EFFECT OF PERFORMANCE DETERMINANTS ON NHL FINAL GOAL DIFFERENCE

EFEITO DOS DETERMINANTES DE DESEMPENHO NA DIFERENÇA FINAL DE GOLS DA NHL

IMPACTO DE LOS DETERMINANTES DE DESEMPEÑO EN LA DIFERENCIA FINAL DE GOLES EN LA NHL

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ABSTRACT

Introduction: In ice hockey games, the team's performance is influenced by many contextual factors, and understanding playing styles allows to reveal how key performance indicators vary under different situations. Objective: This research aims to explore the playing styles of elite ice-hockey teams and to identify key performance aspects under different final goal difference situations. Methods: This article analyzed compared the match performance of 31 National Hockey League teams during 1271 matches considering their playing styles and final goal difference. Results: The principal component analysis obtained 8 performance components describing the technical-tactical styles of the teams. The subsequent analysis found that there was significant difference between three match outcomes in unfavorable state, major penalties, puck possession maintaining ability, shot defending ability, aggressive performance ($p<0.001$; = 0.007-0.273). Conclusions: Higher-ranked teams winning the unbalanced games showed better performance in shot defending ability and aggressive performance. Lower-ranked teams losing in unbalanced games kept less possession of the puck and were more likely to be shorthanded ($p<0.05$, ES=0.131-1.410). The study demonstrates how playing styles can be used to contextualize key determinants from ice hockey games. ***Level of evidence I; Therapeutic Studies Investigating the Results of Treatment.***

Keywords: Athletes; Hockey; Athletic Performance; Principal Component Analysis.

RESUMO

Introdução: Nos jogos de hóquei no gelo, o desempenho da equipe é influenciado por vários fatores contextuais, e entender os estilos de jogo permite revelar como os principais indicadores de desempenho variam em diferentes situações. Objetivo: Esta pesquisa tem como objetivo explorar os estilos de jogo das equipes de hóquei no gelo de elite e identificar aspectos-chave de desempenho em diferentes estilos de jogo e a diferença do resultado final. Métodos: O desempenho de partida de 31 equipes da National Hockey League durante 1271 partidas foi analisado e comparado, considerando o estilo de jogo e a diferença de gol final. Resultados: A análise de componentes principais retornou 8 componentes de desempenho, descrevendo os estilos técnico-táticos das equipes. A análise subsequente revelou que houve diferença significativa entre três resultados de jogo em estado desfavorável, penalidades principais, habilidade de manter a posse do disco, habilidade de defender o lance e desempenho agressivo ($p<0,001$; = 0,007-0,273). Conclusão: As equipes de classificação mais alta que venceram os jogos em desequilíbrio numérico de jogadores apresentaram melhor desempenho na habilidade de defender o lance e no desempenho agressivo. As equipes de classificação mais baixa, que perderam em jogos desequilibrados, mantiveram menos posse do disco e tiveram maior probabilidade de ficar com um jogador a menos ($p <0,05$, ES = 0,131-1,410). O estudo demonstra como os estilos de jogo podem ser usados para contextualizar os principais determinantes dos jogos de hóquei no gelo. ***Nível de Evidência I; Estudos Terapêuticos Investigação dos Resultados do Tratamento.***

Descritores: *Atletas; Hóquei; Desempenho Atlético; Análise de Componente Principal.*

RESUMEN

Introducción: En los juegos de hockey sobre hielo, el rendimiento del equipo está influenciado por varios factores contextuales, y comprender los estilos de juego permite revelar cómo varían los indicadores clave de rendimiento en diferentes situaciones. Objetivo: Esta investigación tiene como objetivo explorar los estilos de juego de los equipos de hockey sobre hielo de élite e identificar aspectos clave del rendimiento en diferentes situaciones de diferencia de gol final. Métodos: El rendimiento del partido de 31 equipos de la Liga Nacional de Hockey durante 1271 partidos fue analizado y comparado, considerando el estilo de juego y la diferencia de gol final. Resultados: El análisis de componentes principales obtuvo 8 componentes de rendimiento que describen los estilos técnico-tácticos de los equipos. El análisis posterior encontró que hubo una diferencia significativa entre tres resultados de partido en estado desfavorable, penalizaciones principales, habilidad para mantener la posesión del disco, habilidad para defender el tiro, desempeño agresivo ($p<0,001$; = 0,007-0,273). Conclusión: Los equipos de clasificación más alta que ganaron los juegos desequilibrados mostraron un mejor rendimiento en la capacidad de defensa de disparos y en el rendimiento agresivo. Los equipos de clasificación más baja que perdieron en juegos desequilibrados mantuvieron menos

