香港教育大學
The Education University of Hong Kong

A Project entitled

Relationship between Sprint Training and the Initiation of Skating in Ice Hockey Players

Submitted by

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Declaration

I, Cheung Tsz Ching declare that this research report represents my own work under the supervision of Prof. Chow Hung Kay, Daniel, and that it has not been submitted previously for examination to any tertiary institution.

Signed

Cheung Tsz Ching 22/04/2022

Content

Abstract

Ice skating is a movement involves lots of muscles and skills. The explosiveness and the power are mostly launched by leg muscles and joints to start-off skating.

Purposes: The purpose of this study is to find out if there are positive effects (significant improvement) on the start-off skating speed after launching the off-ice sprint training for eight weeks. There is a positive correlation between the movement of sprinting and start-off skating. Both of them require leg muscles explosiveness and the power to launch. **Methodology:** 18 participants from 13 to 21 years old, including 4 females and 14 males, with different skating levels, are invited to join this project. They are all from the school ice hockey training program. They were allocated to two groups: the control group – with a normal training schedule; the experimental group – with a normal training schedule with additional sprint-related training two times a week, 8 weeks in a row, with 48 hours of rest in between. Pre-tests and post-tests of an on-ice 30 meters skating test and an off-ice 30 meters running test be performed by both groups. Post-tests will be done 8 weeks after the start of the project. Running or skating time will be recorded by Brower Timing System. The results will only be compared to their previous ones. **Results:** No significant improvements in running and skating time in the experimental group then control group were found.

Conclusion: Larger sample size should be used to test the effectiveness. Have to look for other alternate off-ice training method for ice hockey players to improve their on-ice start-off skating performance.

1. Introduction

1.1 Background

Ice hockey is not a very popular sport in Hong Kong. According to the Hong Kong Sports Institute (2022), athletes in ice hockey are sponsored by the Five-Year Development Program for Team Sports launched by the government, but not in any categories of elite sports. This is a program delivering funding to the athletes who can obtain the training hours per month. As one of the team members of the Hong Kong Women's National Ice Hockey Team, the dearth of ice rinks causes a huge problem. Athletes do not have adequate on-ice practices and may have to look for alternative training methods to boost their performance.

On the other hand, there are more students are playing ice hockey. Ten years ago, there was only an ice hockey school league for secondary school. There were around 6 teams in total. Nowadays, there are also school leagues held in primary school and 9 schools joined; 7 schools for secondary school leagues as well (Hong Kong Academy of Ice Hockey, n.d.). The demand for getting on-ice practice increased, while there are only two rinks built in these ten years not close to the downtown. Moreover, ice hockey players have to share the spot with those who play figure skating, curling, and speed skating. Some rinks like Glacier in the festival walk and The Rink in Element are only open to figure skaters and curlers. The rinks for those who play ice hockey are even less.

1.2. Literature Review

Ice hockey is the combination of different skills, such as stick-handling, skating, shooting, balancing, coordination, etc. Skating is a very essential element in ice hockey. The skating skill one player has could make him differ from a junior player to an elite player (Powering Athletics, n.d.).

Research points out that the percentage for having forward skating contributes a great number to more than 50% of the game which includes two-foot glide, gliding strides, and skating with different intensities (Bracko, Fellingham, Hall, Fisher, & Cryer, 2009). It also mentions that the high scorers usually have spent a long time in two-foot gliding on the ice than low scorers. We can see that skating contributes a very important role in an ice hockey game. Skating skills can be classified into different categories: forward, backward, turning, transitions, etc. (Behm, Wahl, Button, Power, & Anderson, 2005). One of the essential elements to winning the game is to be faster than the opponent which is mentioned by the coach of the champion NHL (Kennedy, 2017). There is a need to improve the skating speed of ice hockey players to enhance their performance.

Moreover, there is some research stating that some other off-ice pieces of training can be done if ice is not available for training. For example, the HIIT program can improve the explosiveness, and strength of muscles, and reduce antagonist coactivation (Kinnunen, Piitulainen, & Piirainen, 2019). The training they provided is 30 seconds of all-out sprinting uphill six times per session. The program only lasts for two and a half weeks. It is a good method to enhance a player's anaerobic power, as ice hockey requires high muscle strength, anaerobic endurance, and power (Montgomery, 1988). However, the study proved that the effectiveness increases only

if it lasts for two and a half weeks or longer. The things it improves cannot be shown on the ice, but only the neuromuscular adaptations (Kinnunen, Piitulainen, & Piirainen, 2019). Moreover, that research did not have a control group. All participants have extra HIIT training while having on-ice practice 3 times a week. The improvement or the extent of improvement cannot be directly seen was led by HIIT or the on-ice training.

On the other hand, the muscles initiating skating are hip extension and plantar flexor muscles, while in the gliding state are knee extensors and hip abduction range of motion (Buckeridge, LeVangie, Stetter, Nigg, & Nigg, 2015). Different programs in HIIT might train these muscles, but the effectiveness may not be as high as performing skating-like motions. Alternatively, people will consider having skating treadmill training to fill up the off-ice sessions. However, the skaters would perform a higher number of strides and lower stride length on the treadmill (Chang, Turcotte, & Pearsall, 2009). Therefore, it is not 'realistic' enough and the muscle strengths cannot be trained effectively. The facilities in Hong Kong are not enough to support athletes to have on-ice training more often. Therefore, there needs a program to practically train the frequently used muscles for skating, but using a skating treadmill may not be an efficient method to improve.

Some research pointed out that skating and running movements are very similar as they both require joint mobility, single leg balance, rate of force development, etc (Neeld, n.d.). The correlation between the two movements is very high. Thus, the training will focus on their accelerating muscles, such as medial gastrocnemius and tibialis anterior to boost the explosiveness, as well as training more powerful hip extensors for continuing powerful strides. The research done by Krause et al. (2015),

found out there is a correlation between skating speed and 36 meters sprints. It is recommended to include sprint training in off-ice sessions. However, it also mentioned that if the player does not have good technique, he or she cannot be a fast skater as well. Therefore, in this paper, the research focus will be on specific types of sprint training which would train the frequently used muscles during skating and evaluate the effectiveness of those training.

1.3 Summary and Conclusion

Knowing about the important muscles used for starting off skating, there should be training related to training up those muscles and seeing the effectiveness of the program. On the other hand, doing tests on the skating treadmill is not so reasonable. As they may perform a higher number of strides and the test results may not be accurate, it is not a good way to do the project. As a user of skating treadmills, different people may perform various forms of skating on the treadmill. Some people will tend to skate with a higher frequency with not much difference in the power applied, while some people will tend to use more power to push and keep the same pace of strides. The training related to this machine may not be effective. In addition, one of the research projects mentioned that both skating and sprinting are movements very alike. If there is improvement in sprinting, it may bring benefits to skating speed as well. For the final report, participants in the HIIT program also do not show improvement in the on-ice context. It does improve their neuromuscular adaptations for them to increase the training intensity. The program introduce should have included a control group and with longer training period.

