Rationale for a hip/groin injury prevention program for ice hockey players: a randomized feasibility study protocol

Romana Brunner[1], Karin Niedermann[2], Bizzini Mario[1], Nicola A Maffiuletti[1]

[1]Human Performance Lab, Schulthess Clinic, Zurich, Switzerland

[2]Zurich University of Applied Sciences, School of Health Professions, Institute of Physiotherapy, Winterthur, Switzerland

Corresponding author:

Romana Brunner, MSc Physiotherapy

Schulthess Clinic

Human Performance Lab

Lengghalde 6, CH-8008 Zurich, Switzerland

Email: Romana.Brunner@kws.ch

Telephone: +41 44 385 71 56

ABSTRACT

Objective To define a plan for evaluating the feasibility of a hip/groin injury prevention program for ice hockey teams in preparation for a prospective cluster, randomized controlled trial.

Background Ice hockey players are at high risk of sustaining traumatic and overuse injuries, especially around the hip/groin region. Muscle weakness surrounding the hip joint has been identified as a risk factor for groin-related pain. However, injury prevention research in ice hockey is scarce. Only one previous investigation showed that an exercise prevention program significantly reduced the incidence of adductor muscle strains in professional ice hockey players. The feasibility of a hip/groin injury prevention program applied to one youth ice hockey team during a preparatory phase and consecutive season needs to be evaluated.

Design A cluster-randomized feasibility study protocol.

Methods Participants will be cluster randomized to either the intervention or control group. Feasibility will be based on the recruitment and dropout rates, use and adherence to the intervention, responsiveness and number of adverse events.

Intervention The hip/groin injury prevention program comprises the Copenhagen adduction exercise and ice hockey-specific functional strength and balance exercises. Each player will also perform individual strength exercises for each hip muscle group in the case of an identified hip muscle strength deficit.

Discussion High participation and low dropout rates, high program use and adherence as well as high responsiveness of players and staff members are expected to be achieved. Biases, e.g. contamination, injury reporting, that may occur will be addressed to minimize their risk when evaluated on a larger scale.

INTRODUCTION

Ice hockey players are at high risk of sustaining traumatic and overuse injuries that mainly affect the head and the lower extremity, especially at the hip/groin region.[1-7] The incidence of traumatic time-loss hip/groin/thigh injuries and the prevalence of overuse hip/groin problems in elite and professional ice hockey players have been reported to range between 10% and 23% and between 16% and 69%, respectively.[2-4 6 7] Long-lasting hip/groin problems can result in physical impairment, reduced ice hockey performance, loss of playing time and chronicity.[3 7-10] Furthermore, these outcomes may lead to a high financial burden for the athlete's employer as well as the health care system.[10] Ice hockey players might potentially benefit from injury prevention strategies focused on the hip/groin area,[3] yet injury prevention research in ice hockey is scarce. Only one previous investigation showed that an exercise prevention program can significantly reduce the incidence of adductor muscle strains in professional ice hockey players.[11] Muscle weakness, i.e. a deficit in maximal voluntary muscle strength, surrounding the hip joint has been identified as a risk factor for groin-related pain.[12 13] It is therefore important to develop an injury prevention program for ice hockey players that targets muscle strength in the hip/groin area, in order to reduce the incidence and prevalence of both traumatic and overuse injuries.[3-5]

According to implementation science, an injury prevention program should be performed by all ice hockey players, not just those identified through screening as "at risk" for a specific injury.[14 15] In particular, athletes aged between 12-25 years who participate in high-risk sports such as ice hockey may benefit from injury prevention programs.[14] Implementation of an injury prevention program early in their career might facilitate program adherence due to the implemented program routine. Multicomponent training programs for team sport athletes are most effective when implemented as a dynamic warm-up not only during the preparatory phase, but also throughout the season.[14 16] All ice hockey players ought to

benefit from injury prevention exercises for the hip/groin regardless of playing position and player characteristics, i.e. age, nationality, previous injuries.[3 17] It is important, however, to assess player and staff member facilitators and barriers that contribute towards adherence to an injury prevention program, so as to evaluate the program's effectiveness and its future implementation in teams.[17] A previous investigation showed that players and staff members reported a perceived benefit of such a program and that a program of 15 minutes 3 times a week is feasible; both were considered as important facilitators towards the uptake and adherence of an injury prevention program in ice hockey teams.[17] It is also important to evaluate program feasibility while incorporating all included stakeholders of an ice hockey team. The distinct stakeholders can be classified on three different levels: (1) the sports chief on the macro level who is part of the team management; (2) the head or assistant coach and medical staff, i.e. physicians, massage therapists, physiotherapists, athletic trainers, on the meso level who are responsible for program delivery; and (3) the players at the micro level who are the program end-users and beneficiaries. The feasibility of a program needs to be previously assessed on all three team levels as well as at the nationwide level involving, in this case, the Swiss Ice Hockey Federation (SIHF) to act on the highest level of the sports delivery hierarchy.[18]

