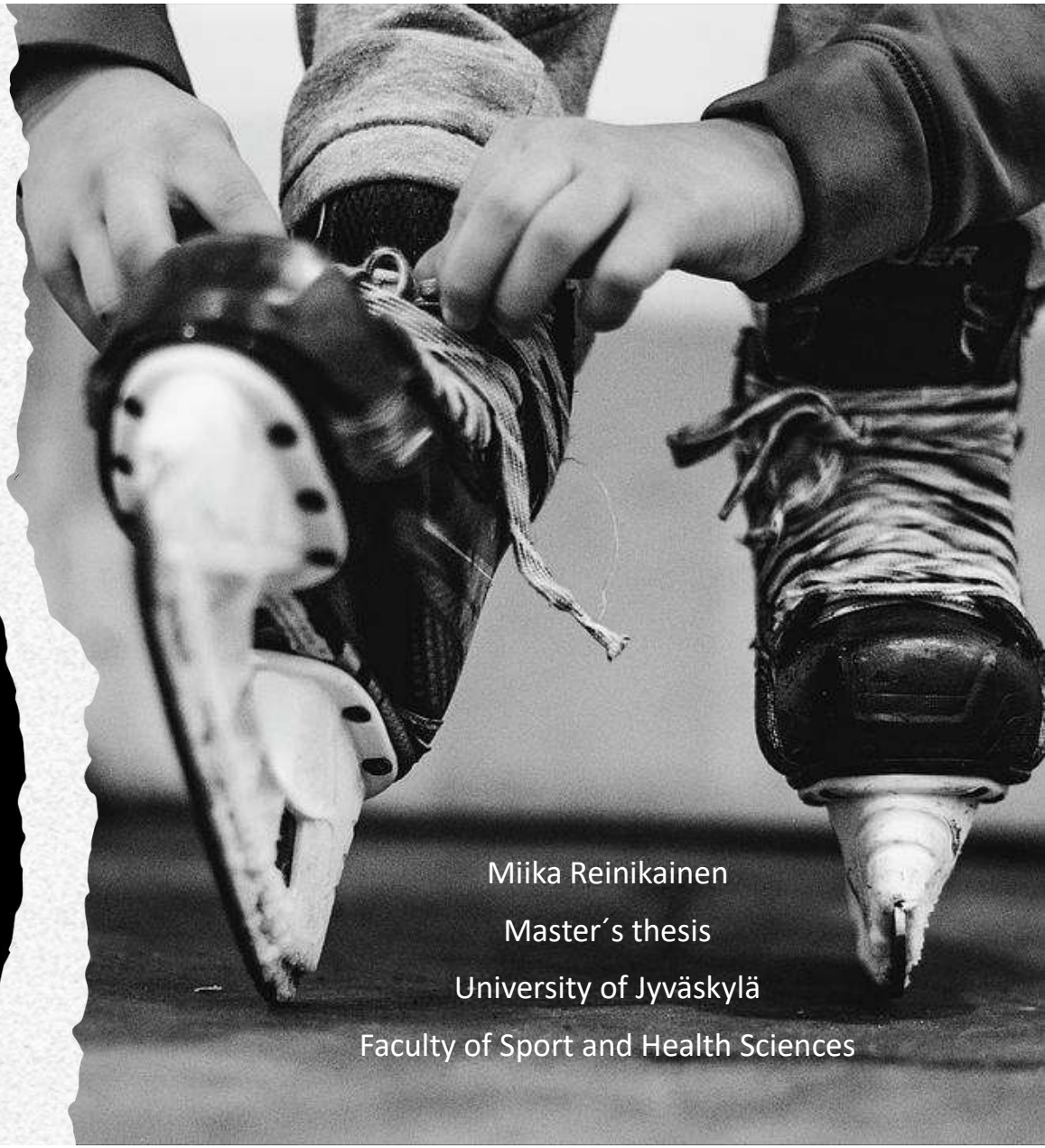
In-season variation of skating load at different playing positions in male elite ice hockey

A single season longitudinal study

24.2.2022



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Master´s thesis

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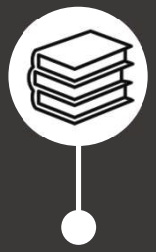

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Backround

- Part of larger Hockey Load-research project of Marko Haverinen in University of Jyväskylä
- Lack of prior research regarding to a full-season of ice hockey specific training load
- Previous studies have not examined the effect of playing position so extensively.

