2019

Perceived Ice Quality in NHL Arenas and the Effect on Player Offensive Performance

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PERCEIVED ICE QUALITY IN NHL ARENAS AND THE EFFECT ON PLAYER OFFENSIVE PERFORMANCE

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Master's Project

Submitted to the School of Human Movement, Sport, and Leisure Studies
Bowling Green State University

In partial fulfillment of the requirements for the degree of

MASTER OF EDUCATION
In
Sport Administration

11/15/19

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Abstract

The playing surface in hockey is unlike any other in sports and because it is so integral to the game, players and coaches believe that ice quality can impact their offensive performance. The purpose of this study was to investigate the effect of ice quality of NHL arenas on player performance by comparing statistics from games played at the best and worst rated arenas and to their season average. One forward and one defenseman from each of the twenty-one teams who do not play their home games in either the top five or bottom five ranked arenas were selected for this study. These players were among the highest scoring players on their teams and played multiple games at the arenas being studied. Each player's average total points per game as well as Corsi for percentage per game were calculated for the season as well as at the top and bottom arenas. Those means were compared in paired-samples t-tests. There was no significant difference in points per game at the top ($\mu = .7069$) and bottom ($\mu = .6759$) rated rinks ($n = 42$, $p = .771$). Both means were lower than the entire season average ($\mu = .8183$) for all forty-two players studied and the average at the bottom five rated rinks was significantly lower than the season average ($n = 42$, $p = .007$). Results showed that there was no significant difference in Corsi for per game at the top ($\mu = 54.0048$) and bottom ($\mu = 54.3579$) rated rinks ($n = 42$, $p = .713$). Furthermore, Corsi was significantly higher than the entire season average (52.1893) at both the bottom-rated arenas ($n = 42$, $p = .005$) and the top-rated arenas ($n = 42$, $p = .016$). These results do not support the perception that ice quality significantly affects player performance. Some possible explanations include points per game and Corsi not accurately measuring offensive performance, the overall talent of the home teams in those arenas, and the psychological effect perception can have on performance.

Introduction

During the 2017-2018 season the NHL added its 31st team, the Vegas Golden Knights, and with it its 31st arena and will add a 32nd in 2021-2022 when the yet to be named Seattle franchise begins play. Nothing in these arenas is more important to the game of hockey than the quality of the ice surface. Hall of Fame forward and current Red Wings GM Steve Yzerman said, "I think ice still is very poor throughout the league. Players are resigned to the fact that the ice is going to be bad in a majority of buildings--even new ones, where they spent a ton of money on aesthetics and suites. But as far as I know they haven't put extra effort into significantly improving ice quality." (Farber, 2004). Every new arena has spent millions of dollars on enhancing the fan experience with massive video boards and displays, in arena entertainment, restaurants, etc. but it all ultimately comes down to the ice that allows the world's best players to put on a show. No other sport has a playing surface that is as integral to the game and requires as much maintenance throughout. Former NHL Forward Jeremy Roenick said it best, "Ice is everything…When ice is good you see better passing, better puckhandling, better games – hockey's beautiful. When the ice is chippy or snowy, and the puck's bouncing and the passes aren't crisp, hockey's real ugly" (Farber, 2004).

With the advancements in training, today's NHL players are bigger, stronger, faster, and more agile and the ice needs to keep up with them. On an ice surface that is only around one to one and a half inches thick, one deep rut in can cause a player to be seriously injured. The New York Rangers experienced two of these such instances in the late 1970s with former players Dale Rolfe, who had to retire after severely fracturing his ankle when his skate got caught in a hole, and Ulf Nilsson, who missed three months after his skate got caught in a rut while sustaining a hit and shattered his ankle (Farber, 2004). Each of the arenas has different unique challenges to providing the best possible ice to allow the players to perform and at the same time limit their risk of injury.

Every arena in the NHL today is used for more than hockey, as all of them host events like concerts, the circus, and basketball. In fact, over a third of NHL teams share their arenas with NBA teams. It is not uncommon for an arena to host, within the span of a week, multiple NHL and NBA games and a concert or two. There is a growing need to improve planning and furnishing of athletic facilities and for those facilities to be multifunctional and meet various social needs (Velickovic, Velickovic, & Krsmanovic, 2017). The constant turnover these arenas go through can put a lot of stress on the systems designed to promote quality ice. During concerts, where they have fans above the ice surface, soda and beer can seep through the floor and onto the ice causing problems for ice crews (Farber, 2004). “At each stop on the 2001 Britney Spears tour, two tons of water was dumped onto the stage as part of her act, and at NHL arenas some of it went through the flooring” (Farber, 2004). To maintain ice quality NHL arenas do not use regular water to create the playing surface so while this might not sound like a big issue it is. The water used to create NHL ice goes through a filtration process to remove minerals and impurities which can make the ice too soft, after it goes through the filtration system they add minerals back to it or the ice would be too hard (Staley, 2015). The NHL has several standards for ice conditions to negate many of these issues.

Even though the arenas are all indoors weather can cause problems for the ice. According to NHL Facilities Operations manager Dan Craig, the ideal conditions for quality hockey ice are “an air temperature between 60º and 64º with 44% humidity, and an ice-surface temperature of 22º” (Craig, 2008). Those numbers are more difficult to reach at a Panthers game in Florida, where even December through February the temperature outside is often 70º or more with high humidity, than a Canadiens game in Montreal, where that type of weather may only occur in the summer. This could explain why in an NHLPA survey of over 300 current NHL players Florida was ranked the worst ice and Montreal the best (NHLPA, 2018). Figure 1 depicts the results of a different survey of 27 current and former players conducted in 2015, showing all warm weather locations. This is not to say that it's just high temperatures that cause the issue, arenas located in cities where the climate can change drastically can run in to a lot of issues (Craig, 2008). While Arizona or Vegas may have to deal with the heat at least the weather is consistent, and they know what to expect, Columbus can see the temperature go from 30º to 70º to 40º in the span of a couple days.