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posesión del disco y tenían más probabilidades de estar en desventaja numérica (p<0,05, ES=0,131-1,410). El estudio demuestra cómo los estilos de juego pueden utilizarse para contextualizar los determinantes clave de los juegos de hockey sobre hielo. ***Nivel de Evidencia I; Estudios Terapéuticos que Investigan los Resultados del Tratamiento.***

Descriptores*: Atletas; Hockey; Rendimiento Atlético; Análisis de Componente Principal.*

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INTRODUCTION

Ice hockey is one of most popular and competitive winter sports originated from North America and widely practiced in Northern Europe, Canada and United States. The match is formed by three 20-min periods where two teams compete to score by shooting the puck into the opposing team's goal. This game requires players to have a wealth of playing skills, such as skating, shooting, passing and body checking to score the puck into the opponent's goal.[1] Since the game does not limit the number and time of player rotation, there is a rule that players will be sent off for a period in the penalty, so there may be unequal numbers of both sides on the ice hockey rink, which increases the uncertainty of the game.

Currently, the performance analysis of ice hockey is divided into skating and shooting,[2] positional characteristics and physical demands,[3] players' and teams' evaluation, etc.[4,5]

Within the domain of match analysis, research focusing on game results showed that the numbers and positions of shooting have a great impact on the scoring.[6,7] Studies have shown that there are significant differences in the number of shots and the efficiency of shots, saves, power play or penalty kill, man-to-man fight, and offensive puck carrying between the winning and losing teams.[8] Moreover, other studies found that the opponent's abilities, player skills and agility would also affect the match outcome.[9] These studies provided useful findings regarding key performance factors in ice hockey but failed to inspect teams' playing style when final score-line is considered.

In comparison, research of other team sports has already evaluated how team's playing style is conditioned by different contextual factors.[10] The study on field hockey compared the differences in pass and interception among qualifying teams, mid-table teams and relegated teams.[11] Research into professional basketball showed that the performance characteristics of the team will change when facing different levels of opponents.[12] Recently, studies evaluated the influence of contextual factors and time on playing styles in professional soccer, and found that teams play more aggressively at home, and their offensive actions increase as the season progresses.[13,14] In this vein, exploring the playing style from ice hockey match statistics would reveal the key performance determinants and better support collective decisions on rink.

In helping to achieve this, the aim of the present study was twofold: (i) to identify the key factors that affect ice-hockey match performance under different types of final score-line; and (ii) to describe the team's playing styles via considering the important performance aspects. It was hypothesized that winning teams would outperform the losing in all performance components and teams of different levels exhibit heterogeneous characteristics in key components. Based on the current findings, it is expected that the information help coaches and analysts to reconsider the playing styles of teams and to fine-tune match preparation.

Table 1. Principal component analysis rotated component matrix.

Indicators (Abbreviation)	F1	F2	F3	F4	F5	F6	F7	F8
Power play time on ice (PP TOI)			+0.96					
Power play opportunities (PP Opp)			+0.97					
Shorthanded time on ice (SH TOI)		+0.92						
Times shorthanded (TS)		+0.96						
Penalty minutes (PIM)		+0.66						
Minor penalties (Minor)		+0.92						
Major penalties (Major)				+0.94				
Face-offs (FO)					+0.79			
Penalties drawn (Pen Drawn)			+0.83					
Penalties taken (Pen Taken)		+0.88						
Shots on Net 5v5 (Shots on Net 5v5)	+0.74							
Shots (S)	+0.72							
Shooting percentage (S%)								-0.76
Hits (Hits)								+0.67
Blocked shots (BkS)							+0.62	
Giveaways (GvA)						+0.71		
Takeaways (TkA)						+0.77		
5v5 Save percentage (5V5 Sv%)							+0.85	
Shots against (SA)					+0.51			
Shot attempt differential (SAT)	+0.94							
Shot attempts percentage (SAT%)	+0.94							
Unblocked shot attempt differential (USAT)	+0.97							
Unblocked shot attempts percentage (USAT%)	+0.97							