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Theory behind
Playing position differences

Physical qualities:

- In general, defensemen are taller and heavier than forwards (Montgomery 1988; Quinney et al. 2008; Vescovi et al. 2006)
- Defensemen have higher overall power production (Burr et al. 2008)
- Players have similar ability to withstand fatigue (Burr et al. 2008)
- Similar on-ice VO_{2max} (Ferland et al. 2021)

Sport specific performance:

- Defensemen skate more meters per match (Douglas and Kennedy 2019; Lignell et al. 2018)
- Forwards skate more meters per minute (Lignell et al. 2018)
- Forwards skate more at high-intensity speeds (>21 km/h) (Lignell et al. 2018)

Theory behind

Fatigue increases during the match

- Skating intensity and distance seem to drop towards the later phases of the match (Brocherie et al. 2018; Douglas and Kennedy 2019)
- Duration and frequency of the sprints decrease in the latter periods (Brocherie et al. (2018)
- ~10% drecrease of explosive efforts high-intensity accelerations, decelerations and change of directions (Vigh-Larsen et al. (2020)

Theory behind

What causes changes in high-intensity performance?

Acceleration

- Sprints are short in duration – few seconds (Spencer et al. 2005)
- 50% of the total work done intantaneously during acceleration phase (Cavagna et al. 1971)
- Short sprints done intermittently has 3-7 times larger energy cost than "linear running" (Zamparo et al. 2015) and even low-intensity accelerations have high metabolic load (Buglione & di Prampero 2013)

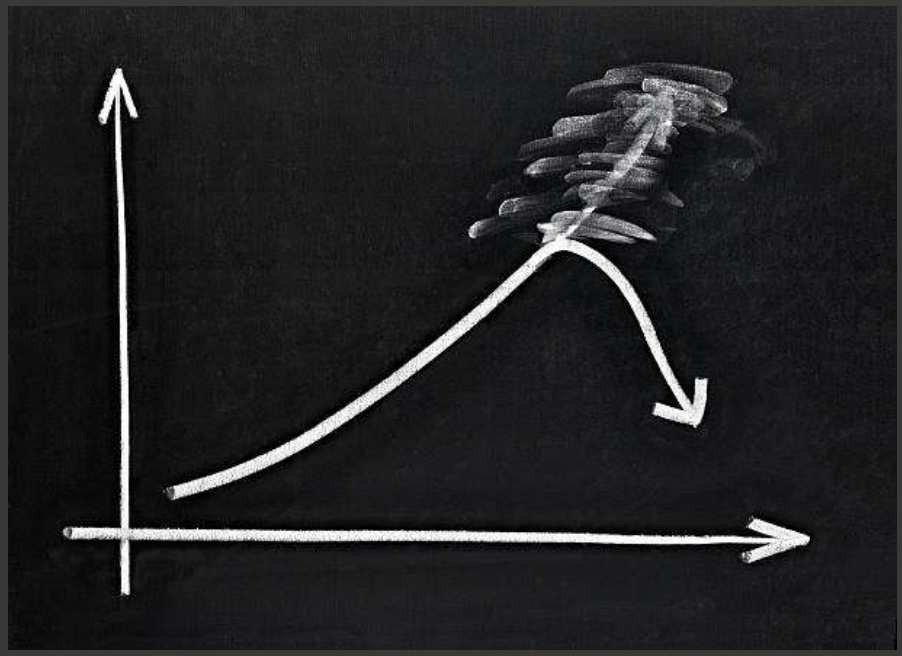
Deceleration

- Duration of high-intensity decelerations last less than 1 second (Bloomfield et al. 2007)
- Mechanical load higher than any other match activity (Terje et al. 2016)
- Repeatedly done affecting muscle damage (Guilhem et al. 2016)

Theory behind

Prolonged effect of ice hockey specific load to performance

- **Fitness deteriorate the latter half of the season:**
  - Increased body fat %, heart rate during prolonged exercise, and post-exercise lactate levels (Delisle-Houde et al. 2017)
  - Decrease of skating velocity at lactate threshold and VO_{2max} value (Durocher et al. 2008)
  - Deterioration of counter movement jump depth (Whitehead et al. 2019)
  - Lower mean power output during repeated high-intensity exercise (Laurent et al. 2014)
  - Decrease of cross-sectional area of different muscle fiber types with no effect on muscle capillaries surrounding muscle fibers (Green et al. 2010)



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Purpose

- To measure skating load in Finnish elite league ice hockey players across the competitive season and evaluate possible changes in different skating variables in different phases of the season (Q1 – Q4) by playing positions (C, W, D).
- To study differences between playing positions (C, W, D) through skating load metrics across the season. To author´s knowledge, this is the first longitudinal study to measure ice hockey players´ playing positional skating metrics during the whole competitive season.

