is still seldom studied or analysed, even when the benefits could be great with the succesfull use of the strategy.

The thesis analyses how effective the use of the strategy has been in season 2017-2018 in Finnish A- & B-junior SM-leagues (U20 & U18). There was 53 games in A-juniors and 49 games in B-juniors in total of the regular season which provides enough data for selected variables.The data was gathered from all the games mentioned.

The data is from the statistics database of the Finnish Ice Hockey Association, but the statistics are not flawless. The statistics are done by hand and not necessarily checked afterwards for mistakes after the referee(s) of the game have approved the datasheet.

Results show great examples about its efficiency and success, but use of pulling the goalie-strategy is still a gamble in terms of its overall success.

The results show detailed information about use the strategy and how succesful the strategy has been in the selected leagues.

Keywords
Pulling the goalie, empty net, extra attacker, statistical analysis,

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1 Introduction

> "The most exciting 90 seconds in sports are created by a man who isn't there. A hockey team is down a goal or two with the clock ticking toward double digits, and the coach pulls the goaltender and sends an extra skater over the dasher for an all-or-nothing gamble. More often than not the puck bounces off sticks, bodies, and walls or ends up in the empty cage. But the six-on-five gamble works often enough that it's worth the risk, especially when the alternative is extinction." (Powers, 2013)

Playing without the goalie is a tactical move seen often in hockey if a game is close and the final minutes of the game are going. If the margin in the game is one goal, it´s almost guaranteed that team that is trailing will pull their goalie for an extra attacker in the last minute(s) of the game to give the team extra chance on scoring.

Pulling the goalie for extra attacker is always an exciting maneuver to do. It always brings up discussion between fans whether it´ll work or not. Although it´s so common strategy in hockey that teams often use, the subject is still seldom studied, analyzed or even trained by the teams. This created my interest towards the subject and so much eventually that I wanted to study and research it. Is pulling the goalie-strategy really worth the risk? That´s what I wanted to study and all the things that is involved to it.

The aim of the study is to produce data and data analysis of use of the pulling the goalie strategy in Finnish junior leagues. Selected leagues for the study are Finnish elite junior league of A-& B-juniors (U20 & U18).

This research-oriented study will look use of the strategy from statistical point of view. Effectiveness of the strategy is analyzed by how many goals and/or points it has produced for its users. Effectiveness of the strategy is also measured by analyzing how long it takes to score with goalie pulled compared to how long it takes to score normally.

Views on using this strategy differ from one coach to another. Providing data of the strategy and how effective it has been may bring new ideas or validation for their views on the strategy. This is one statistic that is not widely followed by teams, coaches or leagues, but is arguably very significant when the teams are entering the final minutes of the game.

It has to be emphasized that all the factors what lead on the decision of pulling the goalie can´t be measured via statistical analysis. It´s because of the nature of a sport where the situations change so quickly and the data from all things occurring in hockey game isn´t measured. The decision of pulling the goalie is always on coach´s responsibility. Hockey coaches don´t make their decision based on just data, there´s often "gut feeling" involved

about the current situation in the game (momentum) and that can´t be measured or viewed from the statistics of the game.

1.1 History of Pulling the Goalie Strategy

Pulling the goalie-strategy has been around for relatively long time and Art Ross is credited to be the first coach ever to pull the goalie to use the extra attacker. He was at the time coach and general manager of the Boston Bruins. This unseen manoeuvre happened in a second semi-final game against the Montreal Canadiens on March 26, 1931, Ross pulled Bruins goalie Tiny Thompson for an extra skater Red Beattie in the final minute of play. Boston´s George Owen got a major penalty with 4-minutes left so the Bruins was shorthanded at the moment and played the rest of the game on equal strength 5-on-5. Canadiens still won the game 1–0. (Smith, 2014)
However, official website of the NHL states that Frank Boucher was the first coach to use it with New York Rangers either 1939-40 or 1940-41 season. (NHL, 2018)

1.2 Hockey as a Sport

Ice hockey is a team sport played on ice surface in a rink with six players per side consisting of five skaters and a goaltender. The goaltender attempts to prevent goals which occur when the puck is played (shot) towards the net and the puck completely goes over the goal line (between goals posts and under crossbar).
Typically, skaters are on the ice for intervals of 30-60 seconds, and are continuously replaced due fast-paced style of the game. During a game, penalties occur and these are assessed by the on-ice officials (referees and linesmen). When a penalty occurs, the offending player is sent to the penalty box and his team is forced to play shorthanded the time penalty lasts. This period of time is known as a power-play for the opponent and it provides them man-advantage with a better opportunity to score a goal. If a goal is scored by the opponent during a power-play resulting from a penalty, the offending player is released from the penalty box (major penalties must be served for full length and player is not released even if they opponent scores).

Ice hockey game is 60 minutes long, divided into three periods of 20 minutes. At the end of the 60 minutes, the team which has more goals wins the game. If a game is tied at the end of regulation time, the game is extended for five minutes overtime whereby the first team to score wins the match. If the game remains tied at the end of overtime, there is a shootout where 5 players (number of the shooters may vary, depends on the rules of the league) for each team take a penalty shot. The team with the most shootout goals wins

the game and is awarded two points in the standings. If a team loses in overtime or in a shootout, they are awarded a single point.
(Beaudoin & Swartz, 2014, IIHF Official Rulebook, 2018)

In ice hockey regular season consist normally 50+ games for each team and after the regular season teams with most points will continue to the playoffs. Standings in the regular season defines pairs in the playoffs, highest ranked team will play against lowest ranked every round.
The playoffs are elimination tournament which typically include 3-4 rounds until two teams play against each other in final round. The winner of the final round is the champion.

1.3 Scoring in Ice Hockey

Scoring is the most important thing in hockey. In order to win a game team needs to score, whether is during the regulation, overtime or in shootout. Every goal counts the same on the scoreboard. Goals in ice hockey may also be considered rare events. In a 60-minute hockey game the mean of goals are roughly six. However, in the NHL the scoring rates have been increasing in recent years. It´s said that there are few factors that plays major role on the trend of increasing goal amounts. The enforcement of rules, especially the interference, slashing and hooking rules have created more space and time for the players. More space and time in high scoring areas as well. In the other hand enforcing these creates more and/or more penalties, which means more power play and with that potentially more goals that way also. Power play percentages, in other words efficiency, are typically around 20 percent, which is far better than equal strength scoring efficiency. (Wyshynski, 2017, Thomas 2017)

1.3.1 Scoring Situations

Scoring opportunities in hockey are divided into (10) different types. Kilpivaara (2011) addresses in his work the Finnish Ice Hockey Associations (2008) categorized scoring situations as follows:

- Regular shot, a shot taken by a player skating towards the net, or from a standing still position, when there is no distraction or other variables.
- Shot taken after pass where puck is moving away from the net.
- Shot from lateral movement, a shot taken while moving laterally on the ice with the puck.
- Shot from lateral pass, shot taken after a lateral pass across the ice.
- Deflection, situation where puck changes its trajectory after the initial shot.
- Shot from net drive starting above the goal line, a shot from puck carrier who is driving to the net above the goal line.
- Shot from net drive starting behind the goal line.

- Shot from rebound, a shot taken from the bounce that that comes into play from goalie´s initial save.
- Screen shot, a shot taken while goaltenders clear view to the puck is blocked by a player.
- Breakaway – Shot taken from a clear 1 on 0 situation against the goalie. No other player involved or distracting.

1.3.2 Scoring Areas in Hockey

In hockey the ice is divided, in terms of tactics, in three zones; defensive zone, neutral zone and offensive zone. Almost all the goals are scored from the offensive zone and the other two zones aren´t considered as scoring areas, although is possible to score from those as well. Kontsas & Lehtola (2014) modified from the educational material of the Finnish Ice Hockey Associations (2008) and divided offensive zone into four different scoring sectors as follows in Figure 1:

1. Net front – Scoring chance when the shot is made right in front of the net.
2. Inside the house – Shots coming between the dots and closer than top of the circles (scoring circle).
3. Point – Shots coming between the top of the circles and blue line.
4. Small angles – Shots coming from outside the dots.