1.4 Research Topic

Relationship between Sprint Training and the Initiation of Skating in Ice Hockey

1.5. Objectives

First, to find out if sprint training has a significant positive effect on skating velocity (i.e., the testing results will be faster in both on-ice and off-ice contexts). Second, evaluate the reasons for having such results.

2. Methodology

2.1 Subject and Protocol

In this project, 20 participants will be recruited with 16 males and 4 females. 2 of them withdrew in the middle of the project due to injuries. They are all from the school ice hockey program of different skill levels aged 13 to 21 years old, with a mean age of 16.56 years old and standard deviation of 1.95 years. The levels can be neglected as the results only compare to their previous ones. Nonetheless, both the experimental group and control group will contain players with different levels. All the test results will be compared to one pre-test result. Before the start of the project, they have to sign a consent form stating that they agree to do the test and collection of data. They can withdraw from the project anytime they want. For those aged under 18, their parents also need to sign the consent form to agree their kids from participating in the test.

They will be divided into a control group and an experimental group. All of them will have their regular training (one on-ice training and one off-ice training per week). The

experimental group will have an additional sprint-related training session 2 times a week, 8 weeks in a row, with at least 48 hours of rest in between; while the control group only has to do regular training. All the other training amounts will keep the same for both groups. They are also encouraged not to have other ice hockey, ice skating, or sprint-related training during the 8 weeks project. Both groups have to perform 30 meters on-ice and 30 meters off-ice tests at the beginning of the project and the end of the project (8 weeks later).

2.2 Training content

Warm-up

Dynamic stretching mainly for the leg muscles and core muscles (about 10-15 minutes)

- jog for 5 minutes
- walking lunges with opposing arm reaching the sky
- high knees marching
- walking inner thigh stretch
- jogging adduction side stretch
- jogging abduction side stretch
- punter kicks
- skipping with arms movement
- skipping with forwarding kick
- butt kicks
- bouncing
- quick feet and explosion

Sprint Training (First Stage: Week 1-4)

1. Jump squats with weight 10 reps
2. Hip rise 12 reps
3. Single leg assisted deadlift or single leg deadlift 12 reps each leg
4. Single leg calf raises 12 reps each leg
5. Lateral step up 10 reps each leg

Do 3 sets in total, 30 seconds rest in between movements, 3 mins rest in between sets

Sprint Training (Second Stage: Week 5-8)

1. Jump squats with weight 10 reps
2. Single leg glute bridge 12 reps
3. Single leg deadlift / 3 points single deadlift 12 reps each leg
4. Sumo squat with calf raises 12 reps each leg
5. Lateral step up 10 reps each leg
6. Bulgarian Split Squat 8 reps each leg

Do 3 sets in total, 30 – 45 seconds rest between movements, 3 mins rest between sets (Source from Home Training for Sprinters: A Practical Guide. (Mvumvure, 2020))

All of them are aimed at improving leg muscle strength, stability, hip joint movement, glute muscle strength, and overall leg and hip muscle power and endurance. To the research conducted by Freitas de Salles, Simao, Miranda, da Silva Novaes, Lemos, & Willardson (2009), the resting time for a combination of moderate level training can be 30 – 60 seconds. It could facilitate the release of growth hormones. For the resting time in between sets, it was suggested that 1 minute is enough, however, due to safety

concerns, having rest for 3 – 5 minutes is also acceptable. Students are from high school and they have no experience in strength training. Making the resting time between sets 3 minutes should be safe enough and not lower the effectiveness. Before the training, the training content was sent to them via Whatsapp group. All movements are supported by YouTube links so that they can have a brief picture of how to do them. On the training day, pictures of the movements were stuck to the wall, and demonstrations were shown. Their ice hockey coach and I will monitor the training process. It is hard for them to do the same training for 8 weeks in a row, thus, training in the second stage was introduced after the collection of feedback. They feel tired after the training, but not too challenging.

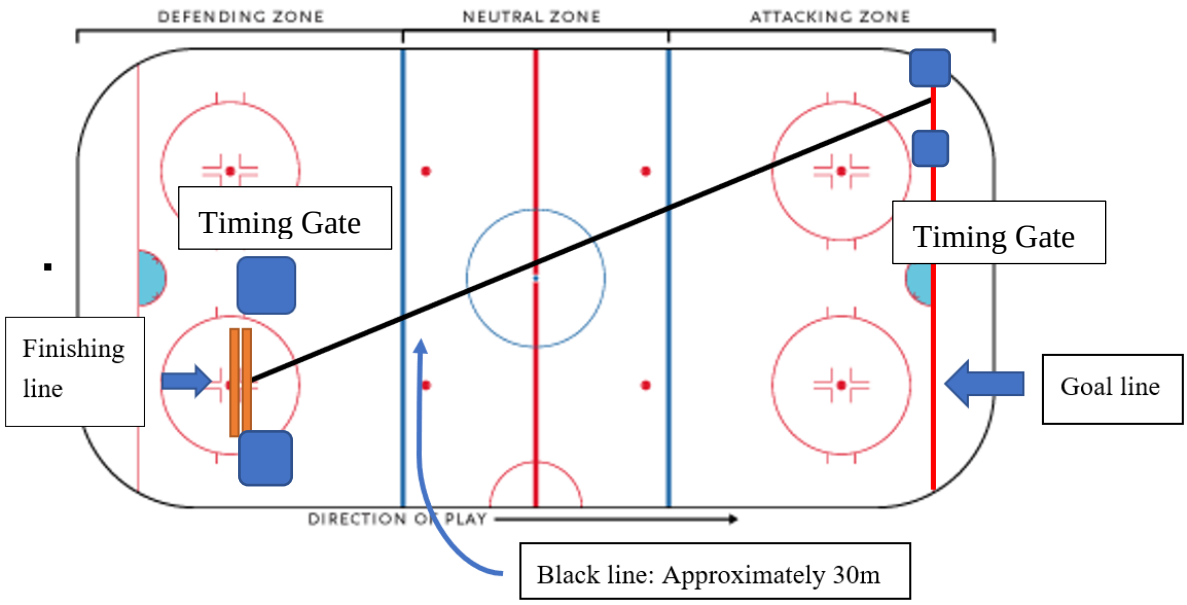
2.3. Procedures

For the pre-test and post-test, they are required to run 30 meters on and off the ice. A study found that on-ice 40 yards (around 36 meters) could indicate the top speed in forward skating (Jeffrey, Nicholas, & Lance, 2015). However, due to the limitation of rink size (18.5m X 35m), it is not possible to perform 36 meters skating test in the venue. It does not meet the requirement as there should have some space for players to buffer after the skate. Another study also used 30 meters as the test method on and off the ice. It mentioned that the distance for measuring maximal speed should be greater than 20 meters to make it valid (Bendus, 2020). Therefore, the test will be conducted in 30 meters. There are two stages in forwarding skating – accelerating state and steady-state. For accelerating state, it includes the 2nd to 6th strides in skating. The other strides in forwarding skating will be regarded as a steady-state as the speed will remain the same (Buckeridge et al., 2015). These will be done within 30 meters.