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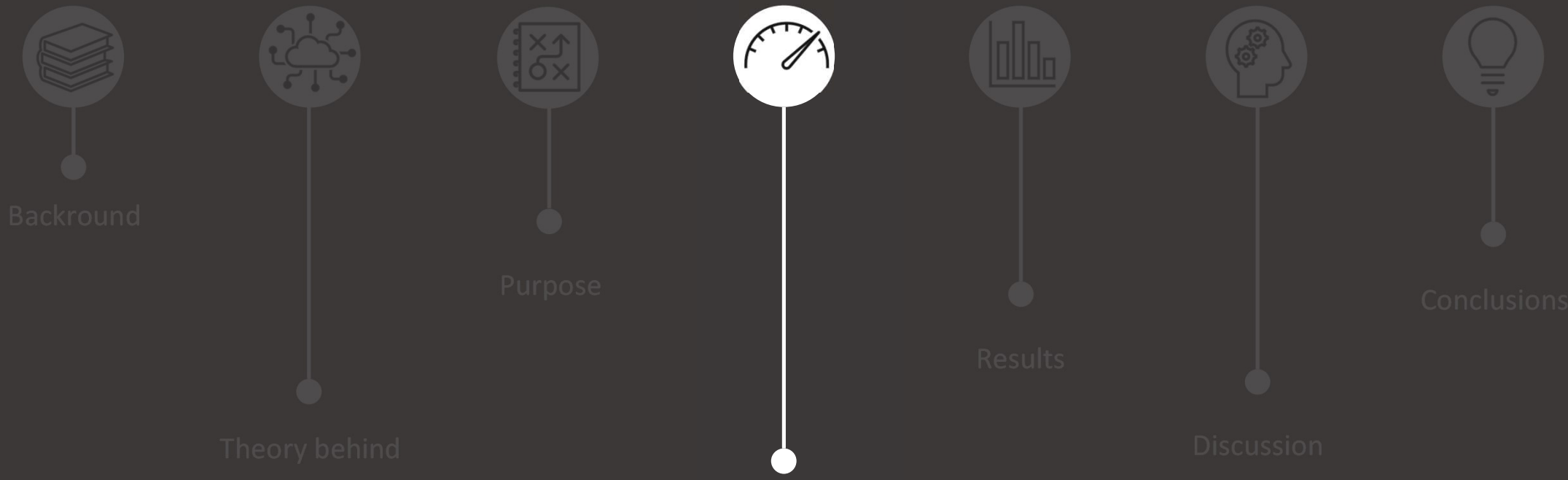
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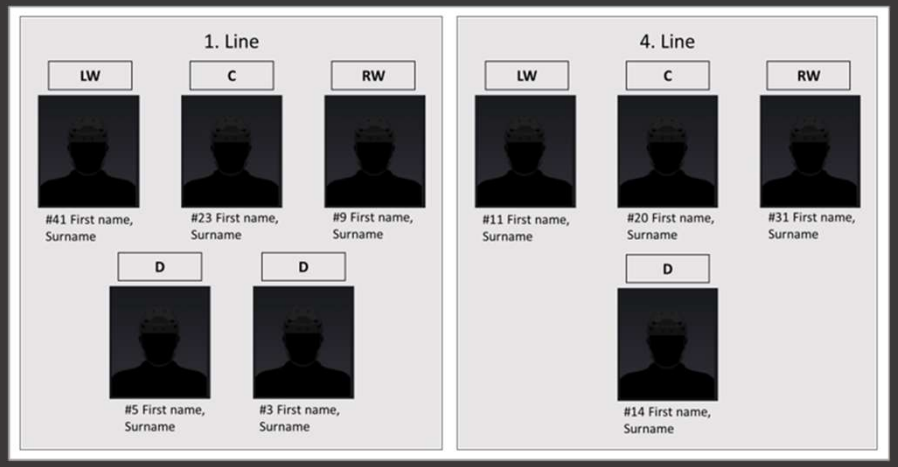
Methods
Participants

N = 146 players (from 9 teams)
(age 17 - 39 years, mean age 25.7 ± 5.1 years)

3 subgroups based on playing position:
- centers (n = 27),
- wingers (n = 70),
- and defensemen, (n = 49)

Playing position information collected from Liiga.fi-website



Methods
Season phases

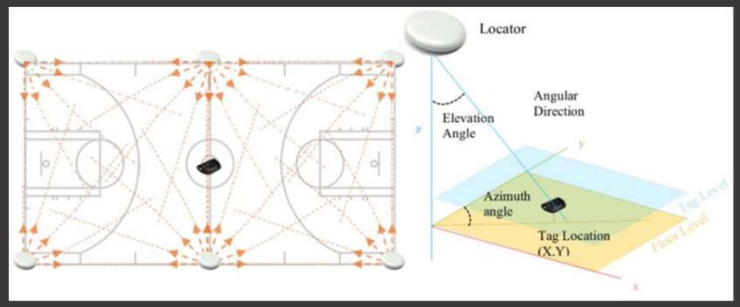
4 season quarters

Season quarters	Timeline	Matches included
Q1	13.9.2019 – 2.11.2019	115
Q2	12.11.2019 – 13.12.2019	73
Q3	18.12.2019 – 7.2.2020	105
Q4	12.2.2020 – 12.3.2020	79
Total	13.9.2019 – 12.3.2020	372

No playoffs due to Covid19 pandemic.