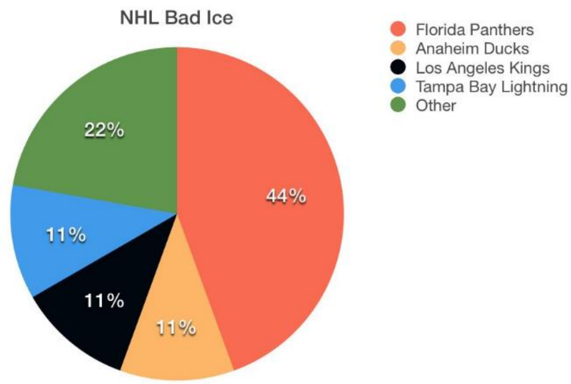

Figure 1 (Wyshynski, 2015)

Over the last few years NHL players have been more vocal with their concerns about ice quality. In an ESPN interview with several players, coaches, and executives some of the consistent complaints included soft ice which leads to a bouncing puck, too many non-hockey events, and having to expect the ice not to be good every game (Custance, McDonald, Burnside, & LeBrun, 2017). There were several issues that arose in the 2016-2017 NHL season that pushed this subject to the forefront including rescheduling a game between the Detroit Red Wings and Carolina Hurricanes to repair refrigerant leaks on PNC Arena's cooling system and compressors (Goldman, 2017). Some think it is more of a psychological issue, "Ice seems bad when someone says it's bad. When no one's talking about it, no one notices it," one NHL team executive stated

(Custance et al., 2017). Whether it is in their heads or under their feet, players are taking notice of the ice conditions.

In Pittsburgh, Sidney Crosby would spend time every day talking with the ice crew and tell them exactly what he felt was wrong and dialogues like that have led to improved ice (Custance et al., 2017). With players becoming more and more vocal about the quality, or lack thereof, of ice this issue has started to get better. In 1997, the NHL hired Dan Craig to address the ice issues and the NHL has since made a concerted effort to improve playing conditions (Farber, 2004).

Many of the players who have talked about poor ice conditions have stated that it can and will affect the quality of hockey played in those games. Former Arizona goalie Mike Smith said after an overtime loss at home, “That ice out there is probably some of the worst ice I have ever seen in my life… Not using an excuse, but that was bad. It’s been bad all year, but you can’t play on that. When you’ve got other teams coming in complaining about it on the ice and we have to skate on that all the time, like I said, it’s not an excuse but it’s something that has to get better. It’s like slush out there” (Goldman, 2017). Arizona’s ice is often ranked as one of the worst in the NHL. While the issue has been discussed by players like Smith, there are little to no studies on the effects of ice quality on player performance. It is obvious that improved ice quality is important to prevent injuries, but can it significantly affect the outcome of the game or at least the scoresheet? Over the last several years the NHL has been looking at ways of increasing offensive statistics including changing the depth of the goals and stricter regulations on goaltender equipment. If increased offense is their goal, a better sheet of ice may help them reach it. The purpose of this study was to investigate the effect of ice quality of NHL arenas on player performance by comparing statistics from games played at the best and worst rated arenas and to their season average.

Literature Review

History

Before hockey or figure skating became competitive sports, ice skating was a means of crossing frozen waterways in northern Europe (Russell-Ausley, 2000). The first mechanically refrigerated ice rink was opened in 1876 in Charing Cross, London (Martin, 2004). The success of this rink spawned many others and the sudden popularity of ice hockey in the 1880s added to the demand for construction of skating rinks (Martin, 2004). Thomas Rankin constructed in the first mechanically refrigerated ice rink in the U.S. in 1879 at the Old Madison Square Garden in New York City (Martin, 2004). Prior to 1918, most indoor ice rinks laid their pipes on wooden stringers on levelled ground and covered it with sand to produce a cold floor base with which to build ice, some rinks still use a similar system today because sand-based floors save on capital costs and provide added accessibility to the refrigerated pipes (Martin, 2004). Most rinks today, however, use a concrete floor to build their ice on which was first used in the Elysium rink in Cleveland in 1918 (Martin, 2004). The original concrete floors were flawed though as they were not constructed to withstand expansion and contraction, after years of experimentation a new type of floor was designed and poured as a monolithic slab with no expansion joints (Martin, 2004). These crack resistant floors led to the construction of thousands of arenas that could be used for multiple purposes, for example every NBA arena built since 1990 has included this type of floor for the ability to have hockey games (Martin, 2004).

The National Hockey League was created in Montreal, Canada in 1917, the league consisted of four teams all located in Canada (NHL timeline, 2016). In 1926, more American teams join the league and outnumber the Canadian franchises, in 1942 due to the Great Depression the league was reduced to the six teams known today as the Original Six, and from 1967 to today the league has expanded to 31, soon to be 32, teams (NHL timeline, 2016).

How Ice Rinks Work

With advances in ice rink engineering being relatively slow since the 1930s, many similarities exist between modern rinks and the first rink built in 1876 London (Martin, 2004). There are five main components to an ice rink's refrigeration system: the chillers, compressors, condenser, piping running throughout the floor, and the refrigerant (Russell-Ausley, 2000; Steinbach, 2008). Figure 2 shows a cross section of a typical ice rink floor and sub floor and includes the following layers A) piping containing the refrigerant, B) piping running throughout the floor, C) ice-bearing concrete slab containing the piping, D) ice skating surface, E) insulation between the cold floor and heated concrete slab, F) heated concrete slab to keep ground underneath from freezing, and G) a sand and gravel base (Russell-Ausley, 2000).