Notes: F1(shooting chance), F2(unfavorable state), F3(favorable state), F4(major penalties), F5(puck possession regaining ability), F6(puck possession maintaining ability), F7(shot defending ability), F8(aggressive performance)

METHOD

Material

The data of 1271 regular season games played by 31 National Hockey League (NHL) teams during the 2018-2019 season was compiled using publicly available official game reports (https://www.nhl.com/), which resulted in a total of 2542 team observations (each team played 82 games). End-of-regular-season ranking of each team is obtained by the cumulative number of wins of all regular season games. The data used in this study are all sourced from publicly available data websites and do not involve clinical human or animal experiments, thus eliminating any ethical issues.

Performance indicators and procedures

After collecting and cleaning the dataset, we extracted 25 game performance indicators, based on the previous studies[15,16] on NHL match-play performance. They are included in the following categories: goal-related, numerical advantage, penalty and face-offs (see Supplementary Table 1 for detailed definition of all indicators and their abbreviations). The number used to describe time is converted to a float in minutes. Subsequently, all performance indicators are normalized according to the following formula:

$$indicator_{new} = \frac{indicator_{original} \times TOI \ \ (mins)}{60} \quad (1)$$

where $indicator_{original}$ and $indicator_{new}$ represent the number of unnormalized value and normalized value respectively, and *TOI* is the goalie's total ice time in minutes (Since the actual game time may exceed 60 minutes and the goalies stay on the ice for the entire game, the total amount of time the goalies spends on the ice during the game is used as the actual game time), while *60* stands for the total match time.

Statistical analyses

A descriptive statistical analysis was performed to explore the indicators of teams within each performance dimension, account for their rankings within regular season: higher-ranked teams (1-10), middle-ranked teams (11-22) and lower-ranked teams (23-31). All indicators were expressed using the mean and standard deviation.

A cluster analysis was done to group the goal difference generated by Goals for (GF) and Goals against (GA) of the teams, and then the elbow rule[17] and the Silhouette Coefficient[18] were used to select the optimal value of *k* for reference. Subsequently, in order extract the indicators' similarities and describe the playing styles, the principal component analysis (PCA) was used to reduce the dimensions of multi-dimensional data information, merging them into new principal components. The Kaiser–Meyer–Olkin (KMO) measure and Bartlett's test of sphericity after extraction[19] were employed to verify the sampling adequacy for the analysis. Performance indicators with factor loadings greater than |0.6| showed a strong positive or negative correlation and indicated a substantial value for factor interpretation.[20]

After testing the normality assumptions for eight components using the Kolmogorov-Smirnov test, a one-way analysis of variance (ANOVA) was run to compare the differences between teams of goal-difference clusters in each principal component. The partial eta-squared (η_p^2) and Cohen's *d* were used as the resultant effect size (ES) statistics, with the magnitudes of η_p^2 being small (0.01), moderate (0.06), and strong (0.14) effects, and the ones for Cohen's *d* being trivial <0.20, small <0.60, medium <1.2, large <2.0.[21]

To explore the key factors of different teams, the research also multiplies the weights of different levels of teams in different game clusters with the scores of different game clusters on each principal component respectively. Then we add them to obtain the score of different teams in different principal components. The level of significance was set at $p < 0.05$. Based on this, more information about the playing styles of team were obtained. All analyses were performed using the IBM SPSS 25 and Python *pandas*, *numpy*, *sklearn*.

RESULTS

Descriptive statistics results about different teams are illustrated in Supplementary Table 2. The most meaningful solution of *k*-means clustering resulted in the generation of three clusters according to the elbow method (when *k*=3, the within-cluster sum of square is 2488.48). The three cluster centers are 3.08, -3.13 and -0.01, and their Silhouette Coefficient is 0.602. The study labeled the games with a positive goal difference 2.31±1.31 as unbalanced winning match; the games with the goal difference of -1.10±0.72 as balanced match; and the ones with -3.64±0.88 goal differences as unbalanced losing match. In the order

Supplementary Table1(a). Related indicators used in the study and their definitions.