Overall, the aim of this feasibility protocol is to propose and evaluate an evidence-based hip/groin injury prevention program for ice hockey players due to the high prevalence of traumatic and overuse injuries affecting this body region. Design issues for conducting a cluster, randomized controlled trial (RCT) in ice hockey teams in the near future will also be evaluated. This protocol is based on the CONSORT statement for feasibility studies.[19]

METHODS

Study design

The hip/groin injury prevention program will be evaluated using a cluster RCT design, where each team represents a cluster. Randomization of participants in the same team will not be practical in this study due to possible high contamination rates.[20] Hence, a training program in a team setting is naturally applied at a cluster level, which has the advantage of ensuring external validity of the trial results.[20 21]

Objectives

The main objective of this protocol is to plan the evaluation of the feasibility of a hip/groin injury prevention program for ice hockey players in order to conduct a prospective study on a larger scale. Feasibility will be based on the recruitment and dropout rates, number of adverse events, responsiveness, i.e. satisfaction, appreciation and acceptability of the program, and use and adherence to the intervention.

Participants

Two teams of the highest ice hockey junior level in Switzerland will be recruited to participate in the feasibility study. Inclusion criteria will be the ability to understand written/oral German or English and provide informed consent to use the collected data for research purposes. Exclusion criteria for players will be previous injuries to the hip/groin that prevent full participation during the preparatory phase. Parental consent will be required to participate in the study for all players younger than 18 years of age. Approval for this study will be obtained by the local ethics committee.

Injury prevention exercise program development

The specific exercises of the program were selected after reviewing the available literature on hip/groin injury prevention while also considering the previously identified context-specific barriers and facilitators for program adherence.[17 22 23] The injury prevention program will be proposed to medical team members, i.e. athletic trainers, physiotherapists and team captains of the National and Junior Leagues of the German speaking part of Switzerland, and discussed in form of a stakeholder dialogue approach[24] within each team to achieve consensus on the program, e.g. appropriate exercise progression, hockey-specific exercises.[25] One of the key elements for ensuring future program implementation and adherence is to actively involve different stakeholders in the associated activities, which range from needs assessment through to planning for implementation and conducting evaluation.[25-27] We will therefore involve medical staff members and team captains in the development process of the program in order to reach program agreement and to enhance program adherence for future implementation.[22 25 28]

Recruitment and randomization

Prior to recruiting players of the two ice hockey teams, informed consent will be obtained from the staff members of each team, i.e. sports chief, head coach, physiotherapist and athletic trainer. The participating teams will be randomized either to the control or intervention group after obtaining player informed consent.

Procedure

The study period will last approximately one year, which includes a preparatory phase (June until August) and a consecutive season (September until April). Prior to the beginning of the preparatory phase, agreement on the program must be reached by the different medical team members. The hip/groin intervention will be applied during the preparatory

phase as well as during the ice hockey season to one of the participating teams.[16] The program deliverer, i.e. athletic trainer, will supervise the exercise performance of the intervention team. At baseline, all participating ice hockey players will be screened for post-season injuries, e.g. back or lower extremity injuries during the last 6 weeks, using a medical baseline questionnaire. All players of the intervention team will be screened by the team physiotherapist for potential hip muscle strength deficits, i.e. muscle weakness. During the study period, one person from each team's medical staff, i.e. physiotherapist or massage therapist, will be responsible for the data collection of hip/groin overuse and traumatic injuries sustained by all participating ice hockey players.

Intervention

The following intervention is described according to the Consensus on Exercise Reporting Template (CERT).[29] The detailed description of the exercises and various intensity levels is shown in Table 1.

Execution: The hip/groin injury prevention program for ice hockey players will be performed in the training room/hallway of the ice hockey arena as a part of the regular warm-up before a training session or game using the minimum and most basic equipment, i.e. different elastic bands.