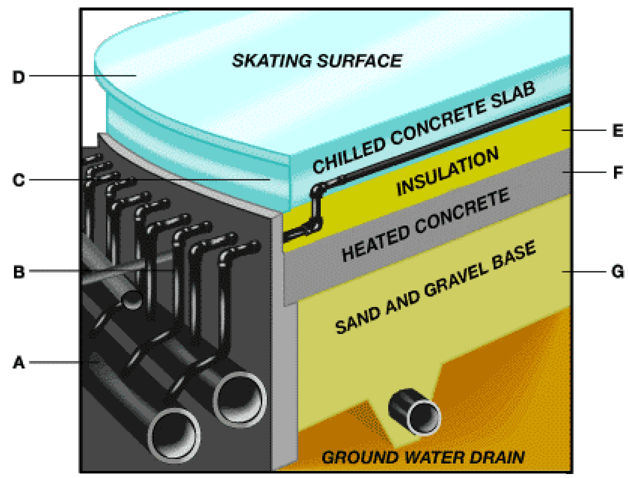

Figure 2

(Russell-Ausley, 2000)

There are two types of refrigeration systems used in ice rinks, indirect and direct (Steinbach, 2000). An indirect system uses a liquid refrigerant that absorbs heat from a secondary liquid, or brine, which pulls heat out of the rink floor as the brine is pumped through the pipes running throughout the floor (Steinbach, 2000). In a direct system, the heat is removed from the rink floor by pumping the primary refrigerant directly through the piping in the floor

(Steinbach, 2000). There are roughly 27,000 liters or 7,000 gallons of liquid refrigerant running through the piping under the floor at any time (R.C., 1994).

Direct systems may be more efficient, but most rinks today prefer the indirect systems because they allow for safer control of potentially harmful refrigerants (Steinbach, 2000). Indirect systems contain refrigerants such as ammonia, which is toxic, and dichlorodifluouromethane (or R-22, as it is commonly known), a type of Freon that is potentially hazardous to the environment, within a rink's mechanical room (Steinbach, 2000). Direct systems, however, circulate these through the pipes in the rink floor, where potential for leaks is much higher (Steinbach, 2000). Leaks can be difficult to detect especially with Freon, which is odorless (Steinbach, 2000). Over the years rinks have used variations within their systems when it comes to the type of liquid refrigerant, type of piping in the floor, type of chiller, or type of compressor (Martin, 2004). All these variations have been made to lower costs, be more energy efficient, and to be more environmentally friendly but in all are not that different from the rinks built nearly a century ago (Martin, 2004; Steinbach, 2008). Everything going on within the system is to build a relatively thin slab of ice that people can skate on safely.

How Ice is Built

The first step in building an ice surface is turning on the cold floor system and lower the temperature to approximately -8ºC or 17ºF (Staley, 2015). Once the floor has reached the desired temperature the crew begins by spraying a few thin layers of water with a spray boom, a type of industrial-strength sprinkler system, and these layers freeze almost immediately (R.C., 1994; Russell-Ausley, 2000). The best ice is built with water that is pure, but not too pure (Steinbach, 2008). Deionization and filtration of the water used to build ice sheets is used now at all arena levels, from small community rinks to NHL arenas (Steinbach, 2008). The removal of impurities such as suspended solids and gases is important to create and maintain a quality sheet of ice (Steinbach, 2008). "Ice will always try to freeze pure, and it will always try to eject the impurities, so you end up with a friable surface on top - or the frozen equivalent of froth - and really poor ice," says Denis Leclerc, facilities maintenance coordinator for Maple Ridge (B.C.) Parks and Leisure Services (Steinbach, 2008). This impure layer can not only be a problem for the blades of ice skates but also taxes the rink's refrigeration system more so than denser ice, which exhibits far greater structural integrity and can withstand the rigors of ice hockey (Steinbach, 2008). It's not only easier to keep pure ice frozen, it's also safer for players to skate on and avoid injury (Steinbach, 2008). In Vancouver they had problems because their water was considered too pure (Staley, 2015; Steinbach, 2008). After an engineer compared their water with those from the top-rated rinks he found that it lacked a certain concentration of salts that the others had (Steinbach, 2008). Once the salts were added to the purified water the arena staff found they could maintain the ice sheet at a colder temperature without being too brittle (Steinbach, 2008).

Once the first few layers of water are set up the crew uses a water paint mixture which is pumped through the boom and creates the white base layer of the hockey rink (Russell-Ausley, 2000). This can take two to three layers to achieve the desired whiteness depending on the rink. The next step is to cap that white layer with a few more layers of water before laying out lines and logos (Russell-Ausley, 2000). The next step is measuring out the blue and red lines, the faceoff circles and dots, hash marks where the players stand, goalie creases and the team and corporate sponsorship logos (Staley, 2015). The painting process can take about eight hours from

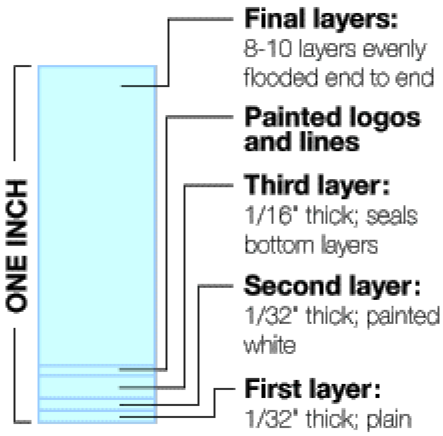

Figure 3

(Russell-Ausley, 2000)

start to finish (Staley, 2015). Some rinks have vinyl logos or lines that do not need to be painted and can instead be laid out and covered with a light layer of water to freeze them in place. Once the markings and logos are completed the crew uses backpack sprayers to cap each individual section before bringing the boom back out to start building the ice (Russell-Ausley, 2000). It is important to not use too much water at the early stages of the process as it will melt away the paint, the best method is gradually building the ice to avoid problems (Russell-Ausley, 2000). Once the ice is thick enough the crew will switch to a flooding hose and eventually the ice resurfacing machine to lay more water down and save time (Russell-Ausley, 2000). The whole process uses about 48,00 liters of water (R.C., 1994). Figure 3 illustrates the layers that lie within a slab of ice. "No other playing surface is so integral to its sport, so complex to maintain and so misunderstood (Clinton, 2017).