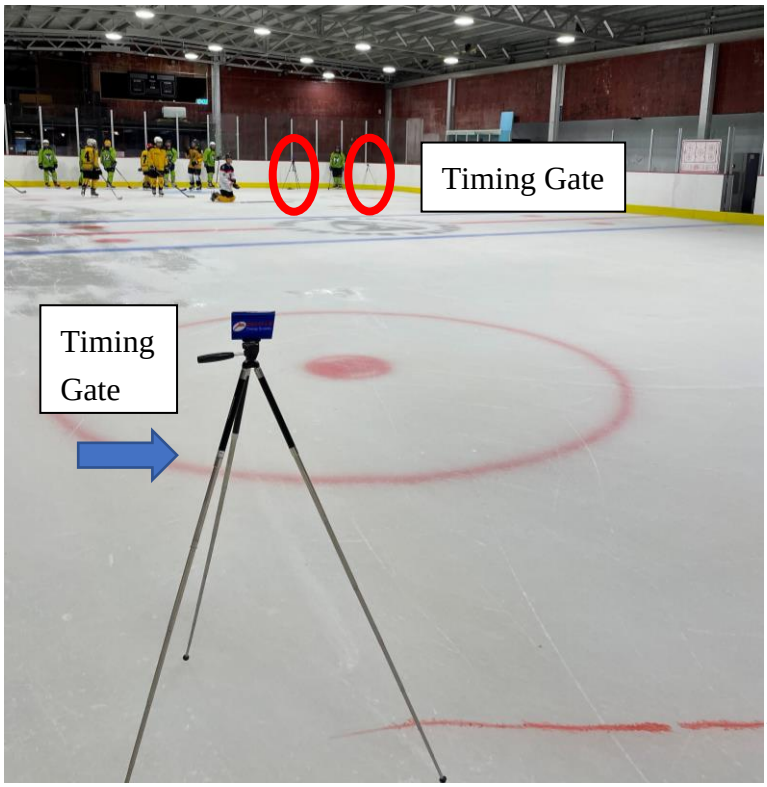
On-ice Test

The test will be performed in a private rink in Sheung Shui. The rink chosen is small in size and other rinks are not available. The skating path will be diagonal to the opposite goal line because the length can be longer, thus, more buffering spaces. The total length will be approximately 39.6 meters. The buffering spaces should be around seven to eight meters. Before the test, participants are required to skate around for 5 minutes with different skating drills, such as skating forward, backward, making the transition, etc. Afterward, players are instructed to start right behind the goal line, and to the far opposite face-off dot. The demonstration will be shown how they should go and which way of leaving. They have to try their best to reach the finishing line as fast as possible. The distance was measured by tape measure. Participants will be wearing helmets, gloves, hockey pants, shin guards, and skates during the test. They can choose to hold a stick or not because some people would feel they can coordinate their arms and legs better using sticks. Skaters will have three trials. The player has to skate as hard as they could after the '3, 2, 1, start!' count down.

To get the most accurate data, two pairs of Timing Gate systems will be placed at the starting line and finishing line to record the time they need for completing 30 meters. It can record the time up to 0.01 seconds so it could narrow down the error to 0.005 seconds. After they have passed through the first pair of the timing system, the time will start counting. When they pass through the second pair, the time will stop. It can also eliminate the measurement error of different reaction times.



(2D graph)

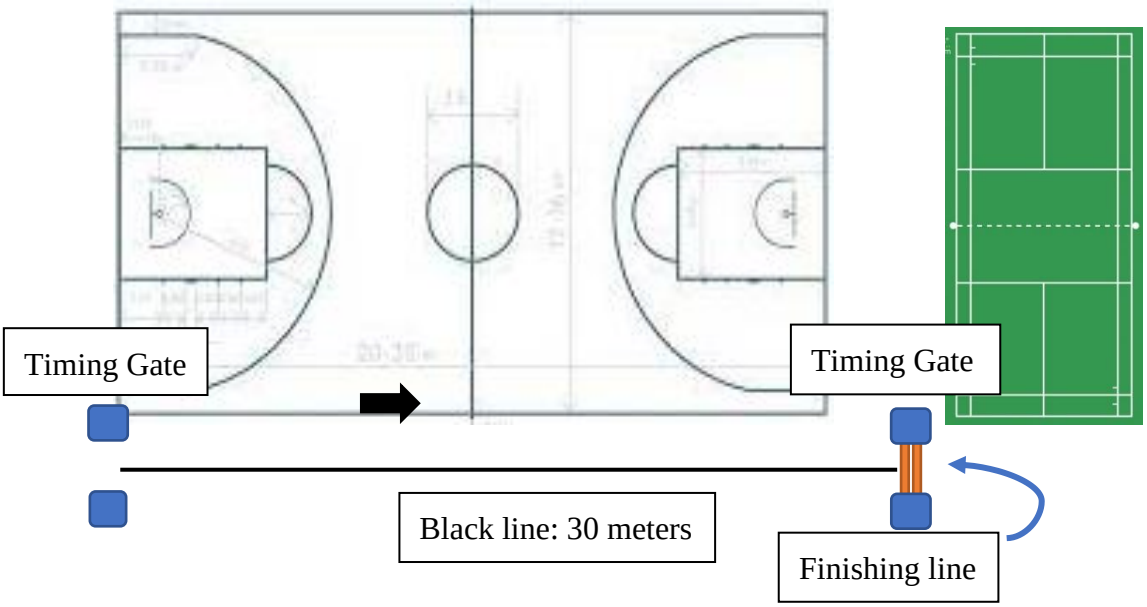


(Photo taken in the venue)

Off-ice Test

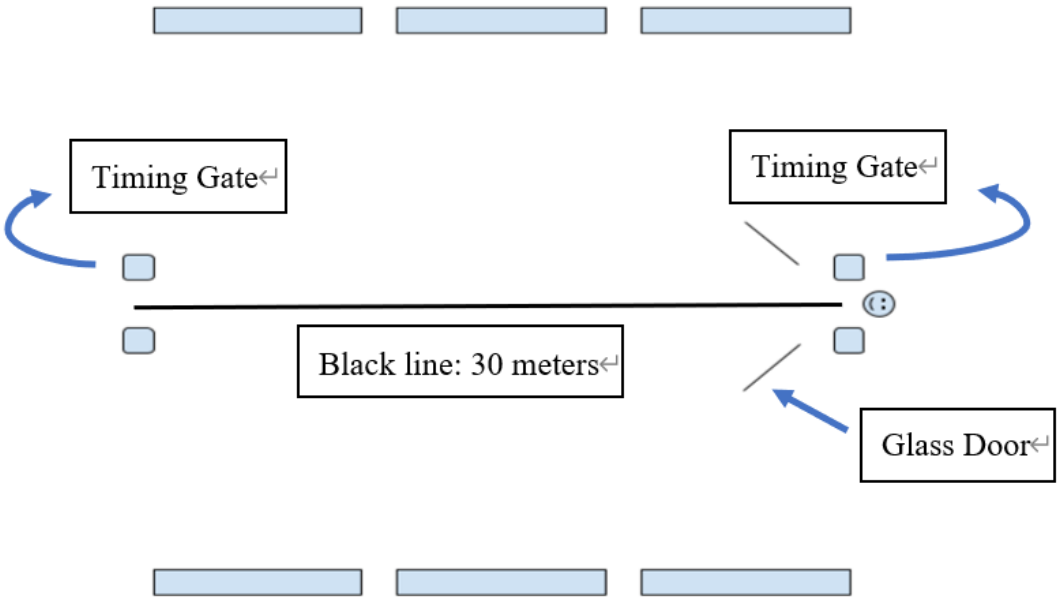
For the off-ice testing, they will perform the sprint for 30m on the school's sports ground. It has a basketball count (28m X 15m) and a badminton court in the middle.