No.	Indicators	Abbreviations	Definition
1	Goals For	GF	the total goals scored by a team
2	Goals Against	GA	the total goals allowed by a team
3	Power play time on ice	PP TOI	the time on ice that a player spends in power play situations, when his team has a man advantage on the opposing team
4	Power play opportunities	PP Opp	number of chances a team has to score on the power play
5	Shorthanded time on ice	SH TOI	the time on ice that a player spends in shorthanded, or penalty killing, situations
6	Times shorthanded	TS	number of chances a team's opponent has to score on the power play
7	Penalty minutes	PIM	a total of all penalty minutes
8	Minor penalties	Minor	a more severe penalty which the offending player is penalized for 5 minutes
9	Major penalties	Major	a penalty which the offending player being sent to the penalty box for 2 minutes
10	Face-offs	FO	number of face-off draws taken by the player
11	Penalties drawn	Pen Drawn	number of penalties drawn by the player
12	Penalties taken	Pen Taken	number of penalties taken by the player
13	Shots on Net 5v5	Shots on Net 5v5	the number of shots on goal taken by a player or team when both sides have 5 players on ice
14	Shots	S	the number of shots on goal taken by a player or team
15	Shooting percentage	S%	the percentage of shots on goal (by a team or player) that go in the net, calculated as goals divided by shots

Note: The No.1and the No.2 are used for clustering, and the rest are used for PCA.

of regular season rankings, the proportion of all games of each team in different clusters is illustrated in Figure 1.

After confirming that no linear correlation existed between indicators, a principal component analysis was performed, obtaining a KMO value of 0.686 and a cumulative contribution rate of 81.94%. The eight principal components based on how much each variable contributes to the principal component with eigenvalues (λ_0) greater than one were labeled as follows: shooting chance (F1: λ_0 =5.76, Variance%=25.05, Cumulative Variance%=25.05), unfavorable state (F2: 4.68, 20.35, 45.40), favorable state (F3:2.18, 9.50, 54.90), major penalties (F4:1.43, 6.22, 61.12), puck possession regaining ability (F5:1.40, 6.08, 67.20), puck possession maintaining ability (F6:1.26, 5.47, 72.66), shot defending ability (F7:1.09 4.74, 77.40), aggressive performance (F8:1.04, 4.53, 81.94). Table 2 depicts the rotated component matrix of the 8 components. Lower scores in F2, F4 and F8 represent better performance in these components.

The result of one-way ANOVA shows significant differences (p<0.05) in five principal components: unfavorable state (F=8.35, p<0.001, η_p^2 =0.01), major penalties (F=9.70, p<0.001, η_p^2 =0.01), puck possession maintaining ability (F=23.86, p<0.001, η_p^2 =0.02), shot defending ability (F=333.17, p<0.001, =0.21), aggressive performance (F=475.17, p<0.001, η_p^2 =0.27). All results passed the Bonferroni method for post-hoc test.

The results of the multiple comparisons between groups used Cohen's d as the effect size are reported in Figure 2, which illustrated intuitively the strength of the effect among unfavorable state (ES = 0.13, 95%CI = [0.03,0.24]; ES = 0.22, 95%CI = [0.11,0.33]), major penalties (ES = 0.22, 95%CI = [0.11,0.34]; ES = 0.15 , 95%CI = [0.06,0.24]), puck possession maintaining ability (ES = 0.35, 95%CI = [0.25,0.46]; ES = 0.16, 95%CI = [0.05,0.27]; ES = 0.19, 95 %CI = [0.10,0.28]), shot defending ability (ES = 1.25, 95%CI = [1.13,1.36]; ES = 0.47, 95%CI = [0.36,0.58]; ES = 0.80, 95%CI = [0.71,0.89]) and aggressive performance (ES = 1.41, 95%CI = [1.30,1.52]; ES = 0.44, 95%CI = [0.33,0.55]; ES = 1.05, 95%CI = [0.95,1.14]).The scores of different level teams are shown in Figure 3, which can see the similarities and differences in different principal components of different levels of teams.

DISCUSSION

Team performance under distinct final goal situations in the NHL 2018-2019 season was investigated, combining the playing style classification and description. The study extends the earlier research from the following aspects: First, the balanced and unbalanced games (winning and losing) were classified by clustering associated with goal differences. Second, unfavorable state (F2), major penalties (F4), puck possession

Supplementary Table1(b). Related indicators used in the study and their definitions.