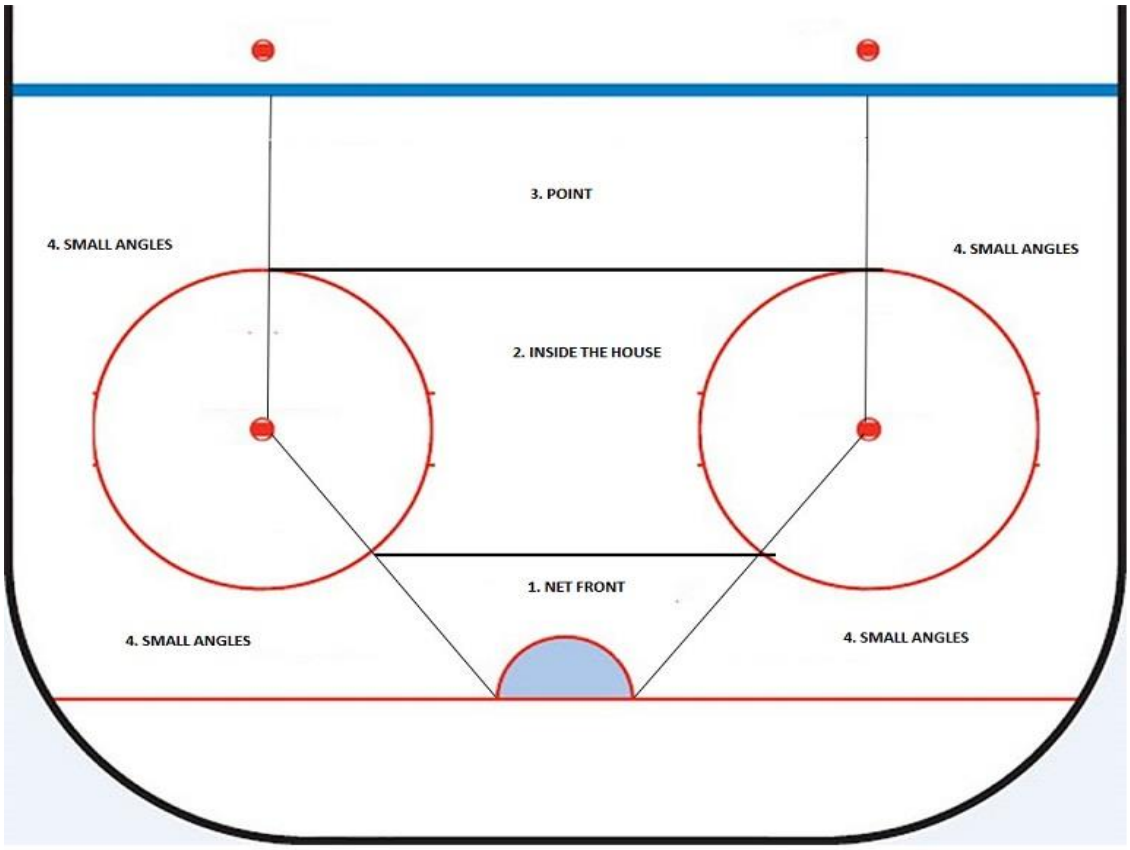

Figure 1. Scoring Areas in Hockey

2 Literature review

In this section we´ll be looking at the previous studies, research and articles written about the strategy of pulling the goalie. The published papers and studies about the subject use different models and data, but all agree that goalies should be pulled earlier than is the usual practice. Some say it should be much earlier. These studies are mainly made from statistical and therefore mathematical point of view. Some of these models consider factors such as which team is better, who has the puck, penalty situation, home or road game, among others. They base the assumption on mainly scoring rates, in other words the probability of a team to score in certain period of time. The main subject of these studies is to determine the optimal time to pull the goalie. The studies also aim to improve the previous formulas with better and/or more data.

2.1 Rules Restricting Goalies Participation in the Game

The official rules define how goalies can participate in the game, other than protecting their net from the pucks coming towards them. The official rules states that goalkeepers are not allowed to participate in play beyond center line (red line), except skate to the bench, during delayed penalty or when coach decides to pull the goalie during the play. If a goalie participates in the play in any manner (intentionally plays the puck or checks an opponent) when he is beyond the center line, a minor penalty shall be imposed upon him. The position of the puck is the determining factor for the application of this rule. (NHL Official Rulebook & IIHF Rulebook, 2018)

2.2 Mathematical Theories Used in the Previous Studies

Viljo & DeJardine (2013) studied how mathematical process, Poisson process, can be used to model scoring a hockey game. The Poisson process is a stochastic counting process that arises naturally in a large variety of daily-life situations. For events to follow a Poisson process they must have three properties; events must be random, rare, and memoryless. Being random means that events occur with no apparent pattern. For hockey this is mostly the case, except when teams pull their goalies. If an event is rare it means that an event could occur many times but only occurs a few times. As a rule an event can be considered rare for the number of trials $n \geq 100$ and the probability of success $p \leq 0.10$. If events are memoryless then the probability of the next event occurring does not depends on previous events. We can see that goals in hockey are indeed rare, memoryless and for the most part they are random, the exception is during the final

minutes of the third period when teams are trailing, normally by one or two goals, they pull the goalie for an extra attacker in the attempt to score late goals to send the game to overtime. In the 2011-2012 NHL-season there were 238 empty net goals scored. It is a reasonable assumption that all the empty net goals were scored during the final minutes of the third period since it is extremely rare for a team to pull the goalie at any other time in the game. In the author discusses this phenomena in more detail and calls it the “end game effect”. In the 2011-2012 NHL-season there were a total of 6545 goals scored, 6426 in regulation and 119 in overtime. Breaking down goals scored by period we see that number of goals scored in the second and third periods are nearly identical (2nd 2254, 3rd 2248), while there were 1924 goals scored in the first period. There are many factors that can lead to teams scoring less in the first period, but for the most part we can see that goals evenly distributed throughout the game.

2.3 Studies and Articles about the Subject

One of the areas where hockey analytics can really change attitudes about is the strategy of pulling the goaltender, a team’s do-or-die type of play at trying to equalize in the last moments of the game by changing their goalie for an extra skater.
Figuring out the best time to pull the goaltender is little more than understanding probability. At different intervals of the game, there is a percentage chance that the trailing team will tie the game before one of two other outcomes occurs: the clock hits zero, or the leading team scores an empty-net goal. If a team can identify the optimal point when they should vacate the net and change their goalie for the extra attacker, they´ll get the best possible chance of taking a game to overtime. There haven´t been significant movement on this area of coaching. Certain teams seem to be more aggressive, but there are many instances where coaches have submarined their team’s chances at tying the game merely because of risk aversion. (Yost, 2016)

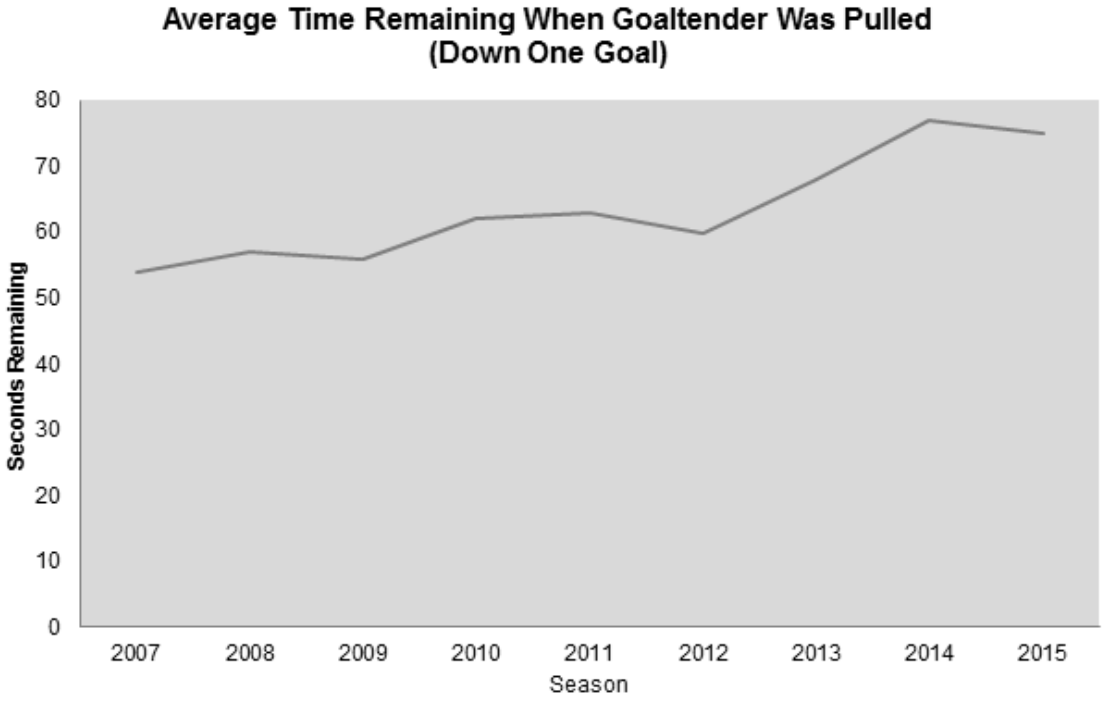

Figure 2 Average Time Remaining When Goaltender Was Pulled (Down One Goal) (Yost, 2016)

In the NHL, coaches have become more aggressive at pulling their goalies, but the change of culture on this area has been pretty slow. On average, most coaches are pulling their goalie trailing with one goal with approximately 75 seconds remaining in the game. That's more than 20 seconds earlier, a 28% increase in a little under a decade. Thinking if this is early enough, probability or chance can be calculated, assuming the one who is making the call knows the following:

- goal-scoring talents of teams involved in games
- the ratio of empty-net goals to equalizing goals (assuming that the ratio is around 75:25)
- the actual time a goalie was pulled from any game in which the team was down one goal.