Dosage: The program will be performed at least 3 times per week during the preparatory phase as well as during the consecutive season.[16] In total, the warm-up will last 20-25 minutes, of which 10-15 minutes[17] will be devoted to hip/groin exercises and 5-10 minutes to endurance exercise, e.g. cycling. The prevention exercises contain three levels of intensity, of which the first level is for symptomatic players only. All players begin the program on the second level of intensity and progress to the third level. The program deliverer will adjust the exercise intensity as determined by the player's ability to complete 2-3 sets of 10-15 repetitions of an exercise with excellent movement quality and

technique.[30] Progression will be achieved by changing from simple to more hockey-specific complex exercises. For symptomatic players, the level of intensity can be adapted based on the level of pain assessed on a 0-10 visual analog scale (VAS), where 0 indicates 'no pain' and 10 'pain as bad as it could be'. Pain up to 2 on the VAS will be considered 'safe', i.e. green zone, allowing a progression to a higher level of intensity; pain up to 5 on the VAS will be considered 'acceptable', i.e. yellow zone, no progression of the level of intensity; and pain above 5 on the VAS will be considered 'high risk', i.e. red zone, first level of intensity with careful supervision of the physiotherapist.[30]

Assessments: Isometric maximal voluntary contraction (MVC) strength of specific hip muscles will be quantified at baseline and bimonthly in the case of one of the following deficits: (1) strength deficit greater than 10% compared to the contralateral side for any given measurement;[31] or (2) strength deficit greater than 10% compared to normative data of hip muscle strength in ice hockey players;[32] or (3) strength reduction of more than 15% compared to the previous strength assessment[33] as identified by the team physiotherapist who will instruct the player to ensure high-quality exercise performance.

MVC strength will be quantified with a stabilized dynamometer using external belt-fixation (Nicholas Manual Muscle Tester, Lafayette Inc., Lafayette, IN, USA)[34] in a randomized order for hip adductors, abductors, extensors, flexors, internal rotators and external rotators as well as for knee flexors. Hip adductor and abductor muscle strength will be assessed in the side lying position, hip extensor and knee flexor strength will be assessed in the prone position, and hip flexor strength as well as internal and external rotation muscle strength will be assessed in the sitting position with the hip in 90 degrees of hip flexion as described by Thorborg *et al*.[35] For all hip strength assessments, the participants will stabilize themselves by holding the sides of a treatment table with their hands.[34] No accessory movements of other body parts than the testing limb will be allowed.[34] For each muscle group, two submaximal contractions will be performed for warm-up and familiarization

purposes. Players will then perform 3-4 MVCs during which they will be asked to perform maximal efforts for 3-4 seconds with a gradual build-up of force. Rest time between trials will be 30-60 seconds. Verbal encouragement will consistently be provided by the physiotherapist. Only the highest MVC will be considered for analysis. Muscle strength assessments will last approximately 45 minutes per player.

Intervention exercises: The first part of the program consists of seven standardized exercises: the Copenhagen adduction exercise[36] as well as ice hockey-specific functional strength and balance exercises for the hip/groin. The isolated hip adductor exercise was included in the standardized part of the program because ice hockey players are particularly susceptible to adductor muscle strains.[6 11 37] Lower extremity strength is important for skating strides, acceleration, turning and stopping, and assists dynamic balance and stability that essentially protects players from injuries.[38] We therefore included functional hip strength exercises that are based on previously described strength and conditioning principles[38 39] as well as on rehabilitation programs for ice hockey players after adductor muscle strains[37] and femoroacetabular impingement (FAI) surgery.[40 41] Balance is critical to all ice hockey activities, but is often overlooked and not a main focus in training sessions.[39] To achieve balance, training of the accessory muscles around the pelvis and lower extremities are important.[39] We therefore included single-leg balance exercises with the focus on balancing while moving, which is vital in hockey.[39] The greatest risk factor for traumatic injuries has been identified as collisions with the opponent's body[1 2 42-46] hence we included a balance exercise with external perturbation to enhance stability.

Individualization: The second part of the program includes selected strength exercises for each hip muscle group. These exercises are less hockey-specific because the aim is to address a specific hip muscle group deficit. In the case of an identified hip muscle strength deficit, the player will perform additional exercise(s) according to the above described progression until muscle strength is either equal to or less than 10% compared to

contralateral strength or normative data or equal to or less than 15% compared to the previous assessment.