No.	Indicators	Abbreviations	Definition
16	Hits	Hits	the number of body checks delivered by a player on the opposing team's puck carrier
17	Blocked shots	BkS	it occurs when an opponent's shot attempt is blocked by a skater, with his stick or body
18	Giveaways	GvA	a form of turnover where the player makes an unforced error that results in giving the puck up to the opposition
19	Takeaways	TkA	a form of turnover in which the player takes the puck from the opposition, rather than gaining possession through an opposition error
20	5v5 Save percentage	5V5 Sv%	the percentage of shots on goal that a goalie prevents from going in his team's net when both sides have 5 players
21	Shots against	SA	the number of shots on goal against a goalie or a team
22	Shot attempt differential	SAT	also known as Corsi, is a plus-minus statistic that measures shot attempts instead of goals
23	Shot attempts percentage	SAT%	the percentage of shot attempts that the team takes out of total shot attempts
24	Unblocked shot attempt differential	USAT	also known as Fenwick, is a plus-minus statistic that measures unblocked shot attempts instead of goals
25	Unblocked shot attempts percentage	USAT%	the percentage of unblocked shot attempts that the team takes out of total unblocked shot attempts

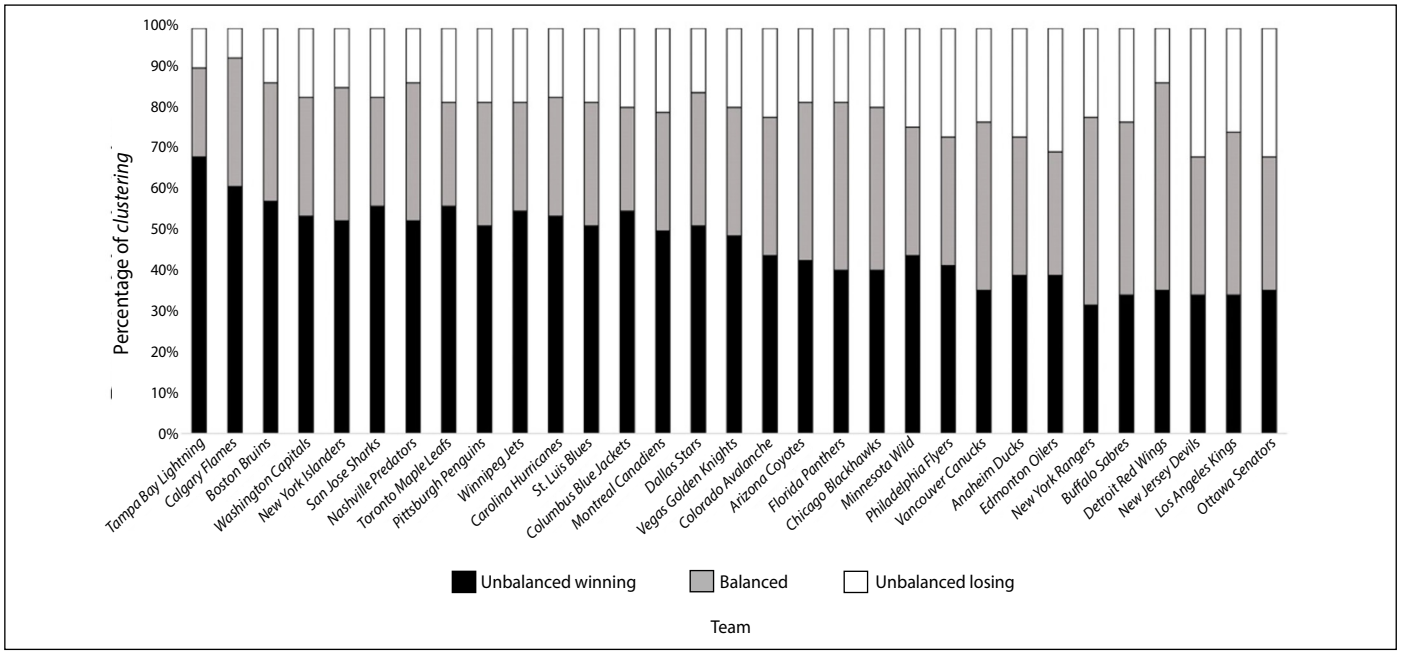

Figure 1. Stacked column chart of the percentage of each teams' cluster category (sorted from left to right by season ranking).

Table 2. Descriptive statistics of three types of team variables.