With that information above, games can be simulated to determine the exact second interval where the trailing team (based on team´s talent vs their opposition's talent) has the best probability of tying the game before the time runs out. (Yost, 2016)

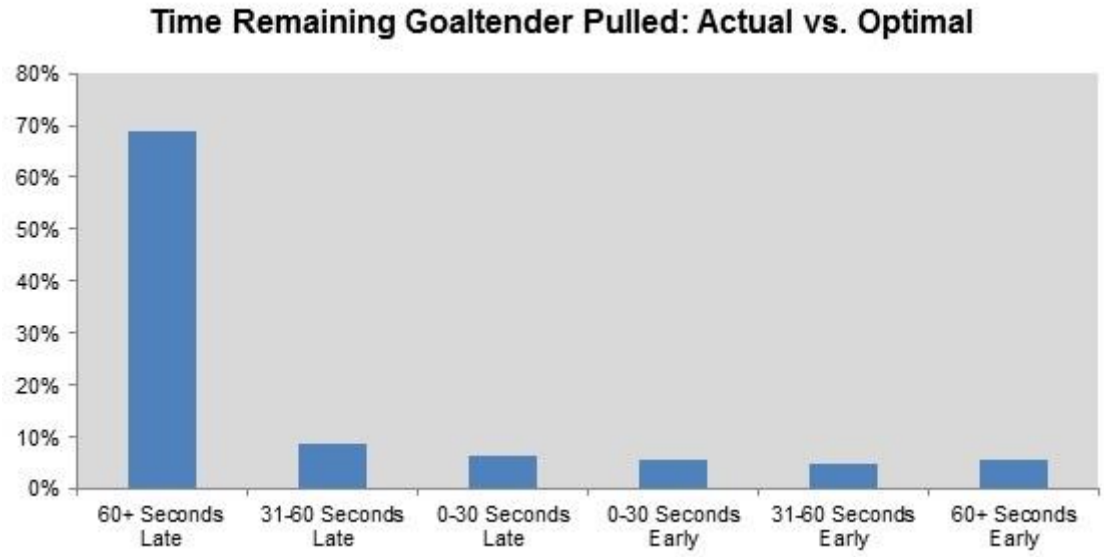

Figure 3 Time Remaining Goaltender Pulled: Actual vs. Optimal (Yost, 2016)

Yost (2016) states that based on their analysis (data of NHL season 2015-16) for the goal-scoring probabilities teams aren't just a bit late in their unwillingness to pull the goaltender, they are painfully off the mark. As Figure 2 shows actual average time of goaltenders leaving the net is about 1:15 remaining and Figure 3 indicates that most of the time goalies are pulled over 60-seconds late when compared to the optimal time.

The first paper of pulling the goaltender was written by Donald G. Morrison (1976). His analysis compared only the options *never pull the goalie* and *pull the goalie immediately,* which was an error later corrected by the study of Morrison and Wheat (1986) with relevant added option *pull the goalie later*. These studies investigated the optimal time for pulling the goalie when teams are of equal strength. Their paper introduced that teams have a general scoring rate of L goals per minute. When a team pulls its goaltender, its scoring rate increases to 2.67L goals per minute, and the opponent's scoring rate increases to 7.83L goals per minute when facing the open net. Optimal time to pull the goalie with one goal deficit is 2:00 to 2:30 left in the game.
The study uses NHL´s data of season 1978-1979 on average goals scored per minute, number of empty net goals and number of minutes played without the goalie. This assumption they introduced is referred to as the proportional assumption.

Morrison said (2015) on an interview about his research that if you pull the goalie with two and a half minutes to go, you have a 19 to 20 percent chance of tying the game and if a coach waits until the minute mark, the chances drop to 17 percent.

Erkut (1987) generalizes the method to the situation where different teams have different scoring rates. However, Erkut's assumption implies that scoring rates with the goalie pulled are directly proportional to the even-strength scoring rate. Based on their study the optimal time to pull the goalie is approximately from 1:30 to 3:00 left in the game, depending how strong or weak the opponent is.

Nydick and Weiss (1989) argue that the proportional assumption for estimating the scoring rates in situations where a team pulls its goalie may not be adequate. Therefore, they suggest the use of situational rates which are constant across teams. Their work shows that results can be very different depending on the estimation method chosen. (Proportional assumption vs. fixed rate assumptions). Nydick & Weiss doesn´t define optimal time to pull the goalie, but they conclude that goalie should be pulled latest at 1:31 left in the game.

Washburn (1991) proposes a dynamic programming approach for determining the optimal time to pull the goalie. Washburn mentions that previous studies concerns the probability that the team currently trailing scores before the opponent scores, and also before time expires in the game. He points out that scoring first (when playing without the goalie) neither necessary nor sufficient for the win. A team trailing by a goal might tie the game but give up another goal before regulation ends. Although the odds for this to happen are

pretty slim, especially when goalie is pulled late in the game. Based on Washburn´s study the optimal time to pull the goalie is from 1:42 to 4:00 minutes depending on the teams scoring rate and whether it is a playoff game or regular season game.

Zaman (2001) considers the problem from a Markov chain point of view. Zaman defines seven possible states for the Markov chain: Goal A, Shot A, Zone B, Neutral, Zone A, Shot B, Goal B. Zaman suggests pulling the goalie when trailing by one goal with five to eight minutes left. This suggestion is much earlier than the traditional approach when to pull the goalie. Zaman also notes that the location of the puck (defensive zone, neutral zone or attacking zone) should be key factor to the coach´s decision when to pull the goalie, what is consistent with the traditional approach. Based on Zaman´s study the optimal time to pull the goalie is 8:07 with the puck in the offensive zone and 5:09 in the defensive zone.

Pulling the goalie increases the team's goal-scoring rate, which increases the probability that the team will tie the game. The opponent's goal scoring rate is likely to increase even more, which increases the probability that the team loses by more than one goal, but in terms of points in the standings, a loss is worth zero points, regardless of how many goals separate the teams. (Although goal differential could matter at the end of the season, as it is used as a tiebreaker in determining which teams enter the playoffs.) Therefore, when the probability of a win is close to zero, a strategy that increases the probability of a tie and thus entering overtime is worthwhile, even if the strategy also increases the probability of losing by a larger margin. (Ingolfsson, 2010)

Beaudoin & Swartz (2014) approach to the subject incorporates penalties in the simulation. They also consider the effect of the home-ice advantage, and the impact of overtime and shootouts, reflecting the current state of affairs in the NHL. Previous papers are based upon general scoring rates, whose estimation combines all possible situations. Beaudoin & Swartz simulated games keeping the situations distinct and developed a Bayesian approach based on Markov chain methods to obtain the scoring rates. In addition, they modified scoring rates according to whether a team is average, above average or below average. Instead of trying to decide what the optimal time for pulling the goalie is they rather address the question teams' face – should they pull the goalie now under the given situation? Therefore their study is about investigating effect of pulling the goalie under situations of interest. They use all the game situations for the simulation (6-on-5, 5-on-5, 5-on-4, etc.), excluding the case when both of the teams play without goalies. They had following findings:

- Teams scored a goal every 8.5 minutes when playing 6-on-5 and when playing 5-on-5 scored a goal every 27.4 minutes
- When playing 6-on-4 teams scored a goal every 5.5 minutes and allow empty net goal every 4.8 minutes, so teams are almost as likely to score a goal as allow one
- Playing without goalie seems to induce more penalties called on the team which is trying to defend its lead.

Andrew C. Thomas (2017) found out in his study that goaltender was pulled in 64% of games played. In 34% of those games a goal was scored with one net empty, and of those goals 30% were scored by the team that pulled their goaltender. However, the data did not specify whether the goalie was pulled because the team was trailing and must catch up, or because the goalie was pulled due to an impending penalty against the opposing team - a circumstance in which the opponent cannot score, since if they gain possession of the puck, or are scored upon, play is immediately stopped by the referee. So in this case, Thomas restricted instances of when the goalie is pulled to be only those in the last two-and-a-half minutes of the game, in which the likelihood that a switch is due to a trailing score is much higher than if a penalty call is pending. Instances of the goalie being pulled are included as the censoring of the next goal that would be scored under regular game circumstances, and represent the shift in the system to empty-net status. If a tying goal or a goal by the leading team is scored, the goalie is replaced and play continues as before.

Ingolfsson (2010) states that the models and the analysis estimates differ, but all of these papers reach the same conclusion: it is optimal to pull the goalie with more than one minute remaining (the estimates of in these papers range from 1.3 to 4 minutes). If the teams scoring rates or teams talents have been estimated and taken into consideration, the strong teams (with high scoring expectation) should pull their goalie sooner than weak teams do, and teams playing against a strong opponent (with high scoring expectation) should pull their goalie later than should teams playing a weak opponent.

The most recent study made by Asness & Brown (2018) build a model that uses five inputs: the probability of scoring goals with a goalie in place, with the goalie pulled for an extra attacker, with a goalie in place but the other team has pulled their goalie for an extra attacker, the goal differential, and the time remaining in the game. Their paper has fewer game-level parameters and game situation parameters than some of the other models. Their paper is not done for precise calculation of real situations in individual games, but for assessing long-term average decision-making.

The team that pulls its goalie nearly quadruples the probability of its opponent scoring, while not even doubling its own chance to score. Asness & Brown notes that the expected value of goals is not the appropriate criterion. What matters is expected number of standings points. A team down a goal with short time remaining gains a lot by scoring, and loses little if the other team scores as losing by two goals is no worse than losing by one. They use following values for calculation:

- Loss is worth zero standing points
- Win is worth two points
- Tie at the end of regulation 1.5 points (only the 1.5 is an assumption, the others are simply known).

They come to conclusion that the maximum advantage from optimal pulling comes at 4:20 and is just over 0.08 points (note, the time of maximum advantage over never pulling is not the optimal time to pull, which actually comes even earlier).