Training of program deliverer/end-users: Movement quality or technique has been described as one of the most critical aspects influencing the success of an injury prevention program.[16] Therefore, it is important to educate program deliverers and end-users to be confident in leading and performing injury prevention exercises and to provide proper feedback to end-users.[22] We will educate the program deliverer, i.e. athletic trainer, and program end-users, i.e. players, within a workshop held for approximately 3 hours, which has previously been described as having a positive effect on the execution of the program.[47] They will receive a detailed manual describing each of the standardized exercises and will be trained to perform the exercises correctly to enhance self-efficacy. Furthermore, it is important that the program deliverer is trained to provide motivation during exercise performance, which can influence the participants effort and force output.[29]

Training of person responsible for data collection and team physician: Each responsible person, i.e. physiotherapist or massage therapist, who will document traumatic hip/groin injury will be trained by the study coordinator (RB) to fill out the injury report form correctly before study initiation, since injuries in Swiss ice hockey teams are not documented on a regular basis. The final diagnosis of each reported traumatic injury will be made by the team physician, who will be trained on which diagnosed injuries surrounding the hip joint should be reported, e.g. inclusion of hamstring injuries. The person responsible for data collection will also be asked to gather information on the number of dryland and on-ice training sessions per week of each player.

Control group: The control group will perform a warm-up of 20-25 minutes, with 10-15 minutes of conventional strength exercises and 5-10 minutes of endurance exercise, e.g. cycling.

Table 1 Hip/groin injury prevention exercises program for ice hockey players

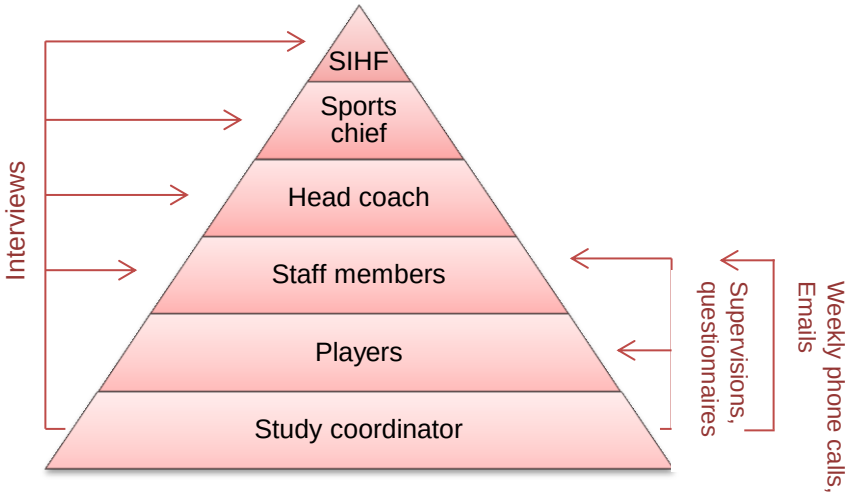
	Level I (for symptomatic players only)	Level II	Level III
Part I: Standardized exercises			
Specific hip muscle strength exercise	Copenhagen adduction exercise[36] (easy)	Copenhagen adduction exercise (moderate)	Copenhagen adduction exercise (hard)
Functional hip muscle strength exercises	Split squats	Reverse lunges with elastic band	Reverse lunges with harder elastic band + increased speed
	Single leg bridge	Hip thrust	Single leg hip thrust
	Side steps	Deep side steps with elastic band	Deep side steps with harder elastic band + increased speed
Balance exercises	Static single leg deadlift	Dynamic single leg deadlift	Single leg deadlift + pelvic rotation
	Dynamic single leg squats	Deep clock excursion exercise	Deep clock excursion exercise with elastic band
	Single leg squat + gentle external perturbation by teammate	Single leg squat + external perturbation by teammate	Deep single leg squat + external perturbation by teammate
Part II: Individual hip muscle strength exercises			
Hip flexors	Standing hip flexion with elastic band	Standing hip flexion with harder elastic band	Plank + hip flexion to right/left hand with elastic band
Hip abductors	*Side bench position:* abduction of the upper leg	*Side bench position:* abduction of the upper leg with elastic band	*Side bench position:* abduction of the upper leg with harder elastic band
Hip rotators	*Side laying position:* internal/external hip rotation with elastic band (clam shell)	*Sitting position:* internal/external hip rotation with elastic band	*Standing position:* internal/external hip rotation with elastic band
Hip extensors	Quadruped arm/lower extremity lift	Quadruped arm/lower extremity lift with elastic band	Quadruped arm/lower extremity lift with harder elastic band
Hamstrings	Nordic hamstring exercise[48] (easy)	Nordic hamstring exercise (moderate)	Nordic hamstring exercise (hard)

Primary study outcomes

Feasibility issues will be documented using a study diary filled out by the study coordinator (RB). Reasons for exclusion, dropouts, adverse events and costs of all aspects of the intervention, e.g. intervention material, time, will be recorded.