Indicators (Abbreviation)	Higher-ranked team	Middle ranked team	Lower ranked team
	Mean (SD)	Mean (SD)	Mean (SD)
Power play time on ice (PP TOI)	4.9 (2.5)	5.0 (2.5)	4.7(2.5)
Power play opportunities (PP Opp)	3.0 (1.5)	3.0(1.4)	2.8(1.4)
Shorthanded time on ice (SH TOI)	4.9 (2.5)	4.8 (2.4)	5.0(2.5)
Times shorthanded (TS)	2.9 (1.4)	2.9 (1.4)	3.0(1.4)
Penalty minutes (PIM)	8.6 (6.8)	7.7 (4.9)	8.7(6.0)
Minor penalties (Minor)	3.2 (1.6)	3.1 (1.5)	3.2(1.6)
Major penalties (Major)	0.20 (0.5)	0.2 (0.4)	0.20(0.5)
Face-offs (FO)	58.56 (7.5)	59.6 (7.2)	58.7(7.7)
Penalties drawn (Pen Drawn)	3.7 (1.9)	3.5 (1.8)	3.5(1.8)
Penalties taken (Pen Taken)	3.6 (1.9)	3.4 (1.7)	3.6(1.9)
Shots on Net 5v5 (Shots on Net 5v5)	25.3 (6.1)	25.8 (6.3)	23.4(5.8)
Shots (S)	31.9 (6.8)	32.5 (7.1)	29.8(6.6)
Shooting percentage (S%)	10.7 (6.2)	9.3 (5.6)	9.3(5.7)
Hits (Hits)	21.7 (8.1)	22.5 (7.8)	22.8(7.4)
Blocked shots (BkS)	13.9 (4.7)	14.4 (4.8)	14.5(4.8)
Giveaways (GvA)	10.2 (5.0)	9.2 (5.2)	10.0(5.1)
Takeaways (TkA)	8.2 (4.1)	8.1 (4.3)	6.8(3.8)
5v5 Save percentage (5V5 Sv%)	92.0 (6.0)	91.8 (6.2)	91.3(6.2)
Shots against (SA)	31.0 (6.7)	30.6 (6.7)	32.8(6.7)
Shot attempt differential (SAT)	2.4 (14.4)	2.1(15.1)	-4.6(14.7)
Shot attempts percentage (SAT%)	51.3 (8.0)	51.1 (8.4)	47.5(8.2)
Unblocked shot attempt differential (USAT)	1.5(11.3)	1.8 (11.7)	-3.4(11.6)
Unblocked shot attempts percentage (USAT%)	51.1 (8.4)	51.3 (8.8)	-47.5(8.6)