Methods
Data collection

The skating data was collected by Bitwise Corporation via Wisehockey analytics platform



Figueira et al. 2018

Bluetooth-based positioning tag modules were installed in the player´s jerseys

Original/raw data vs modified data

Original data

Team	Player	Period	Time on ice (min:s)	Time on ice (s)	Distance (m)	Distance/Time (m/min)	Velocity mean (km/h)	Velocity max (km/h)
<Team name>	<Player name>	1	0:43	43	218.92278659710377	304.2002592826824	18.251823704425743	30.746731462970025

Single shift

Modified data

P#	Position	Season phase	Time on ice (s) Q1	Distance (m) Q1	Distance/Time (m/min) Q1	Velocity mean (km/h) Q1	Velocity max (km/h) Q1
P89	W	1	30,96774194	115,1420225	234,3213498	14,05780448	23,91418936

Season phase average

Methods
Skating variables

14 skating variables

Main variable	Variable	Units
Accelerations / decelerations	Accelerations over 0.5 sec threshold limits per shift	quantity
	Decelerations over 0.5 sec threshold limits per shift	quantity
	Accelerations in different threshold ranges per shift	quantity
	Decelerations in different threshold ranges per shift	quantity
Time	Time on ice per shift	s
	Time on ice per match	min:s
	Relative time in different velocity ranges per shift	%
	Time in different velocity ranges per shift	s
Distance	Distance on ice per shift	m
	Distance on ice per match	m
	Distance in different velocity ranges per shift	m
Skating velocities	Maximum velocity per shift	km/h
	Mean skating velocity per shift	km/h
	Number of over 1 sec visits over different velocity limits per shift	quantity

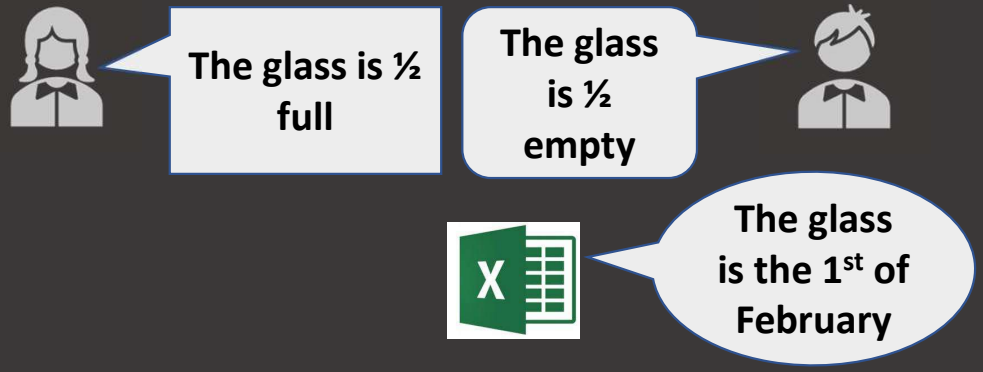
Acceleration and deceleration thresholds

Descriptor		Thresholds (m/s^2)	
		Limits	**Ranges**
Accelerations	Maximal acceleration	≥ 3	≥ 3
	High-intensity acceleration	≥ 2	≥ 2 - < 3
	Intermediate acceleration	≥ 1	≥ 1 - < 2
	Low-intensity acceleration	≥ 0	> 0 - < 1
Decelerations	Low-intensity deceleration	≤ 0	< 0 - < -1
	Intermediate deceleration	≤ -1	≤ -1 - < -2
	High-intensity deceleration	≤ -2	≤ -2 - < -3
	Maximal deceleration	≤ -3	≤ -3

Skating intensity thresholds

Descriptor		Thresholds (km/h)	
		Limits	**Ranges**
Low-intensity skating	Very low-speed skating	≥ 0	0 - < 5
	Slow-speed skating	≥ 5	≥ 5 - < 10
	Moderate-speed skating	≥ 10	≥ 10 - < 15
High-intensity skating	High-speed skating	≥ 15	≥ 15 - < 20
	Very high-speed skating	≥ 20	≥ 20 - < 25
	Sprint skating	≥ 25	≥ 25