Responsiveness: One of the primary feasibility outcome measures of all included stakeholders indicates responsiveness, which is defined as the extent to which the stakeholders are engaged with the program, i.e. satisfaction, appreciation and acceptability of the program.[49] Responsiveness will be assessed using a semi-structured interview[50 51] conducted by the study coordinator (RB) with the corresponding person of the SIHF, the sports chief, team head or assistant coach, physiotherapists and the program deliverer. Open questions will be provided evaluating the provision of the program and intervention information; stakeholders' beliefs, expectations, preferences and experiences of the intervention; and the biweekly Oslo Sports Trauma Research Centre (OSTRC) questionnaire use as well as any needs for program improvement. A self-reported questionnaire will be used for the remainder of the staff members and all players of the intervention team. Responsiveness will be assessed after the preparatory phase. In the case of contrasting attitudes, program adaptions will be proposed and evaluated again at the end of the consecutive season. The communication process of the study coordinator (RB) and all included stakeholders during the study period is provided in Figure 1.

Figure 1. Communication process of all included stakeholders



Abbreviation: Swiss International Ice Hockey Federation, SIHF

Program use and adherence: Program use and adherence will be assessed based on the utilization frequency, i.e. number of sessions completed each week compared to the study protocol; utilization fidelity, i.e. number of exercises completed from the total possible per session; and cumulative utilization, i.e. number of sessions completed during the study period from the total possible sessions[52] using an exercise diary smartphone application filled out by the athletic trainer and by each player. The study coordinator (RB) will supervise the team without advance notification to validate team adherence.

Exercise dosage: The dosage of exercises, i.e. intensity, frequency and duration, will be documented using an exercise diary on the smartphone filled out by each player.

Protocol fidelity: To ensure adherence to the study protocol during the study period, the study coordinator (RB) will provide weekly phone calls to the athletic trainer and supervise the team bimonthly without advance notification.

The regular warm-up of the control and intervention teams will be documented by the athletic trainers.

Secondary study outcomes

Traumatic hip/groin injuries: The incidence of traumatic hip/groin injuries will be assessed using a standardized injury report form.[44] To ensure adherence, the responsible person will be asked to send the data collected to the study coordinator (RB) on a weekly basis. When incorrect completion of the injury report form or missing data arise, the person responsible for data collection will immediately be contacted by the study coordinator (RB) for clarification. For each player, the total time-on-ice during the season will be extracted from the individual statistics page of the SIHF website (www.sihf.ch/de/game-center/national-league/#/mashup/players/playerTimeOnIce/timeOnIce/desc/page/0/2017/2158).

Overuse hip/groin injuries: All players will be asked to fill out the OSTRC overuse injury questionnaire[53] biweekly during the study period to collect information regarding overuse injuries of the hip/groin. The OSTRC questionnaire contains four multiple-choice questions about: (a) the difficulties participating in normal training and competition during the last two weeks, (b) the amount of training volume reduction, (c) the extent of performance impairment and (d) the degree of pain related to ice hockey. The responses to each of the four questions will be allocated a numerical value from 0 (no problems/limitations) to 25 (maximum problems/limitations) and will subsequently be summed to calculate a severity score from 0 to 100.[53]

Self-reported hip/groin disability: All players will be asked to fill out the Copenhagen Hip And Groin Outcome Score (HAGOS) questionnaire at baseline, after the preparatory phase and at the end of the consecutive season. The HAGOS has six subscales: (a) pain, (b) symptoms, (c) activities of daily living, (d) sport and recreational activities, (e) participation in physical activity and (f) quality of life.[54] Each subscale is scored from 0 to 100, where higher scores indicate better hip and groin health.[54]

All study outcomes and other assessments are outlined in Table 2.