2.4 Why Pull the Goalie?

> "So it lights people up and it makes the game exciting and I think the most important thing about it is, you're showing your team that you're never giving up. Because we pull our goalie sometimes with our team down two goals with two minutes to go. That's what you're trying to make your team understand - that you never give up on them. When you don't pull your goalie, you're giving up on your team - and that's not the way it's supposed to be. So there's a strong message for your team when you pull your goalie; and when you score, it's a bonus." King (2010 in Duhatschek, E. 2018)

Every coach and player wants to win every game, that´s obvious. Seasons are long and every point counts and it could be just couple of points, win or even goal difference at the end of the regular season that makes the difference what separates the teams making it to the playoffs or securing their spot on the league for the next season. Money is also huge factor (especially in the professional leagues) when making it to the playoffs brings money to the team affecting the team´s future as well. Vice versa if the team relegates, it normally means that is harder to get i.e. sponsorships or keep their best players in the team for the next season. Using improved strategies, i.e. pulling the goalie can provide vital extra points or even wins, which can eventually lead to loads of additional money for the team.

When to pull the goalie is still a difficult decision for coaches. All the pressure coming from the media and fans, and they are typically questioned on results even if strategies are sensible and reasoned. Coaches have acted on this sense conservatively for decades, so they would probably need support of General Managers in order to implement provocative strategies. (Beaudoin & Swartz 2014)

When thinking about pulling the goalie, it almost always comes to the end of the game. (Naturally game should be close to even think about pulling the goalie.) Pulling the goaltender is always a risky proposition. But so too is losing a game by one goal. This is understandably a delicate balancing act for coaches to maneuver through, but the math on pulling goaltenders is pretty clear, and far more substantiated than the gut feelings that have driven historical decisions. (Yost, 2016)

Pulling your goalie to the bench for the extra attacker gives your team an extra chance to score a goal when it´s needed the most. (Beaudoin & Swartz, 2014)

There are two reasons to pull a goalie. The first is when there´s a delayed penalty, giving your team an extra attacker until the other team touches the puck to stop to the play. The second is when a team is trailing late in the game and the goaltender heads to the bench for a sixth skater. This usually happens with a less than two minutes remaining in game.

There´s a lot of things that goes through the coach´s head when clock is winding down towards the end. That´s pretty often when the most intense coaching in hockey comes into play. When they will pull the goalie, do they get a faceoff from offensive zone or neutral zone. Or will there be a stoppage at all before the game ends. Probably every coach wants an offensive zone faceoff when they are trailing (goal is naturally the most desirable option), so they have chance to take timeout and with that “extra” 30 seconds to go through their plan for the upcoming 6 on 5 (if there is no penalties that affect) play and the faceoff. Coach draw the plan on the board and players try to execute the plan.

> One of the keys is when you pull the goalie. There's something magic about that one-minute mark, but to me, the most important thing is, if you get a faceoff in the offensive zone with a minute and a half left, that's not a bad time to do it right then because you've got the faceoff you want; you're in the offensive zone, where you want to be; and then you can organize. You can call a timeout. Sometimes, you don't get that. Sometimes, you're hoping for a stoppage in play and don't get one. Then you've got to get it done on the fly; that's when it's more difficult. Then you tell the guys, get it to the net and see what happens. Keep it simple. King (2010 in Duhatschek, E. 2018)

Pulling a goalie-strategy is not a decision that players make on the ice. Goalies do not come to the bench by their own decision. It´s always coach´s decision. This strategy reflects how bold is the coach´s view on the game and how he/she sees the team´s ability to score on this do or die type of situation. The coach still needs to have realistic view on his/her team´s talent/strengths and the current state of the teams playing. Are they in control or is the “momentum” of the game their side.

There are, or at lease has been, coaches who don´t believe in pulling the goalie strategy. The most famous example must be from the Lake Placid Olympics in 1980, Soviet Union´s head coach Viktor Tihonov didn´t pull their goalie when they were playing against USA, even though they were trailing at the end of game and finally lost. It just something that he didn´t believe in. However, it should be considered that the Soviet´s didn´t lose, (or were even trailing in) many games through their ice hockey history. (Beaudoin & Swartz, 2014)

Even though the points, wins and goals are crucial to any team, (and pretty often the games are decided within two goal difference) the teams seldom practice the 6 on 5 situations. They train a lot of power play and shorthanded situations, but with or against extra attacker, not so much. Whether they should? Probably yes.
Playing with 6 on 5 (or preparing the team and players for it) in the game is the situation that needs sometimes most coaching during the game. If the teams would practice playing with an extra attacker more, then the coaching in the game situations would be easier.

For example in basketball in similar situations the play is almost always to get the ball to their best player and with the set play to get a shot in the air before the buzzer. In ice hockey that would be hypothetically best option too, to get a one timer set up for the best goal scorer, but it´s more realistic to expect just to get any shot towards the net and get the puck through the traffic, or a deflection or a rebound and get the goal from the middle of the chaos.

3 Research Methods

This thesis was designed as a quantitative study to help find how effective the pulling the goalie strategy is using my own data-collection. In addition, we´ll study how early the goalies are pulled and how that correlates with the traditional or conservative way of pulling the goalie.

The analysis was completed using website www.tilastopalvelu.fi/ih for the statistics of Finnish Ice Hockey Association database of Finnish elite junior leagues of the season 2017-2018. I chose to study regular season games from the Finnish A-junior SM-League (U20) and Finnish B-junior SM-League (U18).
In the A-juniors, the first part of season started in September and ended in December (2017). There was 19 teams participating in the first part, including Austrian team Red Bull Salzburg, which participated in only 12 games during the season. All the other teams played 35 games. The second part of the season was from January to March (2018). The best 10 teams from the first part continued to the “actual” SM-League. Teams played 18 games in the second part.

B-juniors had a similar structure in the league as A-juniors. First part of the season started in September and ended in December (2017). There was 17 teams participating in the first part, including Red Bull Salzburg, who only played 6 games in the league. Other teams played 31 games. The second part of the season started in January and ended in March (2018). The best 10 teams from first part continued playing in the “actual” SM-League and the teams played 18 games each. The rest of the teams from first part played the second part of the season in the “lower” SM-League. The “lower” SM-Leagues (A- & B-juniors) wasn´t part of the data analysis.
Red Bull Salzburg didn´t take part in any of the leagues for the second part of season. Both of the SM-Leagues (A- & B-juniors) had similar structure, season being divided in two halves in which only the best teams continued playing in the “actual” SM-League for the second part of the season. The structure of the leagues made possible to compare the results and the data within the league from the same season.

All the game statistics were looked through and all the essential data was picked for the analysis. For the analysis the following factors were selected:

- time when goalies were pulled
- time when goalie was put back to the net
- average time of goalie been pulled (with goal difference at the moment)
- scored goals during the time goalies were pulled (both ends)
- total goals of the season
- average time it took to score a goal (full strength)
- average time it took to score a goal (with goalie pulled)
- total points of the season
- extra points gained by pulling the goalie-strategy

3.1 Selected Variables for the Statistical Analysis

This analysis includes all the games played in the regular season from selected leagues. Following variables were selected for analysis:

1. Time when the goalie was pulled (how early in the game)
2. How long it takes to score a goal (with goalie vs. without goalie)
3. How many goals (both ends) scored during the time a goalie was pulled
4. “Extra” points gained by the teams by using the strategy (including overtime and shootout)

The selected variables 2 and 3 are highly related to each other, in terms of reliability of the study and one can´t really be addressed without the other taken into consideration. As mentioned previously, even if the team´s which is playing without the goalie probability to score increases, so does (and many times more) the opponent´s.

3.2 Validity & Reliability

Reliability of the study refers to the extent to which the data collecting techniques or analysis procedures have produced consistent findings. Reliability means consistency or the degree to which a research instrument measures a given variable consistently every time it is used under the same condition with the same subjects. It is important to note that reliability applies to data not to measurement instruments. From different perspectives or

approaches, researchers can evaluate the extent to which their instruments provide reliable data. (Yilmaz, 2013)

Validity refers to the accuracy of research data. A researcher's data can be said to be valid if the results of the study measurement process are accurate. Meaning that a measurement instrument is valid to the degree that it measures what it is supposed to measure. External validity reflects the degree to which one can generalize research results or the effects of the treatment beyond the present conditions of testing; that is, other settings, programs, persons, places, times, cases or approaches. The treatment or the program should reflect the construct on which they are based. (Yilmaz, 2013)

4 Results

4.1 Results from the A-junior SM-League, Season 2017-2018

Finnish A-junior SM-League (1st part) included 19 teams and all the teams played 35 games each, except one team, which played 12 games. In the 2nd part included 10 teams and 18 games played by each.