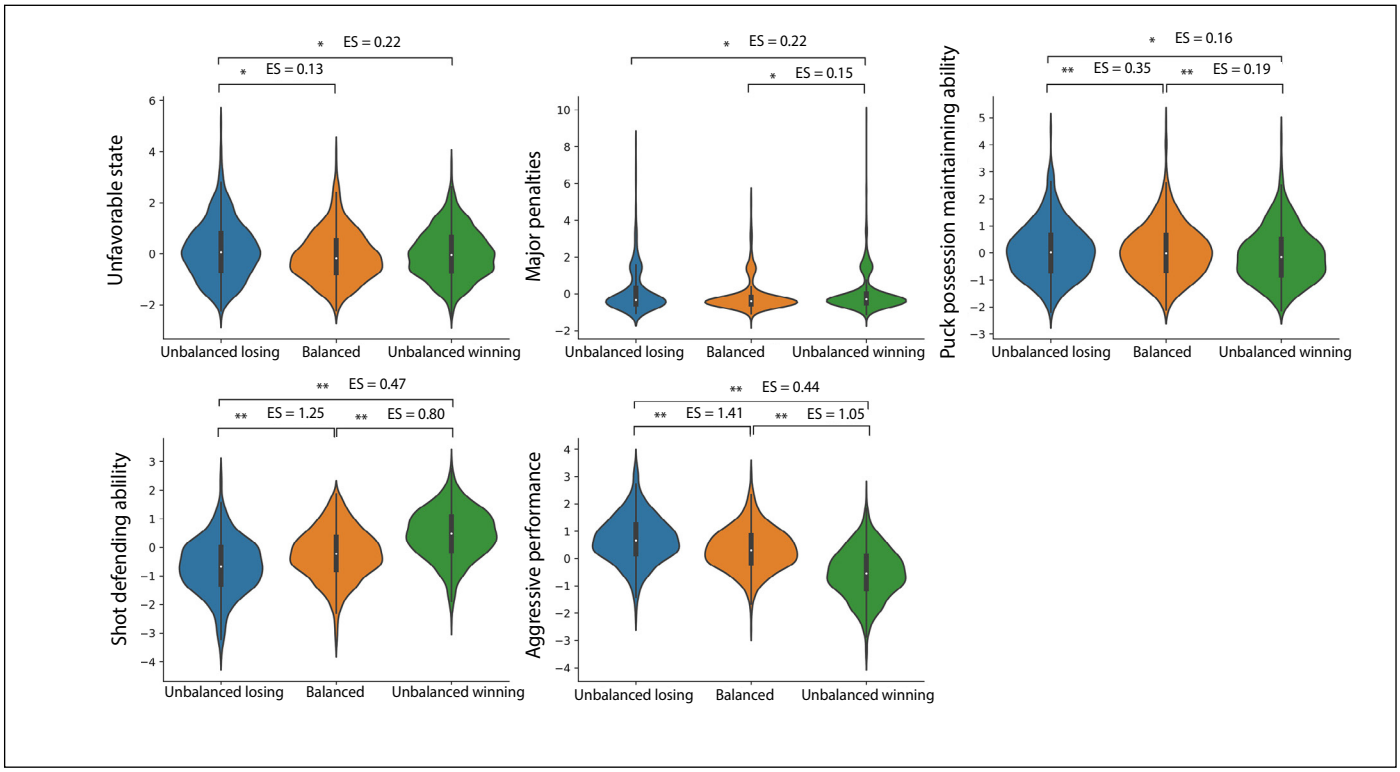

Figure 2. Comparison of unfavorable state (F2), major penalties (F4), puck possession maintaining ability (F6), shot defending ability (F7) and aggressive performance (F8) on Different Goal Differences (The result of multiple comparison * is p<0.05, ** is p<0.01, ES is the effect size.)

maintaining ability (F6), shot defending ability (F7), and aggressive performance (F8) were identified as five key performance determinants that characterized teams' match-play.

Clustering the teams by their goal difference showed higher-ranked teams had the highest proportion of unbalanced winning games, which implies that more competent team often outperformed its opponent and achieved a positive goal difference. Previous studies either used an approach in which the groups of goal-difference were identified via labelling match outcome with a binary status (plus and minus),[6,16] or directly classified the groups based on the final score-line, i.e., -2, -1, 0, 1, 2.[22] Compared to these previous approaches, data mining method seems to be more capable of objectively classifying the goal difference.

The current work constructed 8 components that represent team performance in scoring opportunities, numerical advantage, puck control

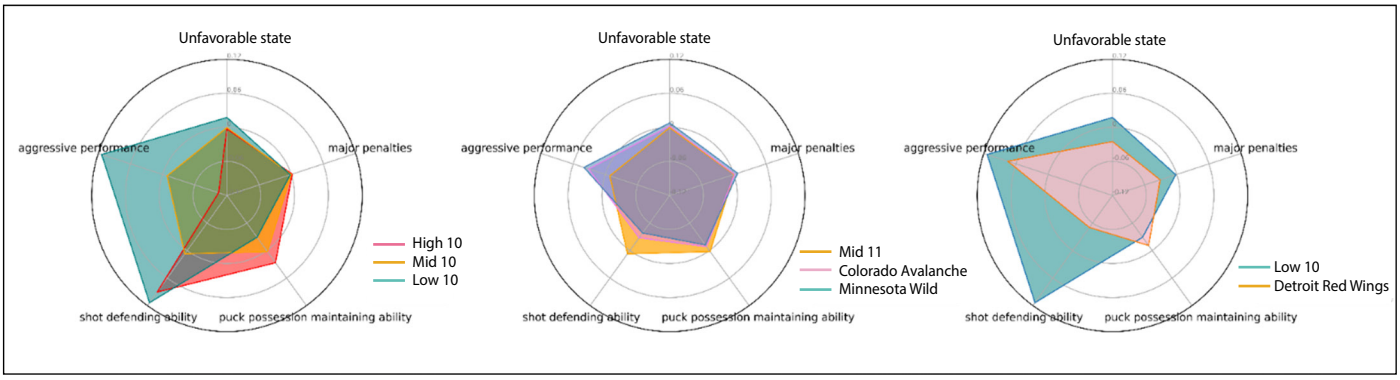

Figure 3. Playing style comparison of different level of teams, Colorado Avalanche and Minnesota Wild in middle-ranked teams and Detroit Red Wings in lower-ranked teams. (The colored areas display the cluster (or team) scores for each principal component).