Difficulty Maintaining Ice Quality

Once the ice making process is complete the challenge is to maintain quality ice for the entirety of the NHL season which can last between seven to nine months. "Every game, at least 0.5 centimeters of the 3.17-centimeter-deep ice is ground off by the two teams of powerfully built men flying along on steel blade skates at speeds nearly equal to that of a racehorse" (Staley, 2015). NHL players today possess more size, speed, and skill than ever before and that can cause issues with the quality of ice, this is particularly an issue late in games (Clinton, 2017).

The air temperature and ice temperature must be adjusted to compensate for the heat and humidity that will come in through arena doors (Russell-Ausley, 2000). The Carolina Hurricanes arena in Raleigh uses 12 dehumidifiers to keep the air in the 770,000 square foot facility dry (Russell-Ausley, 2000). Ice conditions can vary greatly when temperature changes as little as one degree (Russell-Ausley, 2000). Dan Craig set the NHL's standards to meet for quality ice, but he knows that those can be difficult to maintain when its 86 degrees outside with 66% humidity for example (Craig, 2008). When the weather outside is uncooperative the arenas need to rely on their facility crew and their equipment to ensure that the ice is the best it can be. They run two air processors to control the temperature and humidity and have a third if need be, in games where they anticipate large crowds they set the temperature even lower because with tens of thousands of people in the arena the temperature will rise quickly (Craig, 2008). "People bring in a lot of moisture and a lot of heat on their clothes," Brendan Lenko said. "If (the arena) has the equipment to deal with it, it's no problem, but if they don't it absolutely creates a huge load on the ice" (Clinton, 2017). Matthew Miller, VP of facility operations at Quicken Loans Arena, says they deal with humidity the "natural way," which means they carefully balance the outside air with air conditioning (Clinton, 2017).

The time between periods is no longer used solely for resurfacing the ice and even though it may not be a major factor, some of the events that take place during this time can put added stress on the ice (Wigge, 2001). On-ice promotions have become a big part of the fan experience and adds an extra factor that arena crews must account for whether it is more skaters on the ice or the cars that are driven out there during intermission. Even the ice resurfacing machines, which are built to recreate quality, can create issues (Russel-Ausley, 2000). These ice resurfacing machines use hot water, about 75ºC, to melt the first few layers of ice and in doing so creating a smoother surface (Staley, 2015). Because they use such warm water it is important for them to allow enough time for the ice to set up before the teams come back out to play or they will have a wet slushy surface. This hot water also can add to the humidity in the arena which must be accounted for. The drivers must also be aware of their surroundings or they can create new issues like in Detroit in 2016 where the Zamboni ran over one of the net post pegs and dragged it across the ice causing a large, deep rut that required over 30 minutes of work to repair (Johnston, 2016).

"Of all the variables affecting arena ice – humidity, arena temperature and air currents, ice temperature, water composition and the competence of the rink manager and Zamboni drivers – the stress of an arena schedule jammed with nonhockey events is most significant" (Farber, 2004). Arenas house many different types of events and each one has their different requirements or preferences, NBA wants the air temperature around 70 degrees while the NHL wants it around 64 degrees or ice-show performers like Disney on Ice prefer an ice temperature in the mid-to-high 20s while the NHL maximum is 24 degrees (Farber, 2004). Former NHL forward Teemu Selanne said that the best ice is in Europe where they do not use the arenas for other events, it is all hockey and he feels that creates better ice and is the reason why European players perform so well when they come to the NHL (Farber, 2004). The process of covering the ice for basketball or concerts involves removing at least some of the boards, covering the ice with an insulation material, and then the basketball court or concert stage is built on top of that (Clinton, 2017). Switching back to a hockey rink involves a few more steps including removing the event floors and insulated decking, putting the boards back in, edging the ice, dry cutting to remove dirt and any other foreign substances from the top layer, a wet cut, and a flood (Clinton, 2017). "The more it's uncovered and the more oxygen and air that gets to an ice surface, the better it becomes over time," Miller said. "It's a daily challenge in a multi-use facility like ours to really get the ice surface to where it's perfect all the time. If I didn't have to cover it and I could leave it all the time, it would be a hockey player's dream. But I don't have that luxury" (Clinton, 2017). With over a third of the league sharing their arenas with NBA teams, unfortunately, these issues will not be going away any time soon.

Entertainment Value of Arenas

Professional sport arenas today need to be more than just a facility for sport participation with a playing surface, locker rooms, and training areas. They must be able to accommodate several other functions such as shopping, dining, entertainment, hospitality, and educational and political services (Velickovic et al., 2017). Spectators and customers of these arenas desire more than just a view of the playing surface or stage, they want a clean and aesthetically pleasing facility that they can enjoy outside of the event taking place. As new arenas are being constructed around the world, each one seems to come with some new and innovative feature that benefits the fans and adds to their experience. Planning and construction of these multifunctional facilities should meet the principles and functions related to the capital expenses, cost of implementation, customer satisfaction, the functions of the athletes and sports management (Velickovic et al., 2017). Designers can focus on creating attractive and appealing visual and virtual displays throughout the arena that can be used for informational or promotional purposes (Velickovic et al., 2017). If the event is lacking in entertainment the facility must find a way to fulfill that desire of the spectators.

An example of such an arena is Kombank Arena in Belgrade, Serbia (Velickovic et al., 2017). The arena was modeled after Chicago's United Center, home of the NHL's Blackhawks and NBA's Bulls (Velickovic et al., 2017). This multifunctional facility was designed to host sports, such as ice hockey and basketball, as well as concerts, theatrical performances, and circuses (Velickovic et al., 2017). Like many professional athletic facilities, Kombank Arena has become one of the symbols of the city and a prestigious place for performance and hosts, on average, three events per week (Velickovic et al., 2017). Most NHL arenas would have a similar average events per week as the Kombank Arena, and likely more with the high number who also serve as home arenas for NBA teams.

Is there a Home Ice Advantage?