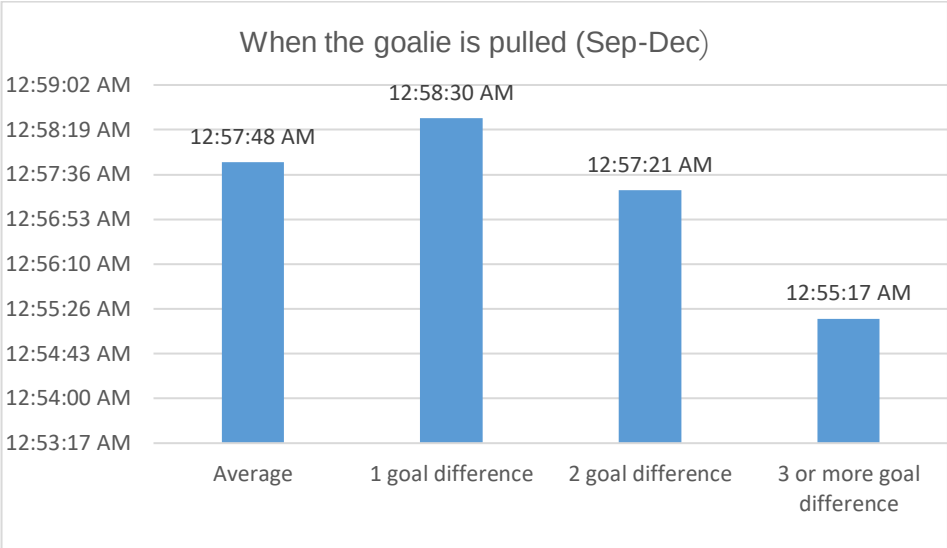

Figure 4 Average time when the goalie is pulled (September-December)

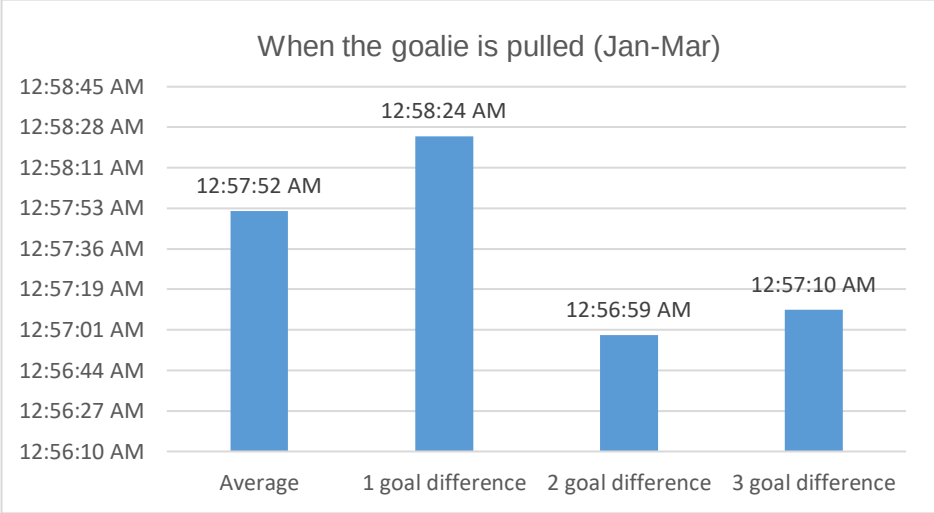

Figure 5 Average time when the goalie is pulled (January-March)

Figures 4 & 5 shows the average times when the goalie is pulled related to the goal difference at the moment. The figures only include the first-time goalie has been pulled in the game.
On the “average”-column it shows that the goalies been pulled relatively early with 0:02:12 and 0:02:08 left in the game. There is no big differences on the times when goalies are pulled except with the “3 or more”-columns, where the difference is almost two minutes. Notable is how with two goal difference goalies were pulled when close to three minutes (0:57:21 & 0:56:59) were left in the game.

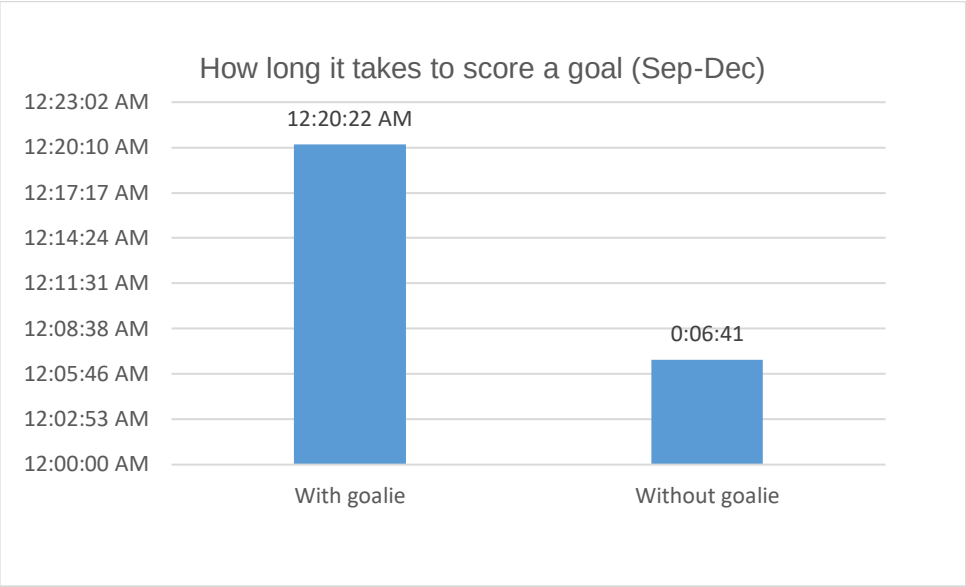

Figure 6 How long it takes to score a goal (September-December)

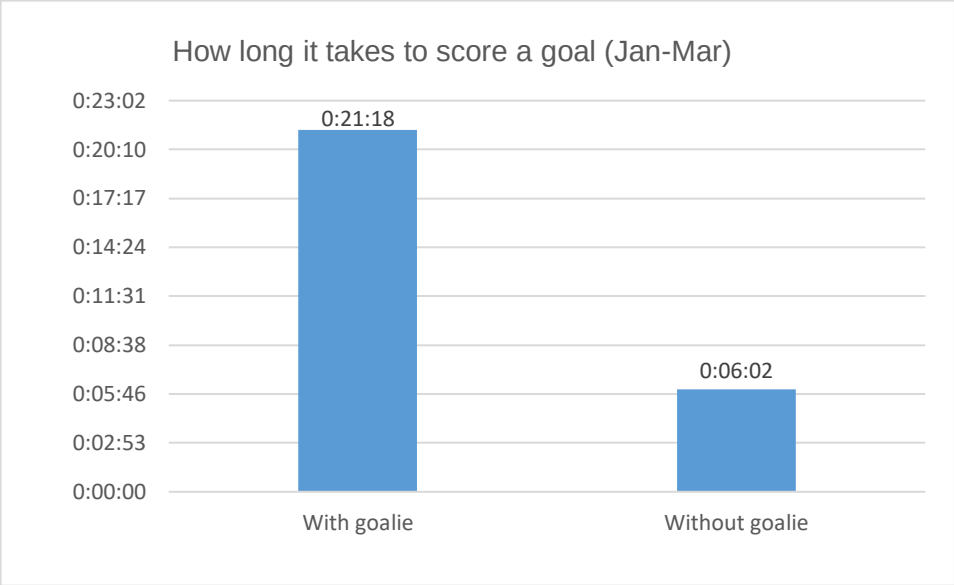

Figure 7 How long it takes to score a goal (January-March)

Figures 6 & 7 show that it took 0:20:22 & 0:21:18 to score a goal with goalie and 0:06:41 & 0:06:02 without goalie. It took 3 times less to score a goal without the goalie.
On Figure 7 notable is how it only took 0:06:02 to score a goal when playing without a goalie, which is 39 seconds less than in the first part of the season. Scoring with the goalie in the net took 56 seconds longer than the first part.

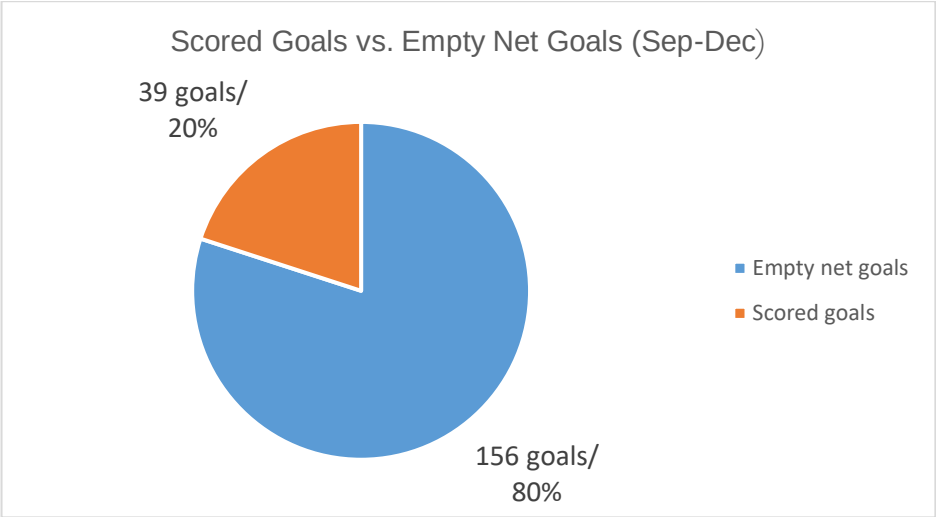

Figure 8 Scored goals and empty net goals (when one net is empty)