during offense and defense. Among them, five components were finally determined as the key performance factors that distinguished three goal--line groups. The unfavorable state (F2) can be interpreted as the lack of players on the rink caused by penalties, which led to vulnerable situation for teams.[16] To confirm the finding, previous study reported that 10 minutes in penalties against a player could result in as many as one goal for opponents.[4] This may further explain the reason that the major penalties (F4), which means longer penalty times, was singled out as an important factor. In line with the study's hypothesis, teams that won unbalanced games showed better performance in these key performance components. Their comparatively lower scores in F2 and F4 could be explained by the fact that they dominated the puck possession in the game to apply pressure on the opponents, forcing them to commit extra fouls.[23] Moreover, GvA and TkA were converted into puck possession maintaining ability (F6), which is similar to "puck carrying" previously defined in other research.[8] In terms of shot defending ability (F7), relevant study verified its capability of measuring defensive performance.[15] In line with Koo, et al. (2016)[6] who found the winning team performed higher blocks and take-aways than the opponents, the study also evidenced that the teams winning more unbalanced games obtained higher scores in puck possession maintaining ability (F6) and shot defending ability (F7).

Shooting chance (F1), favorable state (F3) and puck possession regaining ability (F5) were not shown to influence the final goal difference. Although the shooting chance (F1) accounts for a quarter of total variance, it is primarily characterized by variables such as shots, USAT and SAT that may not be representative of the discrepancy between team performances. Such evidence implies that scoring is not determined by the number of shot attempts but rather the accuracy,[24] which is different from the previous study that found a high correlation between scoring opportunities and goal conversion (Koo et al., 2016).[6] The information contained in favorable state (F3) and puck possession regaining ability (F5) may be explained by the indicators described above. Therefore, we confirm the assumption that different level teams perform differently in key factors.

The current results also provide further evidence to help explore the playing style, as teams of different levels exhibited displayed efficient, balanced and risky playing styles shown by Figure 3. These playing styles are similar with previous work in other invasion sports that identify playing styles based on the different moments in whole match,[25] such as set-piece, established offense, transition to offense; or the different zone of pitch,[26] such as attacking and defending thirds, central and wide areas. In the study, an efficient playing style is characterized by relative dominance in aggressive performance (F8) and puck possession maintaining (F6), because these factors could explain that the teams choose to commence their attack in the oppositions defensive area and shoot near the goal to increase the accuracy.[7,27] Meanwhile, risky style is demonstrated by high shot defending ability (F7) and unfavorable state (F4), which may imply that the teams face great defensive pressure. Finally, teams balanced playing style usually exhibited an equilibrium in all factors. Therefore, low scores obtained in unfavorable state (F2) and major penalties (F4) by teams of such style may tend to play conservatively to reduce the risk of conceding goals. In a word, the present findings suggest that ice hockey teams showed different playing style characteristics.

Despite the study provides novel knowledge about the key performance determinants of professional ice-hockey match performance, there are some limitations to be acknowledged. A traditional way was used to classify the team, and the classification method of team quality can be further studied in the follow-up.[28] Additionally, potentially varying changes of physical training and psychological quality under different context were not considered.[29]

The main findings of this study will inform ice-hockey coaches and performance analysts the key technical-tactical determinants during competitive match-play and refine match preparation against opponents of different playing styles. As for practical application, it is suggested to prioritize the training of different types of shots and to diversify the drills in terms of skating speed, presence of defense/goalie, shoot location, and collective passes. On the other hand, collective defensive movements that lead to successful blocks and takeaways during shorthanded situations should be reinforced.

CONCLUSION

This study identified five key performance determinants that differentiate between balanced match, unbalanced winning match and losing match in the professional ice-hockey competitions. A further exploration of the playing style based on these determinants indicated that teams showing favorable performance in defensive ability, consistent possession skills and high shooting accuracy tend to finish with a higher league ranking. The findings implied that teams should attach more importance to the offensive skills and control of penalties.

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