While ice quality may affect player performance it is possible that some of that affect may be from the perceived advantage of being the home team in sports. There is a statistic that shows in sports that the home team wins over 50% of games played under a balanced home and away schedule (Liardi & Carron, 2008). During the 2006-2007 NHL regular season, home teams won 56.0% of games decided in regulation or overtime but only 47.1% of shootouts (Liardi & Carron, 2008). The home teams also won a majority of the face-offs taken in all three zones of the ice (Liardi & Carron, 2008). NHL rules also favor the home team when it comes to face-offs including the home team getting last change which means they can put a player they believe has the best chance to win the face-off against whoever the away team sends out, as well as that home player getting the final stick placement in the face-off circle which gives them an advantage at winning the face-off (Liardi & Carron, 2008).

While the study above focused on the home ice advantage on face-offs, it can relate to overall offensive performance. Winning face-offs, particularly in the offensive zone, leads to more opportunities to score. This study will focus on players playing on the road and comparing offensive performances during those games, the home ice advantage threatens to affect the results. Rules are also an affect that can skew things toward the home team and alter the potential performance of the visiting player. It is interesting that home teams won a minority of shootouts during the season and may be because it is one-on-one and primarily relies on the shooter and goalies talents and abilities.

Opinions from Around the League

Players have become more vocal about ice quality in the last several years. One common theme is that it is a league wide problem and there is no easy solution. "I think you'd be hard-pressed to find a place that has good ice," Defenseman Brooks Orpik said (Custance et al., 2017). The players have learned to deal with the poor ice and have come to expect it wherever they are playing. New Jersey Devils defenseman Ben Lovejoy said "I think that NHL ice, you expect [it] to not be perfect. A lot of things go on in these buildings. We are professional athletes that are the best at our game. We're not expecting perfect ice sheets every night. We have to go out and execute on them" (Custance et al., 2017).

Poor ice conditions have caused teams and players to adjust the way they prepare for and play the games. Ken Hitchcock, who coached the Stars from 1996 to '02 said, "In Dallas we knew that in October or May we were going to play a very conservative game after 10 minutes of every period. Our team took advantage of tough ice conditions. We'd change our counterattacks. The players would remind themselves of that on the ice. I remember Colorado coming in during the playoffs and complaining about [the ice]. People were psyched out" (Farber, 2004). The poor ice may even be an advantage for the home team because they know what to expect and the visiting team will take time to adjust their game plans. It may also intimidate them when they expect to play poorly due to the ice quality.

The most common theme among players, however, is that if the ice conditions are right their performance will be better because they can skate faster, and the puck moves smoother. "I feel like the puck is bouncing a lot. I don't know if that's the ice, if that's the puck or what it is. Some nights it's good, some nights it's bad. Who knows what it is?" said Ryan Suter, defenseman for the Minnesota Wild (Custance et al., 2017). When the puck is not bouncing and moves smoother on the ice the players have more control and can create more offense because of that. James van Riemsdyk discussed how the league wants more scoring and how the ice affects that when he said, "but for the sake of the product of the game -- we talk about goal scoring and stuff like that -- if you have a better ice surface and the puck isn't bouncing around as much and guys can make plays, you would think that would be as good a reason as any to get more goals in the league. I know they're working on it and they're trying, but it hasn't been good of late" (Custance et al., 2017). Jeremy Roenick further explained that, "for a player who relies on skating, a fresh, hard sheet of ice probably increases his speed by two steps. Ice is the difference between scoring and not scoring. On a fresh sheet the puck lies nice and flat, and the shooter will get all of it and put it where he wants. If the ice is bad, the puck flips on edge before the pass reaches your stick, taking away a scoring chance" (Farber, 2004).

A bouncing puck can be the difference in scoring and not scoring, players can get off a quicker and more accurate shot if the puck is moving smoothly across the ice and they do not need to settle it down before taking their shot. Some of the league's elite players struggle and the perception is that it is due to the ice, "It's disappointing because it brings the quality of the game down, the speed ... you see some of the skill guys like [Nicklas] Backstrom or [T.J.] Oshie having a tough time settling pucks down, you know it's probably the ice," said Brooks Orpik (Custance et al., 2017). The perception is there but does perception equal reality?

Perceived vs Actual Performance

Players and coaches believe that improving the ice quality will lead to better performance and potentially more offense which the league has been pushing for recently. These complaints have motivated the league to investigate the issues and come up with ways to improve the quality of the ice (Goldman, 2017).

As evident from the quotes above, players perceive they play better when the ice conditions are optimal. This study will look to determine whether that perception is reality. Previous studies have been performed in the education field to determine the effect perceived difficulty can have on test performance. In one study, it was found that the perception of a difficult test stimulated worry in the students and deteriorated their actual performance (Chang, 2015). It is possible that the NHL players who know that the ice condition will be poor at certain arenas will create a sense of worry about their potential performance and that could affect their actual performance. Another study found that the perceived test difficulty recalled after examination had greater effect on arousing worry and emotionality (Chang, 2015). In this case it could be that players recall past experiences and poor performances at certain arenas and that can affect their future play.

In Chang's 2015 study, students were administered multiple tests and they were asked to rank these tests in order of perceived difficulty, the results of their examinations were then compared to assess whether they actually performed worse on the most difficult and better on the easiest. It was expected that students would then perceive that they scored lowest on the most difficult and highest on the easiest, but this was only the case for about two thirds of the participants (Chang, 2015). Perceiving the test as difficult did not necessarily mean that students felt that they scored the lowest on it, difficulty does not always lead to bad performance. The NHL players may still perform well in games at arenas that they believe are more difficult to play in.

What Improvements have been made?

Since the NHL brought in Dan Craig to oversee the league's ice, he has implemented several policies that have led to improved ice over the years (Wigge, 2001). It starts with the water that makes the ice, pure but not too pure, the league now has standards for the water that is used to create the best possible ice (Staley, 2015; Steinbach, 2008). Arenas are required to use hot water when resurfacing the ice between periods and due to the potential of the water to not freeze in time Craig and the NHL mandated that on ice promotions during intermission last no longer than twelve minutes to allow time for the ice to set up and can fine teams that go over the time limit (Farber, 2004).