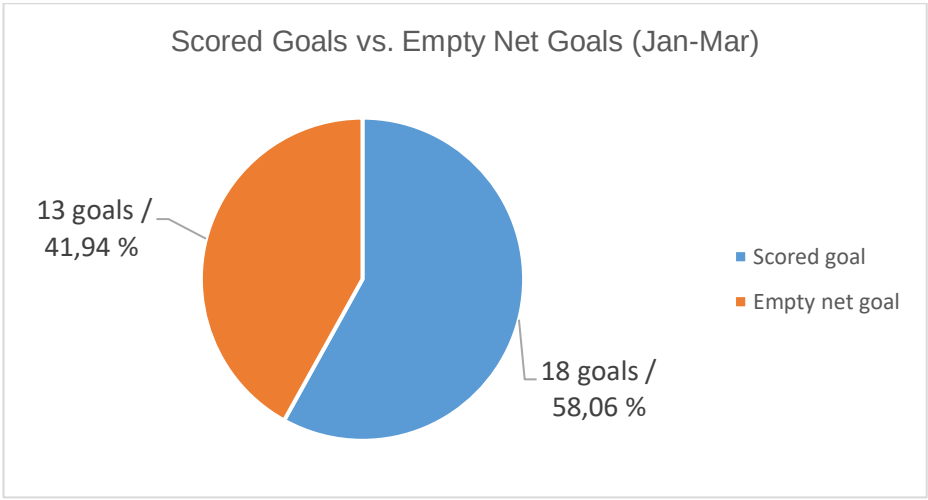

Figure 9 Scored goals and empty net goals (when one net is empty)

The previous studies say that it´s been typically 75:25 percentage ratio to score an empty net goal versus the team to score which is playing without a goalie. Figure 8 of the first part of season shows similar efficiency with 80:20 percentage ratio. Notable is how Figure 9 shows quite significant change on scoring efficiency on second part of the season with 41,94% success rate, which is a very high success rate with goalie pulled.

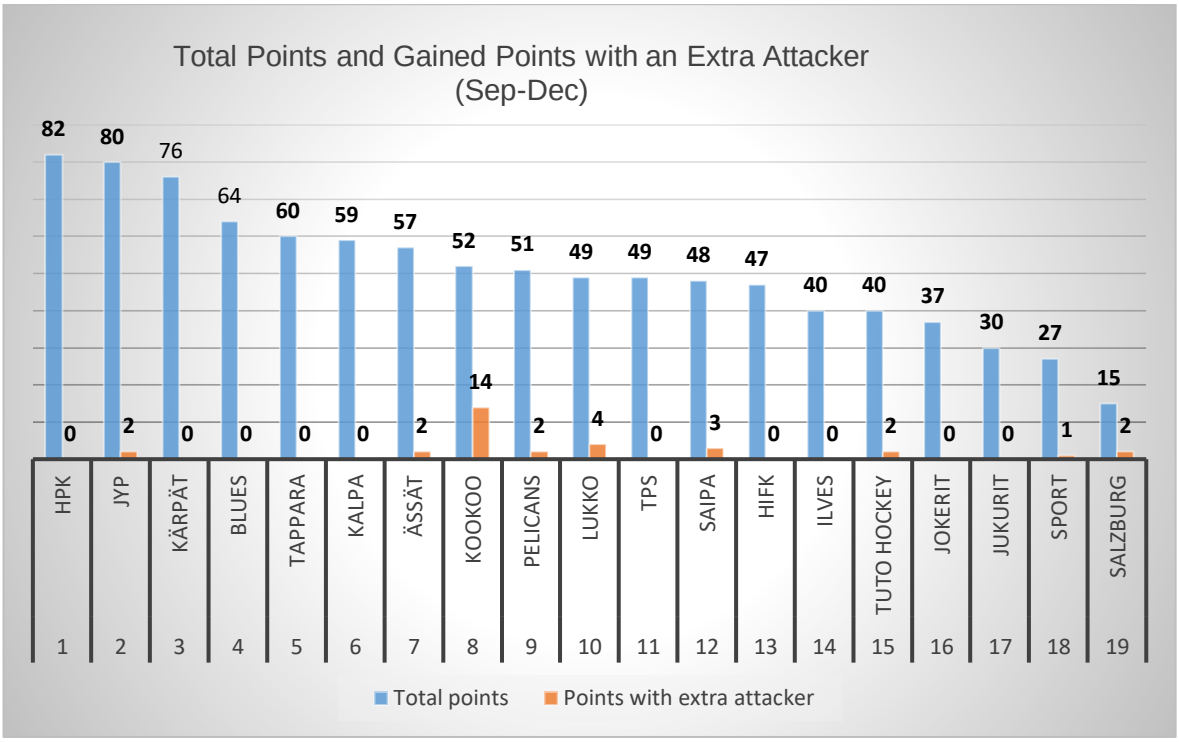

Figure 10 Total Points and Gained Points with an Extra Attacker

The Figure 10 shows how many points teams have gained at the first part of the season (September-December) and how many “extra” points they gained by pulling the goalie. Notable the high amount of points (14) KooKoo have gained and how Lukko and TPS have gained enough points to be in the top 10 in the standings. Notable is also the high amount of points in total gained by using the pulling the goalie strategy (32pts), which means that lot of the goals were goals tying the games.
The best 10 teams continued to the upper league for the second part of the season when the bottom 8 continued to the lower league (Salzburg didn´t take part on the second part of the season).

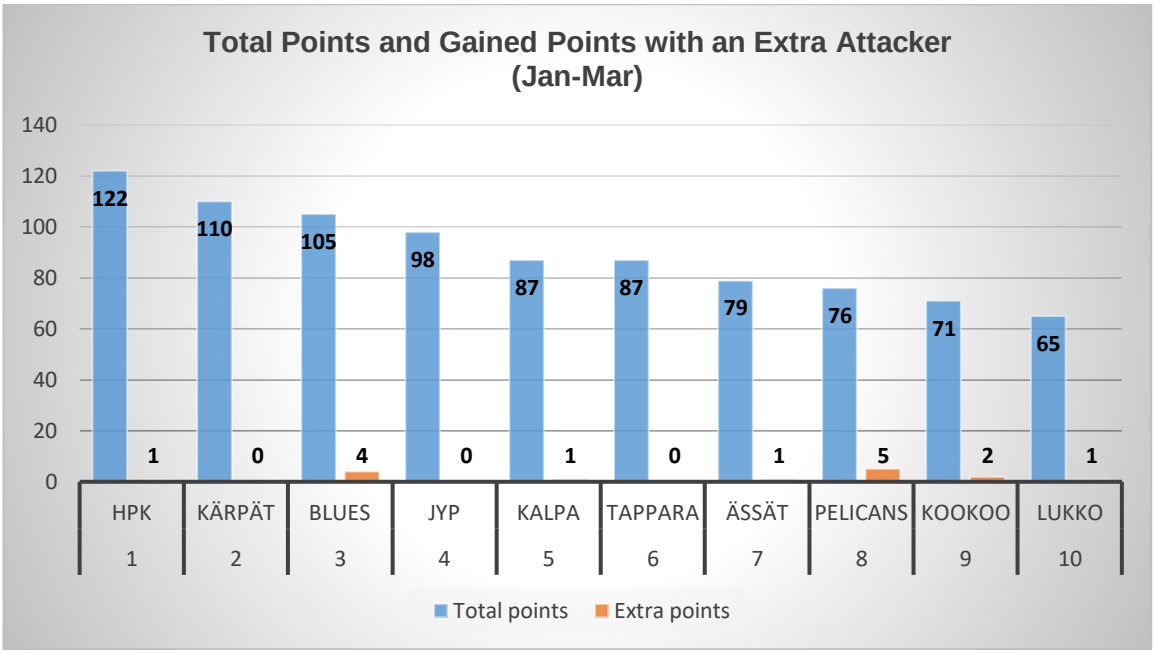

Figure 11 Total Points and Gained Points with an Extra Attacker

Figure 11 shows the total points and the extra points after the regular season. The whole regular season points are summed together (the first and second parts of the season), but the extra points columns show the gained extra points only from the second part of the season. The Figure 11 shows that the extra points did not make significant impact on the standings. If we look how in previous Figures 7 & 9 showed major improvement on the efficiency, it´s notable that it doesn´t correlate with actual points as much you could expect. So it´s reasonable to presume that scoring without goalie happened then more with bigger goal difference in the games.
From the 10 teams, 9 continue to the playoffs. First 4 have the home ice advantage for the playoffs. Teams standing at the places 6 to 9 proceed to the “wild card”-round with the best team of “lower” SM-League.

4.2 Results from the B-junior SM-League, Season 2017-2018

Like previously explained the Finnish B-junior SM-League (1st part) included 17 teams and all the teams played 31 games each, except one team, which played 6 games. The 2nd part included 10 teams and 18 games was played by each team.