Methods
Statistical analysis



- Tools: Microsoft Excel and IBM SPSS Statistics
- Data normality was checked by using a Shapiro-Wilk for centers and defensemen, and Kolmogorov-Smirnov test for wingers
- Main effects and possible interactions were examined by using repeated-measures ANOVA (statistical significance was set at $p \leq 0.05$)
- Bonferroni post-hoc test was used to outline the differences between season quarters or playing positions (statistical significance ($p < 0.001$, $p < 0.01$, $p < 0.05$)

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Prolonged accelerations & decelerations

Short accelerations & decelerations

Other skating metrics

Main variable	Variable	Units
Accelerations / decelerations	Accelerations over 0.5 sec threshold limits per shift	quantity
	Decelerations over 0.5 sec threshold limits per shift	quantity
	Accelerations in different threshold ranges per shift	quantity
	Decelerations in different threshold ranges per shift	quantity
Time	Time on ice per shift	s
	Time on ice per match	min:s
	Relative time in different velocity ranges per shift	%
	Time in different velocity ranges per shift	s
Distance	Distance on ice per shift	m
	Distance on ice per match	m
	Distance in different velocity ranges per shift	m
Skating velocities	Maximum velocity per shift	km/h
	Mean skating velocity per shift	km/h
	Number of over 1 sec visits over different velocity limits per shift	quantity

Results
Changes in performance

Prolonged accelerations & decelerations

Main variable	Variable	Units
Accelerations / decelerations	Accelerations over 0.5 sec threshold limits per shift	quantity
	Decelerations over 0.5 sec threshold limits per shift	quantity
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	Decelerations in different threshold ranges per shift	quantity
Time	Time on ice per shift	s
	Time on ice per match	min:s
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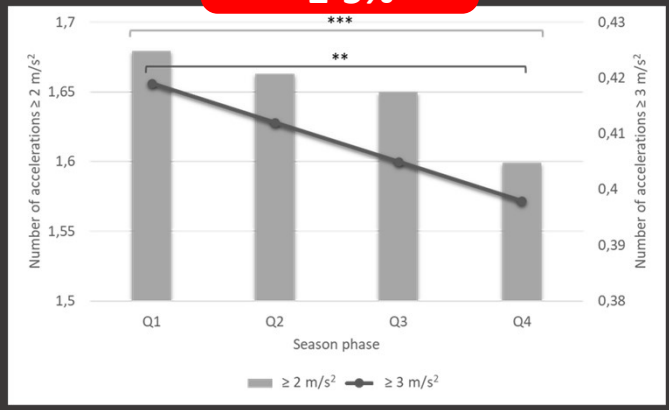
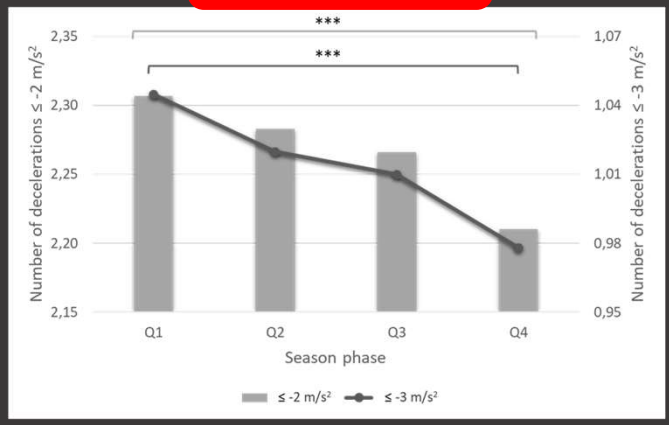
	Time in different velocity ranges per shift	s
Distance	Distance on ice per shift	m
	Distance on ice per match	m
	Distance in different velocity ranges per shift	m
Skating velocities	Maximum velocity per shift	km/h
	Mean skating velocity per shift	km/h
	Number of over 1 sec visits over different velocity limits per shift	quantity