The discussions players have with arena ice technicians is also leading to better ice quality. Brooks Orpik points to a relationship between his former teammate and their ice technician, “I think Pittsburgh actually has good ice, after years of Sidney [Crosby] going over ... it started with all of us bitching about it. It finally got to the point where Sid would go every day and constructively sit down with the guys who ran the rink and tell them exactly what he felt was wrong with it. It was good dialogue between them, and the ice started getting better and better. That's the one place I think is consistently pretty good" (Custance et al., 2017). The players should take their concerns to the men and women who work on the ice to see if there are solutions. It has worked in Pittsburgh and it may work in other arenas if the players who skate on the ice multiple times per week work with the ice technicians and explain what they see and feel and how they want the ice to be.

The NHL and Craig also looked at the pregame events and how they can affect the ice and made some changes to the way those are managed (Farber, 2004; Wigge, 2001). They banned pregame youth hockey events to keep the ice pristine for the NHL players (Wigge, 2001). The pregame player warmups were shortened from twenty minutes to sixteen minutes to lessen the load the NHL players put on the ice (Farber, 2004). In the same vein, prior to the second and third periods only the skaters who will be starting are allowed on the ice (Farber, 2004; Wigge, 2001). Due to the size and skill of the NHL players they create a lot of snow on the ice during play which can cause issues with the movement of the puck and to combat those issues the league uses skaters to shovel the snow off the ice during tv timeouts (Farber, 2004; Wigge, 2001).

There are several things the league does behind the scenes now to improve the ice quality. The league began player surveys during the season to allow them to voice their concerns and potentially allow arena managers to adjust early in the year (Wigge, 2001). Arena managers now are told where their rinks rank in the league which allows them to ask what they need to do to be ranked higher (Wigge, 2001). It is not just the ice that can cause issues, the puck moves better when it is frozen so off-ice officials are required to keep the pucks in a refrigerator prior to their use (Wigge, 2001). There are leaguewide operations meetings to exchange ideas and rink operators are encouraged to take ice-making courses given by the Ontario Recreation Facilities Association and its USA Hockey affiliate, STAR (Farber, 2004). Figure 4, below, represents a player pole of the best and worst ice in the NHL.

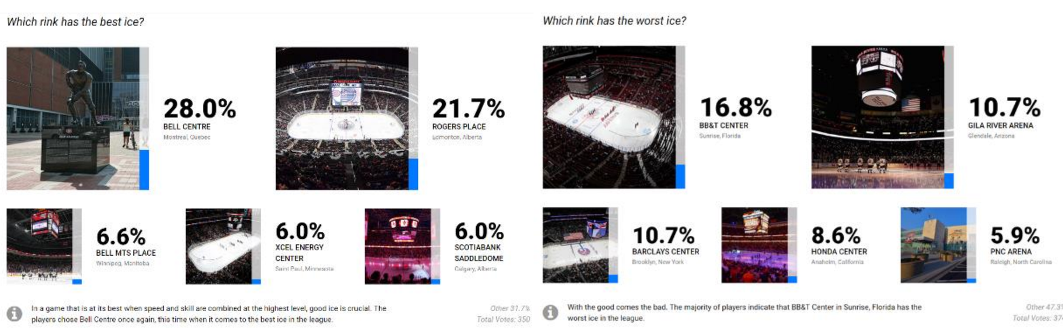

Figure 4 (NHLPA, 2018)

<u>**Methods**</u>

Using the player poll from the 2017-2018 NHL season above, players offensive statistics will be analyzed to determine whether perceived ice quality does influence player performance. The website https://www.hockey-reference.com/ will be used to collect player statistics from the

2017-2018 season. The statistics that will be studied are points (goals and assists) per game and Corsi for percentage, which is calculated by dividing the total even strength shots taken by the player's team while that player is on the ice by the combined total of shots taken by both teams while that player is on the ice (Nandakumar & Jensen, 2019). "Corsi helps identify teams and individual players generating more scoring opportunities through shots, which ultimately should result in more goals and wins." (Nandakumar & Jensen, 2019, p23). A previous study found that Corsi produced the highest correlation (.51) of any of the raw statistics when predicting the number of goals a player would score in the future (Riley, 2017).

One forward and one defenseman from each of the twenty-one teams who do not play their home games in either the top five or bottom five ranked arenas were selected for this study. The players selected are listed in Appendix A and their statistics collected for the study are listed in Appendix C. One of the criteria for choosing these players were they are among the higher scoring and performing players on each team and played multiple games at both the higher and lower ranked arenas. These players, outside of some of the elite talents, are within the peak age range for player performance. One study found that most hockey players reach something close to peak performance by the age of 23 or 24 and their actual peak in their late 20s and typically sees a significant decline by their early (forwards) to mid (defensemen) 30s (Brander, Egan, & Yeung, 2014). The average peak performance age for forwards was found to be between 27 and 28, and for defenseman between 28 and 29 (Brander et. al., 2014). The average age of the forwards selected was 26.95 and the average age of defensemen selected was 27.52 during the 2017-2018 season. Three of the players selected were also eligible for salary arbitration at the end of the season, players who were eligible for arbitration at the end of the 2002-2003 season saw a significant increase in points per game from the previous season (Shirreffs & Sommers, 2006).

Paired t-tests were performed on the players' statistics to determine whether there was a significant difference for offensive statistical performances between the top and bottom rated rinks. It was hypothesized that there will not be a significant difference in points per game but that Corsi will be significantly higher at the highest rated arenas. I believe total points is not as accurate in assessing player performance because of the effect of secondary assists in which a player gets credit for an assist when they make the pass prior to the pass to the goal scorer. This pass could have occurred on the opposite end of the ice and have had little to do with the resulting goal.