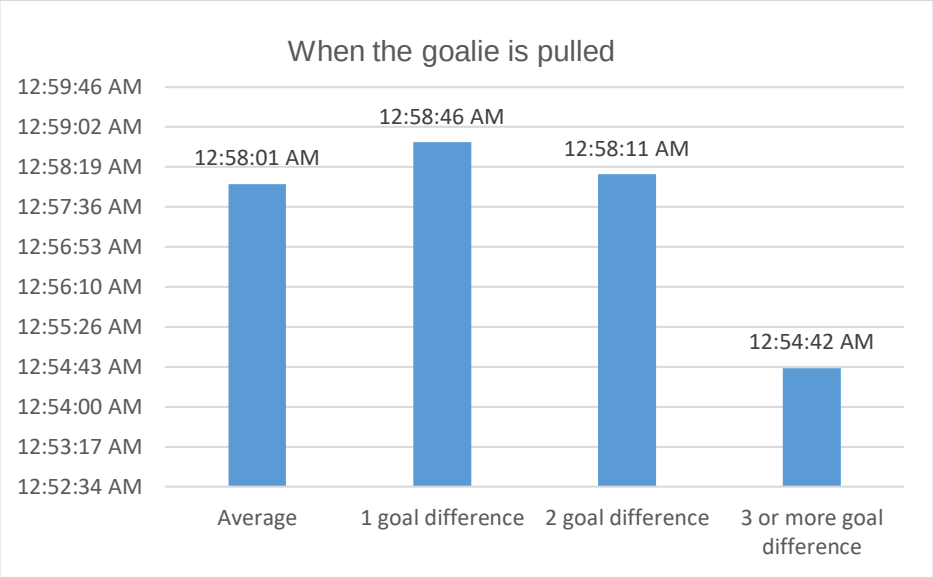

Figure 12 When the Goalie Is Pulled (Sep-Dec)

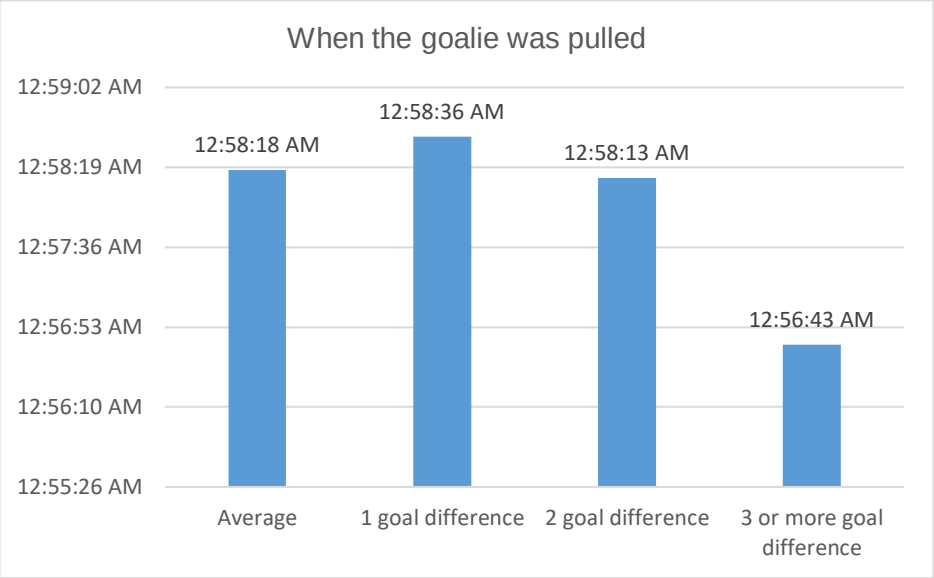

Figure 13 When the Goalie Is Pulled (Jan-Mar)

Figures 12 & 13 shows that in B-juniors the trend of pulling the goalie is quite “traditional” on both 1 goal difference-columns with 74 seconds left on average on Figure 12 and 84 seconds left on the Figure 13. The results are very similar with the “2 goal difference”-column on both parts of the season and the results shows that with 2 goal difference the mentality is even more conservative. Only column that shows more aggressive use of the strategy is the column “3 or more goal difference”.
Figures shows in general that there´s not big differences in results between first and second part of the season.

Figure 14 How Long It Takes To Score a Goal (Sep-Dec)

Figure 15 How Long It Takes To Score a Goal (Jan-Mar)

From the Figures 14 & 15 we can see that B-junior SM-League is relatively high-scoring league when to score a goal took only 18:39 (Figure 14) and 19:20 (Figure 15). On the Figure 15 the scoring without goalie took 1:43 longer than Figure 14.

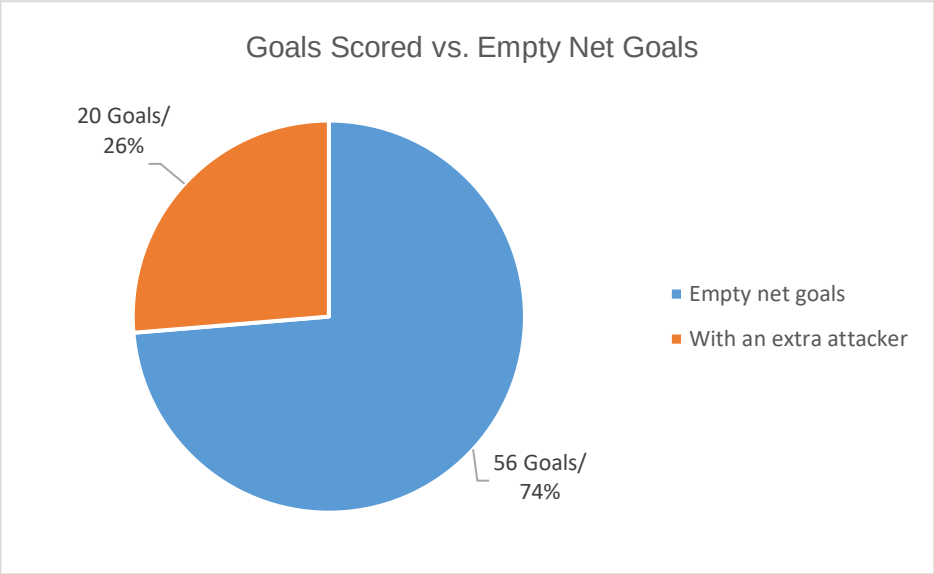

Figure 16 Goals Scored vs. Empty Net Goals (Sep-Dec)

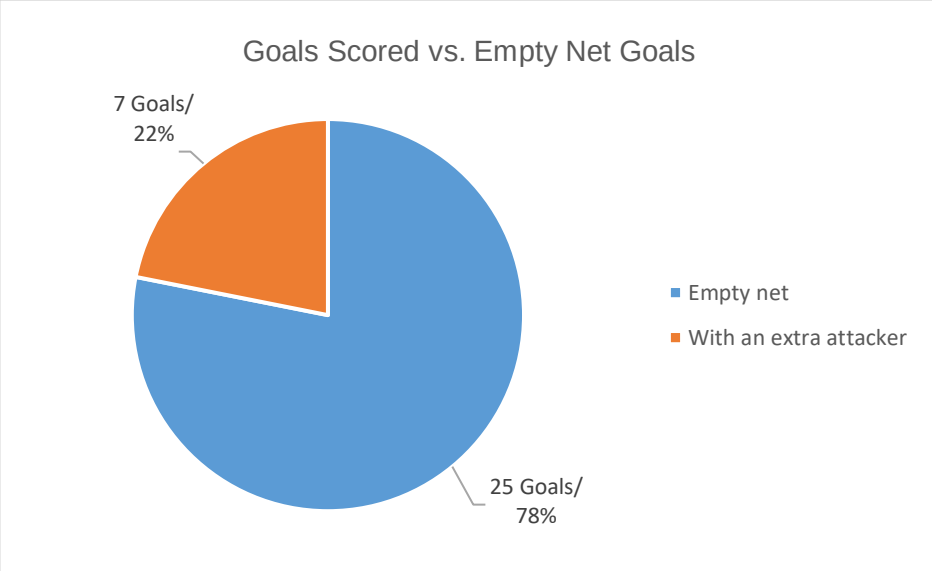

Figure 17 Goals Scored vs. Empty Net Goals (Jan-Mar)

Figures shows that the results are close what previous studies shows with 75:25 percentage ratio on scored goals when one is playing without goalie with Figure 16 74:26 and Figure 17 78:22 percentage ratios.