Accelerations - 2-5%



Decelerations - 3-6%

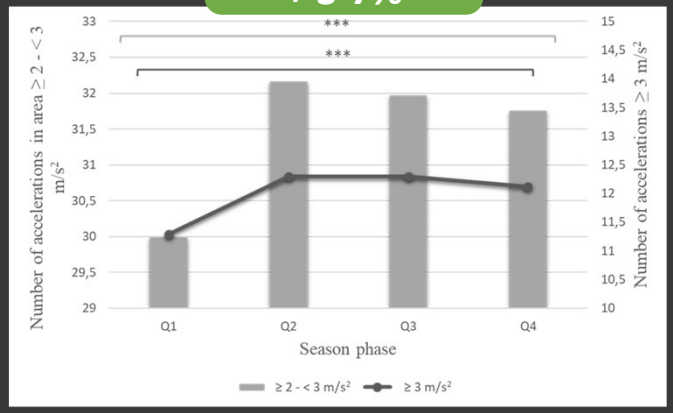


Results
Changes in performance

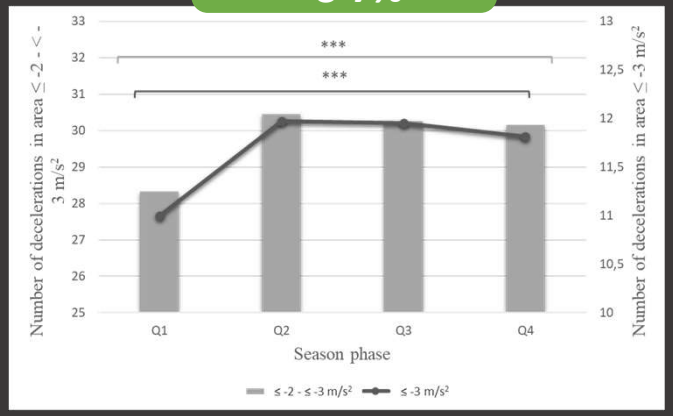
Short accelerations & decelerations

Main variable	Variable	Units
Accelerations / decelerations	Accelerations over 0.5 sec threshold limits per shift	quantity
	Decelerations over 0.5 sec threshold limits per shift	quantity
	Accelerations in different threshold ranges per shift	quantity
	Decelerations in different threshold ranges per shift	quantity
Time	Time on ice per shift	s
	Time on ice per match	min:s
	Relative time in different velocity ranges per shift	%
	Time in different velocity ranges per shift	s
Distance	Distance on ice per shift	m
	Distance on ice per match	m
	Distance in different velocity ranges per shift	m
Skating velocities	Maximum velocity per shift	km/h
	Mean skating velocity per shift	km/h
	Number of over 1 sec visits over different velocity limits per shift	quantity

Accelerations + 3-7%



Decelerations + 3-7%



Results
Changes in performance

Other skating metrics

Main variable	Variable	Units
Accelerations / decelerations	Accelerations over 0.5 sec threshold limits per shift	quantity
	Decelerations over 0.5 sec threshold limits per shift	quantity
	Accelerations in different threshold ranges per shift	quantity
	Decelerations in different threshold ranges per shift	quantity
Time	Time on ice per shift	s
	Time on ice per match	min:s
	Relative time in different velocity ranges per shift	%
	Time in different velocity ranges per shift	s
Distance	Distance on ice per shift	m
	Distance on ice per match	m
	Distance in different velocity ranges per shift	m
Skating velocities	Maximum velocity per shift	km/h
	Mean skating velocity per shift	km/h
	Number of over 1 sec visits over different velocity limits per shift	quantity

~ 3% ($p<0.05$) more relative time in the lowest velocity range (0 - < 5 km/h) in Q1 vs Q3

~ 5% ($p<0.01$) more time in the lowest velocity range (0 - < 5 km/h) in Q1 vs Q3

2% ($p<0.05$) less visits over the limit ≥ 15 km/h in Q1 vs Q2

2% ($p<0.05$) less visits over the limit ≥ 20 km/h in Q3 vs Q4

Results
Changes in performance

Other skating metrics

Main variable	Variable	Units
Accelerations / decelerations	Accelerations over 0.5 sec threshold limits per shift	quantity
	Decelerations over 0.5 sec threshold limits per shift	quantity
	Accelerations in different threshold ranges per shift	quantity
	Decelerations in different threshold ranges per shift	quantity
Time	Time on ice per shift	s
	Time on ice per match	min:s
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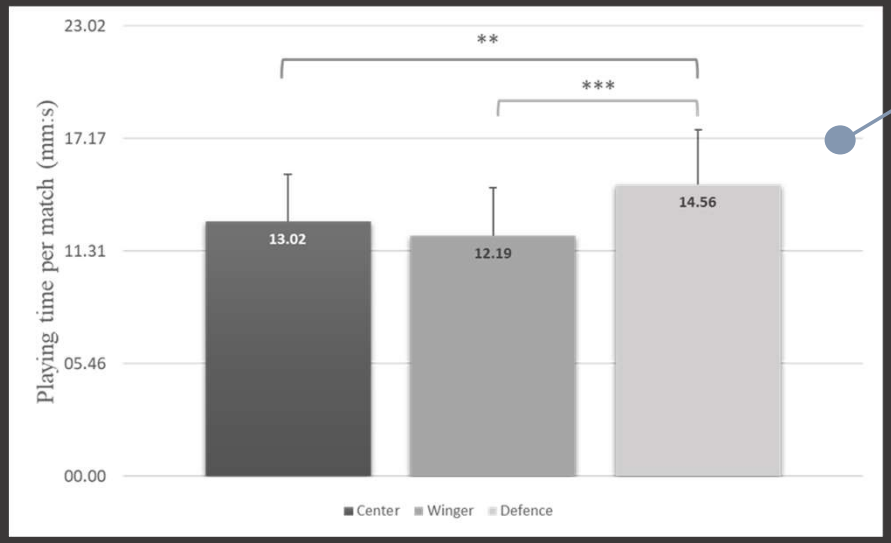
	Time in different velocity ranges per shift	s
Distance	Distance on ice per shift	m
	Distance on ice per match	m
	Distance in different velocity ranges per shift	m
Skating velocities	Maximum velocity per shift	km/h
	Mean skating velocity per shift	km/h
	Number of over 1 sec visits over different velocity limits per shift	quantity