There are marks on the side of the basketball court counting up to 35 for students to gather at the sports ground. The distance between each interval is 1 meter. The tape measure was used to ensure the length is 30 meters. They are required to run from the baseline of the court to the edge of the badminton court. The demonstration will be shown how they go and leave the pathway. All the measurements will be made by two pairs of Timing Gate systems, which were placed at the starting line and finishing line. It can record the time up to 0.01 seconds.

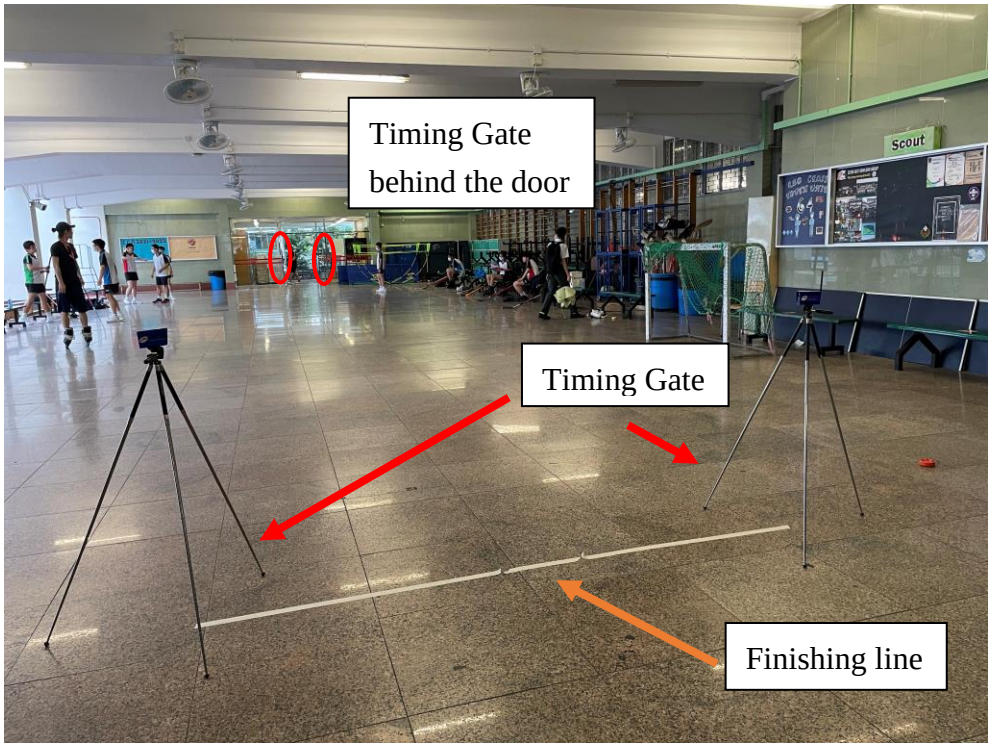


However, on the test day (Friday after school time), the sports ground was used by the basketball team and the test cannot be done there. Therefore, those students will be using the covered playground where they usually have off-ice training. They have done some off-ice practice before warming up their bodies. All settings are the same as the one mentioned above. On the other hand, some students had their test the next day morning (on-ice testing day), because they have other extra-curricular activities and tutorial classes on Friday. Nobody used the sports ground that day, so those students performed their tests there as mentioned above. The testing results are only comparable to their previous ones. They will have the pre-test exactly 8 weeks later again on the same ground. This will not affect the result. The diagram below shows

the covered playground used for the off-ice test.



(2D graph)



(Photo of the venue)

2.4. Data Collection and Method of Analysis

A comparison of data collected will be performed in JASP. The 2-way repeated-measures ANOVA with mixed samples will be used in this project. Firstly, there are two independent variables. They are the time and group of participants. Both data will be collected in both the experimental group and the control group. On the other hand, any other things will remain the same, like the length they need to run in the tests.

On the other hand, after a brief analysis of the data, it can tell from the descriptive statistics that the data are normally distributed. The p-value of the Shapiro-Wilk test is greater than 0.05, of which the confidence level is 95%. Therefore, a parametric test should be performed. The 2-way repeated-measures ANOVA with mixed samples can be used.

Descriptive Statistics

On-Ice

Descriptive Statistics

	PreT		PostT	
	Control Group	Experimental Group	Control Group	Experimental Group
Median	5.870	5.960	5.240	5.360
Mean	5.892	6.279	5.491	5.509
Std. Deviation	0.834	1.463	0.795	1.114
Shapiro-Wilk	0.962	0.925	0.958	0.902
P-value of Shapiro-Wilk	0.822	0.433	0.777	0.267
Minimum	4.400	4.590	4.320	4.320
Maximum	7.040	9.160	6.910	7.870

Descriptive Statistics

Off-Ice

Descriptive Statistics

	PreT		PostT	
	Control Group	Experimental Group	Control Group	Experimental Group
Median	4.950	4.700	4.850	4.610
Mean	4.988	4.930	4.892	4.750
Std. Deviation	0.239	0.505	0.295	0.507
Shapiro-Wilk	0.921	0.854	0.974	0.874
P-value of Shapiro-Wilk	0.402	0.082	0.929	0.137
Minimum	4.710	4.380	4.400	4.090
Maximum	5.420	5.610	5.360	5.360

3. Results

On-ice test: For the final result, there is no significant improvement seen comparing the experimental group to the control group.

There are significant improvements shown in both groups as the p-value of time ($F = 56.354$, $p < .001$) and time by group interaction ($F = 5.591$, $p = 0.031$) is statistically significant. When viewing the time within the group, all results are significant which is correlated to the within subject effects. (Control Group: $F = 30.917$, $p < .001$; Experimental Group: $F = 30.988$, $p < .001$).

Repeated Measures ANOVA

Within Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p
Time	3.086	1	3.086	56.354	< .001	0.779
Time ✻ Group	0.306	1	0.306	5.591	0.031	0.259
Residuals	0.876	16	0.055			

Note. Type III Sum of Squares

Simple Main Effects

Simple Main Effects - Time

Level of Group	Sum of Squares	df	Mean Square	F	p
Control Group	0.724	1	0.724	30.917	< .001
Experimental Group	2.668	1	2.668	30.988	< .001

Note. Type III Sum of Squares

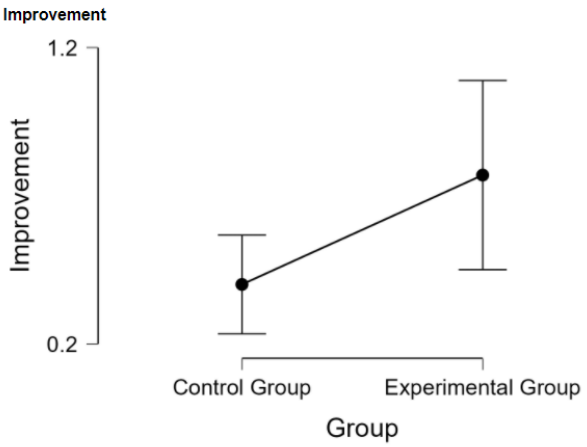
To further view the details, Independent T-test was performed and the descriptive plot shows that experimental group has a generally greater improvement than the control group on the ice.