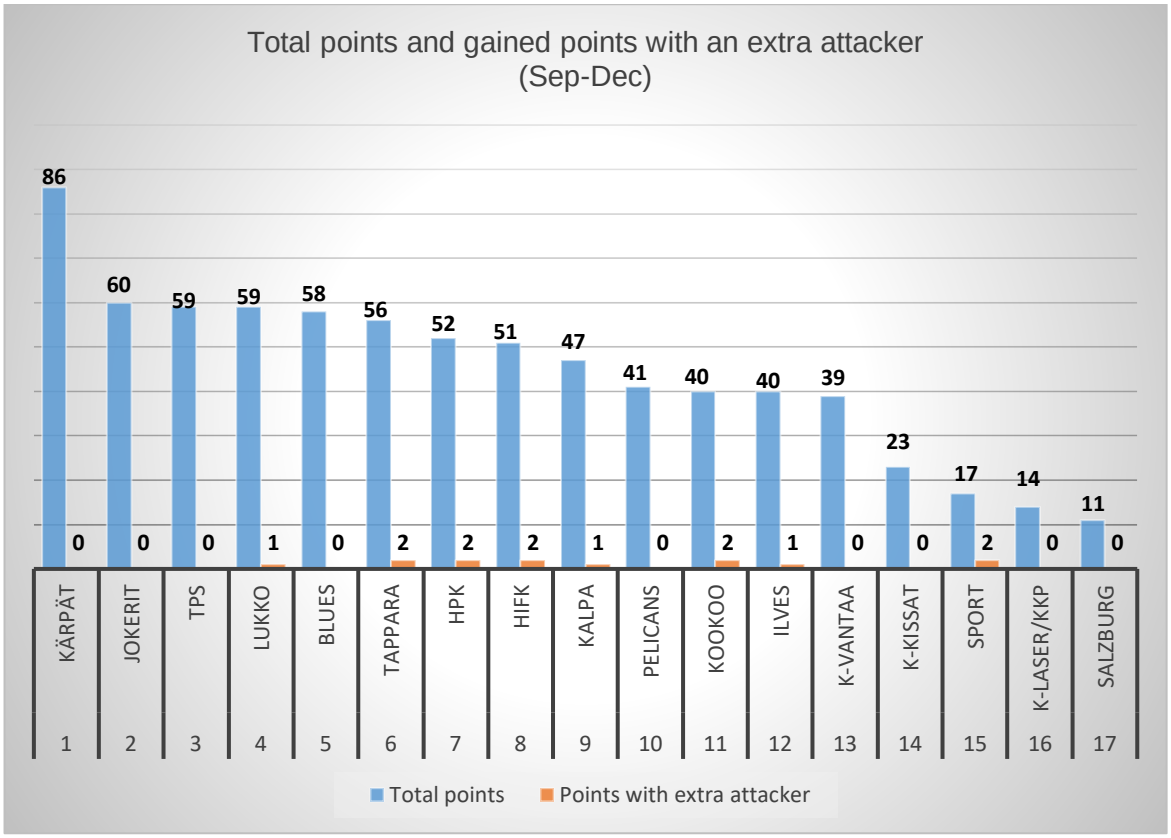

Figure 18 Total Points and Gained Points with an Extra Attacker

The Figure 18 shows how many points teams have gained at the first part of the season and how many “extra” points they gained by pulling the goalie. There is no significant amount of extra points for teams gained by the pulling the goalie strategy. Neither in total of extra points nor for individual teams. Notable is that there are quite big differences in points, especially for bottom 4 teams versus others. Notable also is how dominant Kärpät is in points (86pts) compared to others.

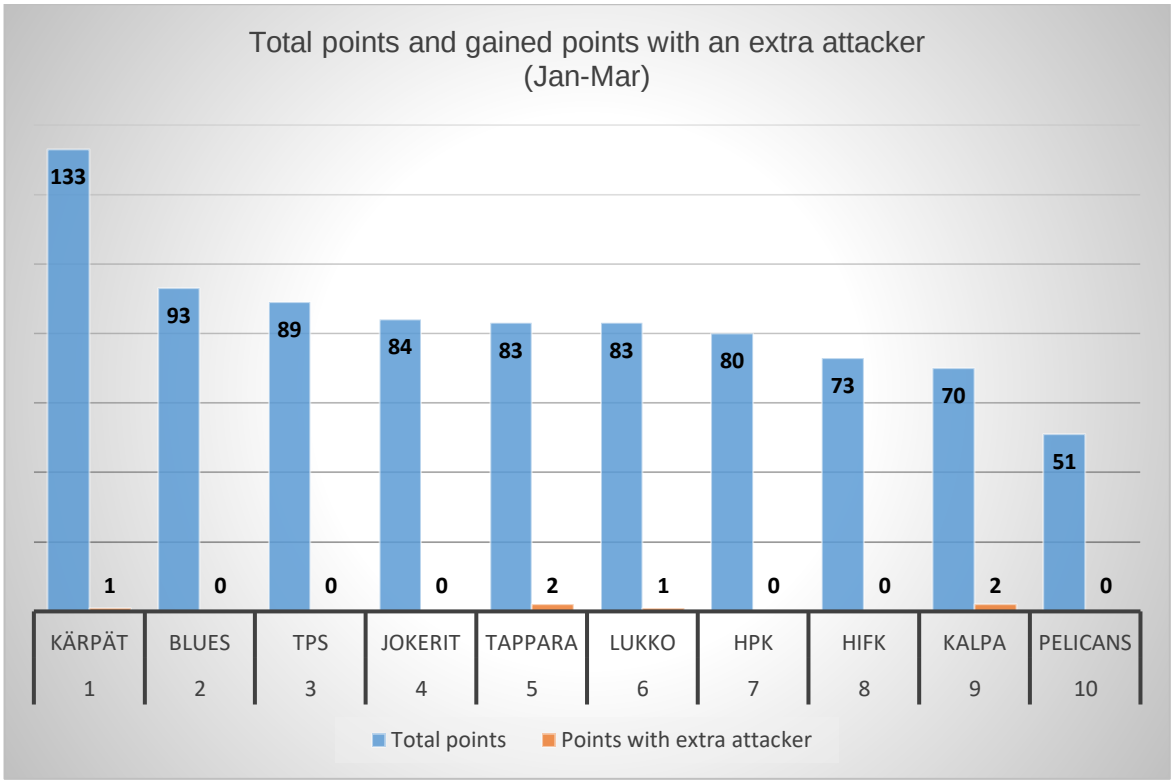

Figure 19 Total Points and Gained Points with an Extra Attacker

Figure 19 shows the total points and the extra points after the regular season. The whole regular season points are summed together (the first and second parts of the season), but the extra points columns show the gained extra points only from the second part of the season.
The Figure 19 follows the same trend as first part of the B-junior SM-League with only few points gained by the strategy. In terms of points the league is rather close, except first and last place on their relation to other teams. Tappara is on the 5th place thanks to two gained extra points.

5 Discussion

Looking at the results and comparing them to the conservative way about pulling the goalie, (pulling the goalie with one minute left when trailing by one and pulling the goalie with two minutes left when trailing by two) we can see that the goalies are pulled earlier in the leagues under study. Results show that on average the goalies are pulled close to 58-minute mark on the play clock, which relatively early, when considering the traditional way to use the strategy. This is still not as early as the previous studies represented suggest. Future seasons will show where the trend is going, but we can predict that we´ll see more bold use of the strategy.

If we compare the A- and B-junior leagues, there are lots of similarities in results, especially in the first parts of the seasons. In percentage ratios when one´s goalie pulled. Those results follow the “typical” 75:25 ratio. Surprising was the second part of the A-junior season (Figure 9) with the 41.94% of the goals scored by the team with goalie pulled.

When thinking about the effectiveness of the strategy, the most relevant and the most important information is how many points have been gained by using pulling the goalie strategy. In the results, extra points were calculated for the teams if they have gained points by equalizing the game using the strategy.
If the game went to overtime or the shootout and the equalized team won, they got two points and if they lost on the overtime or the shootout, the got one point. There was actually one time when team (KooKoo, A-juniors) won the game in regulation after they had equalized with goalie pulled. Then they were rewarded with 3 points. Please note, that this is extremely rare case in hockey.

There´s relatively low amount of gained extra points in B-juniors compared to the A-juniors when the other results don´t indicate that the differences in points should be so big. One explaining factor could be that the goals scored with goalie pulled were done when the margin was more than one goal and so it doesn´t show on the gained points, if the teams weren´t able to equalize.

KooKoo, team in the A-junior league is the stunning example to show with total of 16 extra points of the regular season with thanks to successful use of the strategy. Although the second part of the season wasn´t nearly as great as first part, in light of these extra points, we can still say that KooKoo was placed in the “upper” league in thanks to the successful use of the pulling the goalie strategy.

In all the other leagues under the study there wasn´t one that stood out as KooKoo, when looking into points gained by the strategy.

Playing without goalie isn´t part of statistics that Finnish Ice Hockey Association keeps track on, which made it harder to pick the information what is needed for the analysis. Information is there, but it needed more work to get it analyzed for the thesis.

It is notable that the data wasn´t always 100% reliable, because in the Finnish junior leagues, the stats in the games are mostly done by parents of the players and there are sometimes mistakes done in the stats. There were few games where the time when the goalie was pulled were missing, even though it was marked that one of the teams scored empty net goal or without a goalie. Sometimes there was marked that team pulled the goalie, but it was obvious that there was delayed penalty in play (a penalty was called to the opposing team at the same time when the goalie was marked back to the net), which was the actual reason for pulling the goalie. The data isn´t "double-checked" from the video afterwards as they are in the professional leagues.

It´s hard to make decisive conclusions about the subject. As mentioned earlier, there are great examples about its efficiency and success, but the success rate still makes it high risk gamble. Probably with added variables and data more conclusive analysis could be done.

As Tim B. Swartz (2017) says in his research paper "hockey is a difficult sport for analytics. It is a fluid game, a so-called "continuous" game where there are many moving pieces. Also, what happens "off the puck" is not typically measured; these difficult to detect actions can have a profound impact on the results of a game".

With so much data in nowadays hockey, it´s hard to limit what to study and what to use for the analysis. In the other hand, that gives tons of options and point of views to be taken. Although, there´s still missing some data (in Finnish junior leagues, at least) which could be very relevant when thinking about the use of pulling the goalie strategy. How effective team´s power play and penalty killing has been and does those correlate with team´s effectiveness when one is playing without the goalie. For example, the figures that shows how long the scoring takes included all the goals the teams had scored (except the ones scored with goalie pulled) could be more reliable when the power play goals and it´s efficiency related to time were put to its own column for the comparison.
The penalties also effect a lot in the coaches willing to pull the goalie earlier in the game, especially if the goal difference is bigger than one. How much penalties effect on the

coaches decisions on pulling the goalie could be reasonable addition for the future research and also does the opponent get penalties more probably when other is playing goalie pulled.

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