All the players had identical result: 0.5 visits per shift

	Km/h	Playing position	Q1	Q2	Q3	Q4	F-value[a]	P
tensity skating	≥ 0	Center	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	N/A	
		Winger	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0		
		Defence	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0		
	≥ 5	Center	3.13 ± 0.36	3.14 ± 0.35	3.08 ± 0.28	3.10 ± 0.32	(2.916, 417.011) = 2.625,	
		Winger	3.26 ± 0.30	3.26 ± 0.31	3.21 ± 0.30	3.19 ± 0.34		
		Defence	3.41 ± 0.33	3.40 ± 0.35	3.39 ± 0.36	3.38 ± 0.33		

Results
Observed playing position differences

* = p<0.05
** = p< 0.01
*** = p<0.001

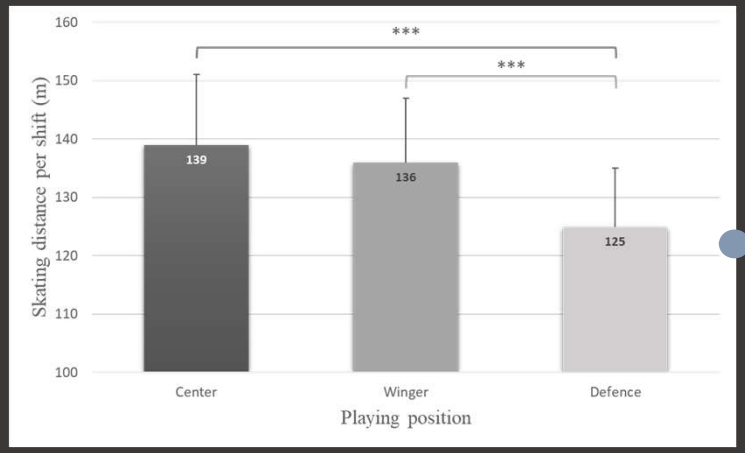


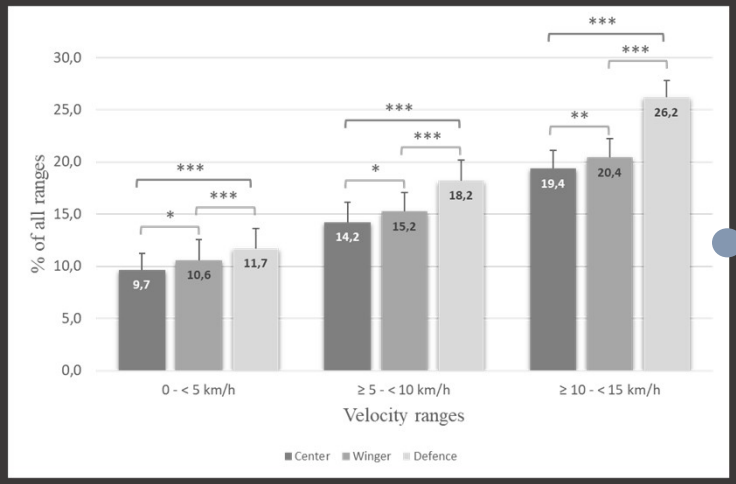
Defensemen

- spent ~13% more time on ice per match compared to centers and ~18% more time on ice than wingers
- spent more relative and absolute time in low-intensity speeds
- skated 8% more distance per match than wingers
- had 5-8% more visits at the ≥ 5 km/h and 10-13% more visits at the ≥ 10 km/h limit than forwards

* = p<0.05
** = p< 0.01
*** = p<0.001

Results
Observed playing position differences





Forwards made more high-intensity decelerations and skated more in high-intensity and sprint skating speeds, and skated more meters per shift than defensemen.