Descriptives

Group Descriptives

	Group	N	Mean	SD	SE
Improvement	Control Group	9	0.401	0.216	0.072
	Experimental Group	9	0.770	0.415	0.138

Descriptives Plots



However, when viewing among the groups, it shows that the improvement of the experimental group is not significant comparing with the control group (F = 0.160, p = 0.694). Therefore, in on-ice context, it is not significant.

Between Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p
Group	0.368	1	0.368	0.160	0.694	0.010
Residuals	36.805	16	2.300			

Note. Type III Sum of Squares

Off-ice test: For the final result, there is no significant improvement seen comparing the experimental group to the control group.

There is no significant improvement in at least one group as the p-value for time by group interaction is greater than 0.05 threshold (F = 2.614, p = 0.125). When viewing the data within groups, there is no significant improvement in control group (F =

5.327, p = 0.05), while experimental group got significant improvement (F = 31.956, p < .001).

Repeated Measures ANOVA

Within Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	η^2	η^2_p
Time	0.171	1	0.171	27.833	< .001	0.031	0.635
Time ✻ Group	0.016	1	0.016	2.614	0.125	0.003	0.140
Residuals	0.098	16	0.006				

Note. Type III Sum of Squares

Simple Main Effects

Simple Main Effects - Time

Level of Group	Sum of Squares	df	Mean Square	F	p
Control Group	0.041	1	0.041	5.327	0.050
Experimental Group	0.146	1	0.146	31.956	< .001

Note. Type III Sum of Squares

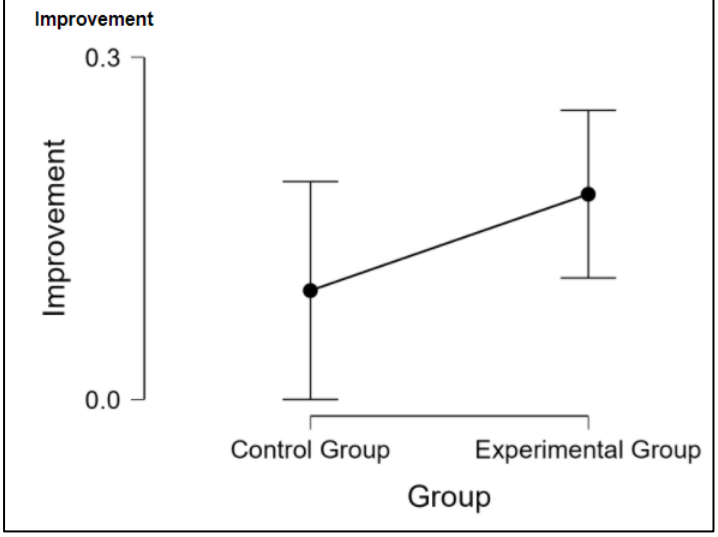
To further view the details, Independent T-test was performed and the descriptive plot shows that experimental group has a slightly greater improvement than the control group off the ice. There is also an extreme value of a participant having no or very little improvement in the test.

Descriptives

Group Descriptives

	Group	N	Mean	SD	SE
Improvement	Control Group	9	0.096	0.124	0.041
	Experimental Group	9	0.180	0.096	0.032

Descriptives Plots



When viewing among the groups, it shows that the improvement of experimental group is not significant comparing with control group ($F = 0.280$, $p = 0.604$). Therefore, in off-ice context, it is not significant.

Between Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	η^2	η^2_p
Group	0.090	1	0.090	0.280	0.604	0.016	0.017
Residuals	5.150	16	0.322				

Note. Type III Sum of Squares

4. Discussion

From all the pieces of literature reviewed, it was hypothesized to have significant improvement when comparing the experimental group to the control group. The testing distance is reasonable and the training is long enough to show improvement.

The action in sprinting and the initiation of skating are very similar, and they are positively correlated. The results shown can be explained by having external factors affecting.

4.1. Internal Factors

As the range of age, height and weight are quite large, they may be the factors affecting the results too. For the protocol, the females are equally assigned into two groups. They are all in the intermediate level, so can be randomly assigned. For the males, there are 2 elite ice hockey players and 4 novice players. The assignation of the levels is equally distributed into two groups. However, the ages of the elite players are 15 and 21 respectively. Skill level is one of my concerns, as the lower-skilled participants have a better room for improvement than the advanced. The testing results may not be accurate if this was neglected. The data analyzed of the participant's age, height, and weight are as shown in the diagram:

Age:

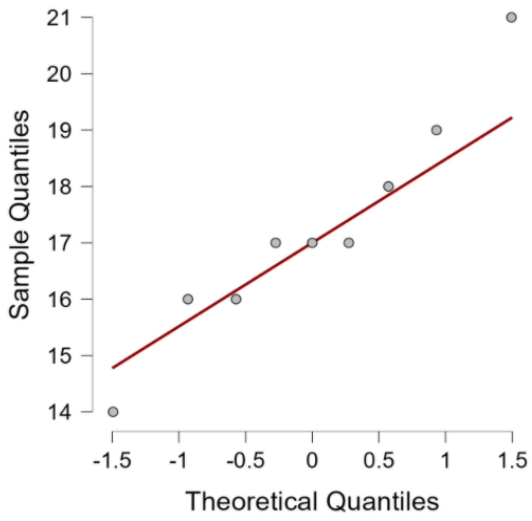
Descriptive Statistics

	Age	
	Control Group	Experimental Group
Valid	9	9
Median	17.000	16.000
Mean	17.222	15.889
Std. Deviation	1.986	1.764
Range	7.000	6.000
Minimum	14.000	13.000
Maximum	21.000	19.000

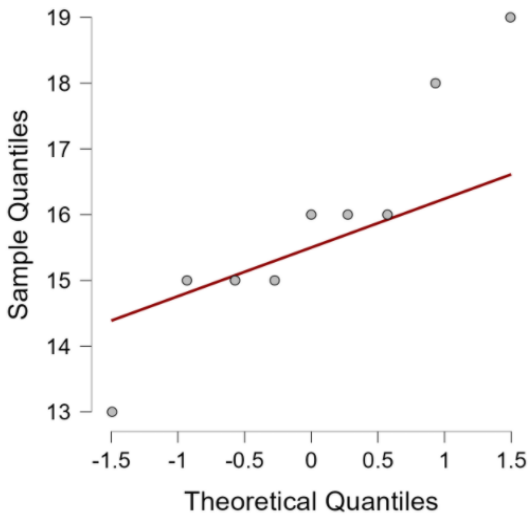
Q-Q Plots

Age

Control Group



Experimental Group



Height:

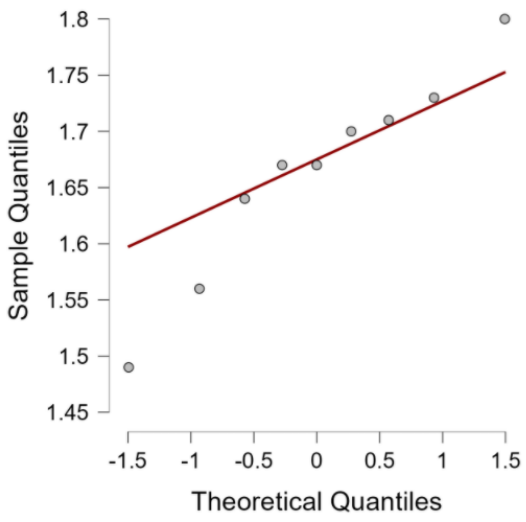
Descriptive Statistics

	Height	
	Control Group	Experimental Group
Valid	9	9
Median	1.670	1.590
Mean	1.663	1.628
Std. Deviation	0.092	0.071
Minimum	1.490	1.560
Maximum	1.800	1.750

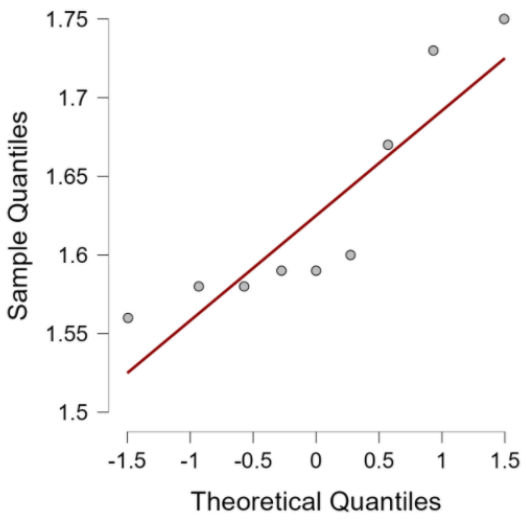
Q-Q Plots

Height

Control Group



Experimental Group



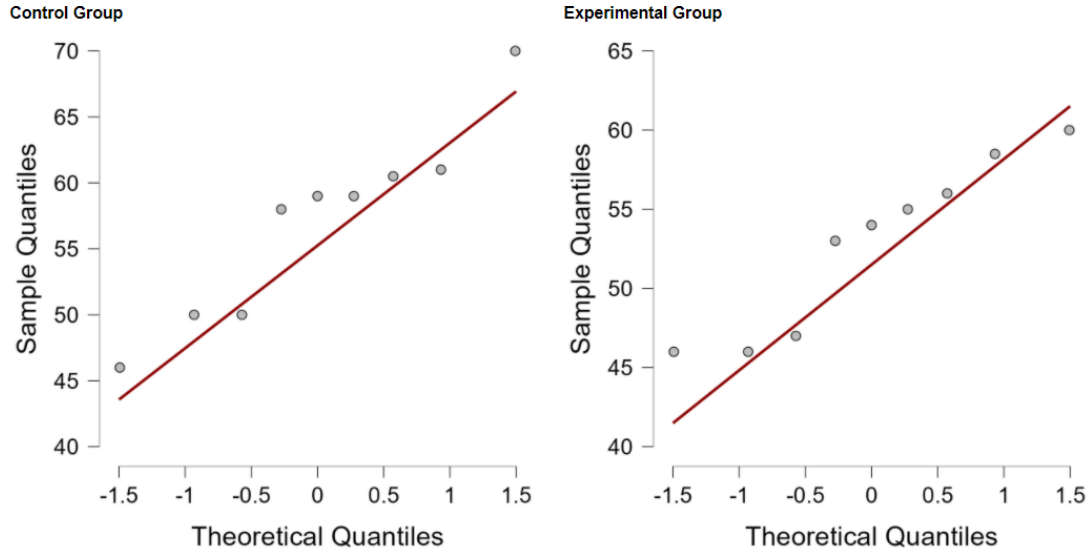
Weight:

Descriptive Statistics

	Weight	
	Control Group	Experimental Group
Valid	9	9
Median	59.000	54.000
Mean	57.056	52.833
Std. Deviation	7.291	5.327
Minimum	46.000	46.000
Maximum	70.000	60.000

Q-Q Plots

Weight



From all the statistics above, the age, height, and weight of the control group are slightly higher than the experimental group. Because the participants are older, all the information mentioned above could be reasonably higher. Statistically, the experimental group and control have no significant difference in age, height, and weight from each other. Therefore, the test results are not likely to be affected by these factors.

4.2. Sample Size Problem

The sample size is small. It is hard to find ice hockey players who have the same training amount in Hong Kong. The most possible way is to find a school that has an ice hockey program conducted. However, due to the limited number of students on a sports team in school and the barrier to joining this sport is quite high. Thus, the sample size for this experiment is not enough. The research conducted by Gelman & Stern (2006), mentioned that the smaller the sample size, the greater the error rate. When there is a slight increase in the data, it affects the result more as the portion it shares is greater. In the off-ice control group, there is an extreme value that makes the improvement rate of the control group insignificant. It is a sample size of 1 out of 9. The portion is great and it affects the results much. However, if the sample size is larger and it is only 1 out of 100, the result would not be affected much.

4.3. Skill Level Differences

Because of the skill level, some participants are not doing “push-off” movements. As mentioned above, there are two stages of skating. According to the research done by Buckeridge et al. (2015), the knees extend more, and hip
abduction range of motion is greater in steady states; while in acceleration
state, the plantar-flexor muscle usage, and hip extension movement are greater. Rewinding to the videos filmed in the on-ice test, some participants with
lower skill levels did not perform sprinting like motion. There are differences
in movements between high and low-skilled players. From the research done by Robbins,
Renaud, & Pearsall (2021), mentioned that the ankle inversion for
push-off and recovery, knee extension, and knee external rotation are

greater in push-off when comparing high-level players to low-level players. Higher skilled players can push further and bring back the leg during acceleration, but not only push hard to extend their legs. the video shows novice players skating with their legs wide, straight body, and with a lower extent of bringing the leg back in the longitudinal axis as shown below:



Below is the screencapture of the movement of elite player.





These two players are at the same height and similar weight. They are both males. The movement is very different. Elite players tended to lean forward, bending knees, swinging arms, bringing the leg back to the centerline; while the novice player stood straight, with slight arm swing movement, bringing the extended leg back to shoulder's width. The test results may not be accurately shown the results, as some players are not skillful enough to perform a proper initiation of skating. The sprint training may bring effects to their performance, but was limited due to skill level.