Results

On a point per game basis, the paired samples t-test showed that while the average points per game was slightly higher at the top-rated rinks there was no significant difference between the players performances at the top-rated and bottom-rated rinks ($n = 42$, $p = .771$). The average points per game for the players used in this study at the top five rated rinks was .7069 points/game, the average at the bottom five rated rinks was .6759 points/game, and the season average was .8183 points/game. While both means were lower than the entire season average for all forty-two players studied, only points per game at the bottom five rated rinks was significantly lower than the season average ($n = 42$, $p = .007$).

Corsi was predicted to be significantly higher at the top five rated arenas than the bottom five but the paired samples t-test results showed that there was no significant difference between the two means ($n = 42$, $p = .713$). Interestingly, the average Corsi for the players studied was slighty higher at the bottom five rated rinks, 54.3579, than the average at the top five rated, 54.0048. Furthermore, Corsi was significantly higher than the entire season average (52.1893) at both the bottom-rated arenas (n = 42, p = .005) and the top-rated arenas (n = 42, p = .016) for all forty-two players studied.

Discussion

Players, coaches, and analysts have all maintained that players will perform better when they feel that the playing surface is at its best, the results of this study have shown that that may not be the case. From a points per game and Corsi standpoint the results from the 2017-2018 season show that there is no significant difference between player performance at the arenas they feel have the best ice and those they feel have the worst ice. When you look at the season as a whole the players performed significantly worse in points per game at the bottom-rated rinks than they did on the season, however, they significantly outperformed their season average in Corsi at both the top and bottom rinks.

This study raises the question of how we should evaluate player performance. Analytic statistics in sports is still relatively new and hockey has lagged behind other sports in data analysis (Riley, 2017). Total points can be a misleading statistic when it comes to player performance. Shots can ricochet off of other players and into the goal and assists and secondary assists are simply just the pass or two passes prior to the goal and in some cases had minimal impact in creating that goal. The statistics used in this study are univariate performance measures, to fully capture a players performance more multivariate methods should be used (Riley, 2017). Using measured variables for offense, defense, and possession, Riley’s 2017 study focused on creating such a multivariate measurement for performance. Future research should look into examining the effect of ice conditions more well-rounded statistics like these.

Another potential explanation for there being no significant difference between the two statistics is the poor performance of the teams who play their home games in the bottom-rated arenas. While studies have shown that there can be a home ice advantage in both the outcome of the games and player statistics, overall team ability does come into play (Liardi & Carron, 2008). Of the teams who play in the bottom five arenas only Anaheim made the playoffs, and in fact they were the only one to finish in the top half of the league standings. When comparing the averages for the top and bottom rated arenas the average rank was 16.4 to 19.2, the average wins was 39.8 to 37.6, and the average points was 89.6 to 86. Teams in the top-rated rinks had better seasons on average than those in the bottom. It is possible performances were more positive in those arenas because of the home teams' inability to defend their home ice. It is also possible that those teams performed so poorly because they play on such a poor playing surface. If they practice on those rinks or on some with similar ice quality it could affect their training and overall ability to play even when they play on high quality ice.

An aspect of the game of hockey that may have impacted the results of this study is the different types or roles of players and how those effect offensive performance. All players studied were at the top of their teams scoring lists, but that does not mean that they were some of the best offensive players. A previous study examined the different roles players play and what impact those roles have on player performance (Chan, Cho, & Novati, 2012). Their study found that top line forwards and offensive defensemen are the ones who have the greatest impact on goals and assists while other roles were more impactful in the areas of hits and blocked shots (Chan et. al., 2012). On less successful teams, players may be playing outside their roles and though they are the higher scorers, they would likely be lower on another team that has more offensive talent.

Also, as discussed in Chang's (2015) article it is possible that even though players perceived that their performance was worse at the lower rated arenas it does not mean that they actually did not perform well. With the lower quality of ice, the players likely had to work harder in order to perform at a high level and it might be that difficulty that they are focusing on and not their actual performance. The difficulty of the opponent may also influence the player's perceived performance, because the opponents are not as good, players may undervalue their performance against them because they expect better results.

Conclusion

Perception is not always reality. Player performance is affected by several variables and the condition of the ice is just one of those variables. The NHL has worked to institute new standards and dictate the process by which ice is built and maintained in order to create a consistent playing surface throughout the league and yet we still see players complaining about the ice conditions all over the league. This study has shown, however, that it may not be the ice that is the primary variable affecting player performance. Poor ice quality as well as poor performance may be more of a psychological issue.

Players and coaches have designed game plans and changed the way they play by assuming that ice conditions affect their play. As many have said, the ice is considered poor across the league and there may not be many rinks that have high quality ice. Having to deal with ice conditions has become a part of the game and the players have adapted. While this study did not find a significant impact of ice quality on playing performance, the result might be due to the relativity of the performance. Meaning, ice quality would equally influence both offensive and defensive performances simultaneously. It is still possible that the overall entertainment value of hockey games might be affected by quality of ice.

This study's purpose was to determine whether ice quality affected player performance but may have raised a different question of whether the current measures of performance are enough to truly evaluate the issue. Sports analytics have come a long way but are still lagging behind in hockey and it may be the case that the metrics by which we evaluate performance are not where they need to be to determine whether the ice quality has the effect that the players are adamant it does.

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Appendix A

Team	Forward	Defenseman
Boston Bruins	David Pastrnak	Torey Krug
Buffalo Sabres	Ryan O'Reilly	Rasmus Ristolainen
Chicago Blackhawks	Patrick Kane	Duncan Keith
Colorado Avalanche	Nathan MacKinnon	Tyson Barrie
Columbus Blue Jackets	Artemi Panarin	Seth Jones
Dallas Stars	Tyler Seguin	John Klingberg
Detroit Red Wings	Dylan Larkin	Niklas Kronwall
Los Angeles Kings	Anze Kopitar	Drew Doughty
Nashville Predators	Filip Forsberg	P.K. Subban
New Jersey Devils	Taylor Hall	Will Butcher
New York Rangers	Mats Zuccarello	Brady Skjei
Ottawa Senators	Mike Hoffman	Erik Karlsson
Philadelphia Flyers	Claude Giroux	Shayne Gostisbehere
Pittsburgh Penguins	Sydney Crosby	Kris Letang
San Jose Sharks	Joe Pavelski	Brent Burns
St. Louis Blues	Brayden Schenn	Alex Pietrangelo
Tampa Bay Lightning	Nikita Kucherov	Victor Hedman
Toronto Maple Leafs	Mitch Marner	Jake Gardiner
Vancouver Canucks	Daniel Sedin	Alexander Edler
Vegas Golden Knights	William Karlsson	Colin Miller
Washington Capitals	Alexander Ovechkin	John Carlson