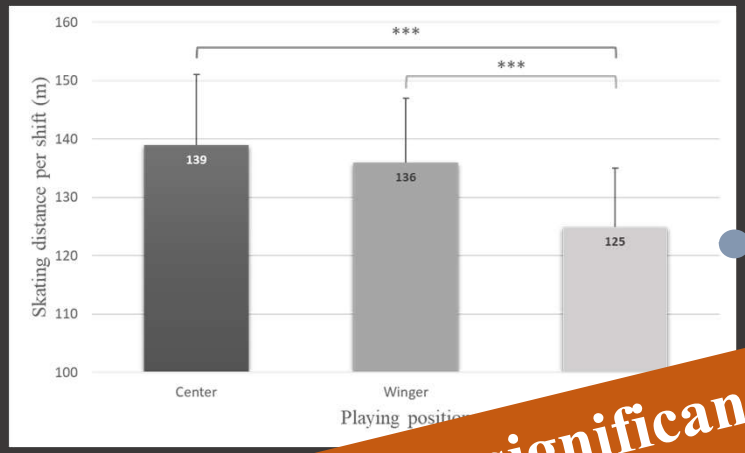
Centers outperformed wingers:

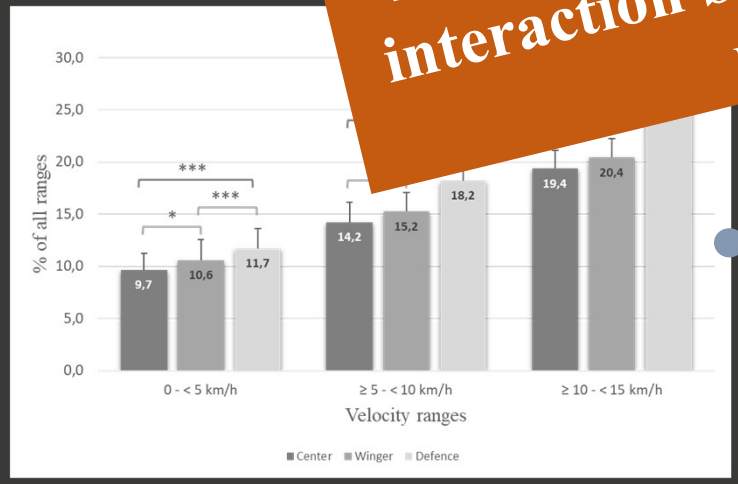
- higher relative skating time in high-intensity (8%) and sprint speeds (12%)
- absolute skating time in high-intensity (6%) and sprint speeds (13%)
- more very high-intensity speed meters (7%)
- higher mean skating speed per shift (3%).

Wingers had 5-9% higher relative skating time in low-intensity skating speeds (< 15 km/h) than centers.

Results
Observed playing position differences

* = p<0.05
** = p< 0.01
*** = p<0.001





No significant differences found within interaction between season quarters and playing position

Forwards made more high-intensity decelerations and skated more in high-intensity and sprint skating speeds, and skated more meters per shift than defensemen.

- high-intensity
- ime in high-intensity (6%)
- sprint speeds (13%)
- more very high-intensity speed meters (7%)
- higher mean skating speed per shift (3%).

Wingers had 5-9% higher relative skating time in low-intensity skating speeds (< 15 km/h) than centers.

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Discussion
In-season changes in performance

- First quarter of the season will act as a **tapering phase** and the level of sport specific performance potentiate during the early phase of the season as shown by other sport specific studies
- Contrary to short efforts, **prolonged efforts require more** from force-velocity characteristics and put more strain to neuromuscular system, which may reflect as a decrease in prolonged acceleration and deceleration efforts.
- Plenty of short efforts, **very few sprints**
- **The velocity limit used in this study was too low?**
  The limit may not reflect the maximal effort that players in top level need to perform when exceeding the sprint limit time and time again during the season
- Effect of **measurement method?**

Discussion
Playing positional differences

- The positional role is reflected through **space and time** during match
- Possible explanation to playing positional skating intensity differences may be **backward skating**
- Differences in results may be explained by **differences between league levels as well as measurement methods**

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Conclusions

- Novelty of this study is that this was the **first longitudinal study** to measure ice hockey players´ playing positional skating metrics during the whole competitive season.
- Overall load from the full competitive season **specifically affects the explosive efforts** related to prolonged accelerations and decelerations.
- The other skating metrics do not seem to be affected.
- No interaction was observed between different season phases and playing positions regarding changes of skating variables, and thus sport specific **load is** somewhat **universal and not playing position specific.**
- Results from this study are in line with prior studies regarding to differences between forwards and defensemen, but it was also found that **centers tend to skate with higher intensities than wingers**.
- By looking at only commonly used metrics (skating distance, playing time or even maximum skating speed), **sport specific crucial indicators** such as accelerations and decelerations **may be left undetected.**

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- Pictures without reference: Getty Images.
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Thank you!