4.4. Actual Acceleration Length

As mentioned above, the maximum speed of an ice hockey player on the ice and off the ice can be more accurately determined if they do the skating and running test for

36 meters in length (Jeffrey et al., 2015). Because of the rink size problem, they can only perform a maximum of 30 meters skating test. The venue is a newly built private rink, which only hires ice hockey players who know the owner. The secondary school ice hockey team has regular training at this venue. Therefore, the project can be done there with large group size. The on-ice testing length is shortened, as they have to spare some space for buffering. From the videos, all novice players stop moving their feet before reaching the finishing line. One of them even keeps gliding for one-third of the testing length. For intermediate players, most of them stop moving their feet before reaching the finishing line, and one or two of them stop moving their feet after they reached the line. In contrast, elite players, stop moving their feet when they reached the finishing line and can stop immediately behind the line. In the limited space, skillful players can finish the test with 30 meters pushing their legs, while the lower-skilled players glide at the end without acceleration. Different players require varied buffering spaces, the test results cannot accurately show the improvement of the participants; thus, the results are not exact enough.

4.5. Measurement Error

Last but not least, there may have measurement errors. The data collected shows that all participants got improvement in the on-ice context, but not off the ice for the control group. The measurement made on-ice was using a tape measure manually, which was marked by myself. The tape measure was put on the ice and a marker was used to mark every ten meters. This technique was introduced to lower the measurement error and measurement should be practiced to be accurate enough (Yoshida, Isoya, Ejiri, Hara, & Fujinawa, 2011). There may be a mismeasurement of the post-test on-ice test for being shorter than 30 meters, or shorter than the pre-test.

From the research done by Badii, Wade, Collins, Nicolaou, Kobza, & Kopec (2014), the tape measure has only around 50% measuring sensitivity and specificity. There were seven out of twenty subjects were being measured with a shorter length of discrepancy in their leg than they are. This can also explain that participants skate for a slightly shorter distance, thus making all the records a little bit faster. All the results on the ice were faster than before. Although by observation, the line was straight and got slight tension on the tape measure, there may still have measurement error.

5. Limitations

5.1. Training Levels

It is very hard to monitor the individual MVPA level. The project was not done in a laboratory setting. Participants are free to do whatever they want. They are in different forms in school. Their PE lessons are about learning different sports. If the individual is learning about the Athletics topic, he may have practiced sprinting or running. This is inevitable and cannot be controlled by all participants. Although they have signed the consent form stating that they will try their best not to take part in other ice hockey, ice skating, and sprint-related training for this project, some of them have afterschool activities like basketball training, football training, etc. Moreover, from the attendance record, some of them have been absent from regular on-ice and off-ice training because have time to crash with other activities. The training level of individuals is mostly not the same.

5.2. Conditions of Individuals

Students from different forms may receive different levels is pressure. The form three students are pressurized by getting a good grade for choosing the subjects they like. For high form students, they have to prepare themselves for the DSE and mock exams. The off-ice test was conducted on Friday after school time and Saturday morning. The on-ice test was conducted on Saturday afternoon. Those who test off-ice on Friday afternoon may rush down for practice. They may have academic pressure or their condition may not be good after a whole day of class. In addition, some participants may suffer from test anxiety. The test was conducted in an open area, where their schoolmates can watch the testing. it may bring pressure on them. They may afraid of being humiliated by others. on the test day, after they have finished their run, they always ask for their results. The results will only be told to that participant. However, they are curious about others' results. From the consent form signed, the results posted will be anonymous. I did not tell them other's running times, but they keep asking or competing with each other. From the research done by Raglin (1992), he mentioned that sports performance can be affected by stress, not limited to positive effects, some of them will be negatively affected. In the study, nearly half of the distance female athletes think they can perform best when the stress level is low, while 30% of them have the best performance at a high-stress level. It can also differentiate the performance of participants.

5.3. Comprehensiveness

There are adequate researches that point out what muscles group are used for the initiation of ice hockey. From the research done by Lafontaine (2007), he mentioned that apart from the movement of athletes can alter the result, the skating shoes they

are using can also make a difference. In this project, the equipment used was not framed. They can use that from any brand and model. Some players with longer years of experience will tend to buy higher quality skating shoes, as they are expensive and people will tend to upgrade their equipment from time to time. During the project, some novice players changed their skating shoes because they rented the skating shoes until they can find a suitable one. Due to the pandemic, the shipping was hindered and their shoes arrived late. Therefore, some of them have different hockey skates for pre-test and post-test. The results can be altered by the advancement of equipment.

On the other hand, the technology used was only the Timing Gate System. There is adequate information on which muscle groups are used during the take-off. However, it cannot tell which muscle groups were trained in the sprint training workout. If electromyography (EMG) was used to test, the results can be more significant. The EMG system is used to test muscle response through the nerve system and record the electrical signal the target muscle makes during a movement (The Johns Hopkins University, n.d.). Although the target group of muscles was stated in the extra sprint-related training, the 'real' muscles they were using cannot be monitored by the ice hockey coach and myself. Only the participants know if they have done the movement correctly using that target muscles.

6. **Follow-up Work**

As the results are not significant, that means the sprint-related training was not effective enough to boost their performance to a 'significant level', some participants

from the experimental group were interviewed. For the elite player, he mentioned that in his daily routine, he has three off-ice training three times a week to boost his performance. The training includes agility, balancing, single-leg stability, etc. He thinks that those training may be more effective than the homogeneous training aims at strengthening the leg muscles. The project done by Novák, Lipinska, Roczniok, Spieszny, & Stastny (2019), mentioned that agility is one of the essential areas in ice hockey, and it can be improved by having off-ice agility training. If the agility level of a player increases, they could have better control in a high-speed movement.

The female participant in the experimental group was also interviewed. She thinks that her muscular strength and neuromuscular adaptation have improved. Except for ice hockey, she seldom exercises. She had less delayed onset muscle soreness (DOMS) at the end of the project. she did not have muscle soreness the next day when the intensity was not high. With the enhancement of skill level, the training becomes tougher. There are also hockey games she can join because she has obtained a certain level. All of these lead her to feel the sore and tired muscles the day after. These occur normally and have the sense of ‘losing muscle strength’, but usually will be recovered in one to three days (MacIntyre, Reid, & McKenzie, 1995). When she started doing the extra training, she got DOMS for three days. The situation got better in week 2. She also feels her legs are more powerful than before. She can skate a little bit faster with better balance and with less muscle soreness the day after. Overall, she thinks that the training is beneficial to her ice hockey development and she will continue to do extra workouts in the future.

7. Conclusion

Ice hockey is a combination of various skills, which requires powerful legs to do the acceleration and gliding. There are still a lot of factors that have to be improved to boost the game performance. Although the data collected in this project was insignificant, it somehow shows the benefits of having sprint-related training. From the interview with participants, they mentioned that they can feel their leg muscles are getting more powerful and with a lower level of DOMS the next day. Due to the pandemic, the sports facilities were all closed for four months. Workout is one of the best alternative exercises they can do for muscle strengthening. Statistical significance sometimes is not as important as practical performance (Gelman & Stern, 2006). They can continue the training before figuring out a better method to replace the "staying at home" period. On the other hand, a further study of having better control of the participants can be done. The sample size should be larger with the enforcement of activity level control. The recruitment of participants could be adults. Last but not least, the use of the EMG system can also enhance the accuracy of the test.