Appendix B

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PPGTop5	.7069	42	.34464	.05318
	PPGBottom5	.6795	42	.37974	.05860
Pair 2	CorsiTop5	54.0048	42	5.04724	.77881
	CorsiBottom5	54.3579	42	6.24569	.96373
Pair 3	PPGTop5	.7069	42	.34464	.05318
	PPGSeason	.8183	42	.25703	.03966
Pair 4	PPGBottom5	.6795	42	.37974	.05860
	PPGSeason	.8183	42	.25703	.03966
Pair 5	CorsiTop5	54.0048	42	5.04724	.77881
	CorsiSeason	52.1893	42	2.51191	.38760
Pair 6	CorsiBottom5	54.3579	42	6.24569	.96373
	CorsiSeason	52.1893	42	2.51191	.38760

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	PPGTop5 - PPGBottom5	.02738	.52451	.08093	-.13607	.19083	.338	41	.737
Pair 2	CorsiTop5 - CorsiBottom5	-.35310	6.18517	.95439	-2.28053	1.57434	-.370	41	.713
Pair 3	PPGTop5 - PPGSeason	-.11143	.38521	.05944	-.23147	.00861	-1.875	41	.068
Pair 4	PPGBottom5 - PPGSeason	-.13881	.31808	.04908	-.23793	-.03969	-2.828	41	.007
Pair 5	CorsiTop5 - CorsiSeason	1.81548	4.69948	.72515	.35101	3.27994	2.504	41	.016
Pair 6	CorsiBottom5 - CorsiSeason	2.16857	4.72758	.72948	.69535	3.64179	2.973	41	.005

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
PPGTop5	42	.00	1.60	.7069	.34464
PPGBottom5	42	.00	1.29	.6795	.37974
PPGSeason	42	.30	1.56	.8183	.25703
CorsiTop5	42	43.82	65.50	54.0048	5.04724
CorsiBottom5	42	39.98	65.71	54.3579	6.24569
CorsiSeason	42	46.70	57.00	52.1893	2.51191
Valid N (listwise)	42				

Appendix C

Player	Top 5 PPG	Bottom 5 PPG	Season PPG	Top 5 Corsi	Bottom 5 Corsi	Season Corsi
N. Kucherov	0.5	1.29	1.56	56.92	55.93	53.6
S. Crosby	0.4	1.25	1.09	55.96	65.71	55.9
A. Kopitar	1	1.25	1.12	49.43	46.15	53.1
N. Makinnon	0.6	1	1.31	49.44	44.78	50.9
T. Hall	1	1	1.22	62.2	55.04	53.3
D. Larkin	0.5	1.14	0.77	54.92	47.1	50.7
T. Seguin	0.71	0.57	0.95	59.29	55.67	51.55
W. Karlsson	0.44	1.14	0.95	53.84	59.64	53.8
R. O'Reilly	0.67	1.17	0.75	57.1	49.87	50.8
M. Zuccarello	0.33	0.57	0.66	57.98	49.46	46.7
P. Kane	1	0.67	0.93	55.62	55.22	52.5
D. Pastrnak	1	1.14	0.98	65.5	56.99	55.5
A. Panarin	1.5	0.43	1.1	58.88	65.36	57
J. Pavelski	0.71	0.29	0.8	52.41	53.76	53.1
F. Forsberg	0.78	0	0.96	46.99	55.6	53
B. Schenn	1.22	0.4	0.85	54.5	64.3	54.6
A. Ovechkin	1.6	1.13	1.06	56.96	63.48	51.4
M. Marner	0.67	0.5	0.84	54.78	57.88	52.9
D. Sedin	0.88	0.33	0.68	58.34	57.42	53.4
M. Hoffman	1	0.38	0.68	49.28	56.49	49.4
C. Giroux	0.6	0.88	1.24	61.9	58.33	53.2
V. Hedman	0.4	1	0.82	54.18	49.47	52.2
K. Letang	1.4	0.29	0.65	51.62	63.03	55
D. Doughty	0.88	0.75	0.73	47.26	49.8	53.2
T. Barrie	0.57	0.8	0.84	53.69	42.14	48.3
W. Butcher	0.67	0.17	0.54	53.45	54.7	53.9
N. Kronwall	0.33	0.29	0.34	46.3	55.7	49.5
J. Klingberg	0.43	0.86	0.82	58.13	59.94	53.7
C. Miller	0.56	0.86	0.65	57.33	65.49	56.3
R. Ristolainen	0.8	0.29	0.56	58.2	50.19	48.5
B. Skjei	0.33	0.25	0.3	47.87	46.01	47.2
D. Keith	0.44	0.67	0.39	46.68	50.25	52.4
T. Krug	1.17	0.29	0.62	63.12	59.31	54.6
S. Jones	0.33	0.29	0.73	54.12	53.41	54.1
B. Burns	0.86	1.29	0.82	53.04	55.14	54.4
P. Subban	0.67	0.33	0.72	48.98	54.93	51.2
A. Pietrangelo	0.67	1	0.69	49.51	49.86	51.5
J. Carlson	0.8	0.5	0.83	43.82	49.94	49.2
J. Gardiner	0.5	0.83	0.63	49.5	49.52	50.7
A. Edler	0.57	0	0.49	50.06	39.98	46.8
E. Karlsson	0	0.5	0.87	50.8	55.15	51.4
S. Gostisbehere	0.2	0.75	0.83	58.3	54.89	51.5