8. References

Badii, M., Wade, A. N., Collins, D. R., Nicolaou, S., Kobza, B. J., & Kopec, J. A. (2014). Comparison of lifts versus tape measure in determining leg length discrepancy. *The Journal of rheumatology, 41(8),* 1689-1694.

Behm, D. G., Wahl, M. J., Button, D. C., Power, K. E., & Anderson, K. G. (2005). Relationship between hockey skating speed and selected performance measures. *The Journal of Strength & Conditioning Research, 19(2),* 326-331.

Bendus, V. (2020, October 7). Maximum Velocity Sprinting For Hockey Players. Retrieve from: https://www.prohockeystrength.com/public/Maximum-Velocity-Sprinting-For-Hockey-Players.cfm

Bracko, M. R., Fellingham, G. W., Hall, L. T., Fisher A. G., & Cryer, W. (2009). Performance skating characteristics of professional ice hockey forwards. Sports Medicine, Training and Rehabilitation, 8(3), 251-263. https://doi.org/10.1080/15438629809512531

Buckeridge, E., LeVangie, M. C., Stetter, B., Nigg, S. R., & Nigg, B. M. (2015). An on-ice measurement approach to analyse the biomechanics of ice hockey skating. *PloS one*, *10*(5), e0127324. https://doi.org/10.1371/journal.pone.0127324

Chang, R., Turcotte, R., & Pearsall, D. (2009). Hip adductor muscle function in forward skating. *Sports biomechanics*, *8*(3), 212–222. https://doi.org/10.1080/14763140903229534

Freitas de Salles, B., Simao, R., Miranda, F., da Silva Novaes, J., Lemos, A., & Willardson, J. M. (2009). Rest interval between sets in strength training. *Sports medicine, 39(9)*, 765-777.

Gelman, A., & Stern, Hal. (2006). The Difference Between "Significant" and "Not Significant" is not Itself Statistically Significant. *The American Statistician, Vol. 60, No. 4*. DOI: 10.1198/000313006X152649

Haukali, E., & Tjelta, L. I. (2015). Correlation between "off-ice" variables and skating performance among young male ice hockey players. *International Journal of Applied Sports Sciences*, 27(1), 26-32.

Hoff, J., Kemi, O. J., & Helgerud, J. (2005). Strength and endurance differences between elite and junior elite ice hockey players. The importance of allometric scaling. *International journal of sports medicine, 26*(7), 537–541. https://doi.org/10.1055/s-2004-821328

Hong Kong Academy of Ice Hockey. (n.d.). Hong Kong School Ice Hockey League. Retrieve from https://hkaih.org/zh-cht/training-programs/hkaih/hong-kong-school-ice-hockey-league

Hong Kong Sports Institute. (2022). Five-Year Development Programme for Team Sports 2018-2022. *Supporting The Sports*. Retrieve from https://www.hksi.org.hk/support-to-sports/five-year-development-programme-for-team-sports/

Jeffrey M. J., Nicholas M. B., & Lance D. D. (2015). Multiple Off-Ice Performance Variables Predict On-Ice Skating Performance in Male and Female Division III Ice Hockey Players. *Journal of Sports Science and Medicine* (14), 522 - 529.

Kennedy, R. (2017, Jan 12). The Most Important Skill in The Game Today is Skating. The Hockey News. Retrieve from https://thehockeynews.com/news/the-most-important-skill-in-the-game-today-is-skating

Kinnunen, J. V., Piitulainen, H., & Piirainen, J. M. (2019). Neuromuscular Adaptations to Short-Term High-Intensity Interval Training in Female Ice-Hockey Players. *Journal of strength and conditioning research*, *33*(2), 479–485. https://doi.org/10.1519/JSC.0000000000001881

Krause, D. A., Smith, A. M., Holmes, L. C., Klebe, C. R., Lee, J. B., Lundquist, K. M., ... & Hollman, J. H. (2012). Relationship of off-ice and on-ice performance measures in high school male hockey players. *The Journal of Strength & Conditioning Research*, 26(5), 1423-1430.

Lafontaine, D. (2007). Three-dimensional kinematics of the knee and ankle joints for three consecutive push-offs during ice hockey skating starts. *Sports Biomechanics, 6(3)*, 391-406.

MacIntyre, D. L., Reid, W. D., & McKenzie, D. C. (1995). Delayed muscle soreness. *Sports medicine, 20(1)*, 24-40.

Montgomery D. L. (1988). Physiology of ice hockey. *Sports medicine (Auckland, N.Z.)*, *5*(2), 99–126. https://doi.org/10.2165/00007256-198805020-00003

Mvumvure, G. (2020). Home Training for Sprinters: A Practical Guide. Retrieve from: https://simplifaster.com/articles/sprinters-home-training-practical-guide/

Neeld, K. (n.d.). Speed Training Methods for Hockey. *Athletics Acceleration.* Retrieve from: https://athletesacceleration.com/speed-training-methods-hockey/

Novák, D., Lipinska, P., Roczniok, R., Spieszny, M., & Stastny, P. (2019). Off-ice agility provide motor transfer to on-ice skating performance and agility in adolescent ice hockey players. *Journal of sports science & medicine, 18(4)*, 680.

Raglin, J. S. (1992). Anxiety and sport performance. *Exercise and sport sciences reviews*, *20*, 243-243.

Robbins, S. M., Renaud, P. J., & Pearsall, D. J. (2021). Principal component analysis identifies differences in ice hockey skating stride between high-and low-calibre players. *Sports biomechanics*, *20(2)*, 131-149.

The Johns Hopkins University. (n.d.). Electromyography (EMG). Retrieve from https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/electromyography-emg

Turcotte, R., Pearsall, D., Montgomery, D., Lefebvre, R., Ofir, D., and Loh, J. (2004). Comparison of Ice Versus Treadmill Skating — Plantar Force Distribution Patterns. *Safety in Ice Hockey, 4(A)*, 265-271. https://doi.org/10.1520/STP11624S

Yoshida, K., Isoya, R., Ejiri, H., Hara, K., & Fujinawa, O. (2011). Measurement errors of a test to determine the scapular position using a tape measure. *Journal of Physical Therapy Science, 23(6)*, 851-854.

9. Appendix

Videos relating to the projects:

Off-ice Test (Sportsground)

https://drive.google.com/file/d/1wkljgjiq7tlzjHqOROBpd6hYVPhVz44M/view?usp=sharing

Off-ice Test (Covered playground)

https://drive.google.com/file/d/1d5D9tqYZqnIyKxQq--nwn5Gb1NKx5BUs/view?usp=sharing

On-ice Test (Elite)

https://drive.google.com/file/d/1-bNjJx914eGasiEuHbCsgo03dpVyXMae/view?usp=sharing

On-ice Test (Intermediate)

https://drive.google.com/file/d/1csl5-5DmKSvSQbYTJqncN5nK1yAu40uY/view?usp=sharing

On-ice Test (Novice)

https://drive.google.com/file/d/1Y_T5C5RTYzWh5s_r0ak5IDQmUeuCYfbT/view?usp=sharing