Table 2. Study outcomes and assessments

	Preparatory phase				Consecutive season								
Months	05	06	07	08	09	10	11	12	01	02	03	04	
Primary outcomes:	**I N T E R V E N T I O N**												**Responsible person:**
Responsiveness													Study coordinator
Program use and adherence													Staff members, players
Exercise dosage (intensity, frequency and duration)													Staff members, players
Protocol fidelity													Study coordinator
Secondary outcomes:													
Incidence of traumatic hip/groin injuries													Staff member
Prevalence of overuse hip/groin injuries													Staff member
Self-reported hip/groin disability													Study coordinator
Other assessments:													
Medical baseline questionnaire													Team medical doctor
Hip muscle strength													Physiotherapist

Feasibility criteria

Success of feasibility will be defined as a program participation rate of at least 80%, i.e. at the individual player level, and a maximum dropout rate of 15% during the study period.[47] The risk level for severe musculoskeletal adverse events, e.g. muscle/ligament tear, should not be greater than 1% of all healthy participants.[55 56] High responsiveness of all stakeholders must be reached, i.e. no requirements for program improvement, to ascertain success of feasibility. Success of program use and adherence will be defined when 70% of utilization frequency, utilization fidelity and cumulative utilization are achieved.

Sample size calculation

Since the study aim involves the evaluation of feasibility of a hip/groin intervention, a formal sample size calculation is not applicable. However, a minimum of 12 players per team is recommended for feasibility studies.[57] Due to the cluster randomization in this feasibility trial and to account for possible dropouts, we doubled the sample size to 24 players including one ice hockey team per group.

Data analysis

Descriptive statistics will be used to present the rates of participation, dropout, occurrence of adverse events as well as frequencies and proportions of any recorded traumatic injury and the HAGOS score. The overall incidence of traumatic injuries will be calculated as the number of injuries per 1,000 game or training hours during the season. Qualitative data analysis will be performed to explore the answers of the semi-structured interviews and open questions of the questionnaire. The study coordinator (RB) will systematically assign codes and analyze the answers to identify themes using techniques of constant comparison.[50 51] Individuals displaying contrasting attitudes, e.g.

negative cases, will be studied in detail to understand the underlying reasons and to gain a deeper understanding of the data and findings. Two members of the research team will analyze approximately 10% of the qualitative data independently to compare coding and enhance dependability of findings. The findings will be presented descriptively and if necessary, improvements will be proposed.

Program use and adherence will be validated based on the agreement between the reports of the players and program deliverer regarding the number of sessions and exercises of the program. Data will be presented as proportions of agreement on the micro level.

The prevalence of overuse hip/groin injuries will be calculated as the number of players who reported overuse problems, identified by a score greater than 0 on any of the four questions or substantial overuse problems, divided by the total number of respondents.[53] Substantial hip/groin overuse problems will include only those leading to moderate or severe reductions in training volume or performance, or an inability to participate in normal training/competition.[58] The cumulative severity score will also be calculated by summing the severity scores of the respective body part for all players over the study period divided by the number of respondents within the 2-week interval.[53]

DISCUSSION

This protocol defines a plan for evaluating the feasibility of a hip/groin injury prevention program for ice hockey players in order to conduct a prospective study on a larger scale. Program responsiveness is expected to be high in players and staff members because both groups recognized a high perceived benefit of an injury prevention program as well as the relevance of injury prevention in ice hockey in our previous investigation.[17] High responsiveness of the SIHF is also expected because injury prevention should be one of their primary interests.

Success of program participation as well as use and adherence during the study period are expected to be achieved because players and staff members previously acknowledged the feasibility of a prevention program in the form of a warm-up of 15 minutes at least 4 times per week.[17] Surprisingly, time was not considered as a barrier for program adherence.[17]

Our proposed hip/groin injury prevention program includes standardized and individualized exercises, where the latter were identified as an important facilitator for program uptake and adherence.[17] However, this makes the program more difficult to promote as an end-product to ice hockey teams because the individual exercises differ from player to player and the program might last longer for some of them. On the other hand, ice hockey teams have access to their own physiotherapists and also have the appropriate setting to conduct standardized hip muscle strength assessments, which supports the practicality for program individualization. We therefore expect a high responsiveness of the individualized part by the team physiotherapists and players. If the standardized exercises are dictated by the athletic trainer, it is expected that the program will be performed regularly in a team setting. It is therefore important to attain a high responsiveness of the program deliverer in order to increase program adherence of the players. This is expected because most of the staff members clearly saw a benefit of a prevention program in preparing the body for training[17], and this aspect will be included in the development process of the program.

We only proposed the inclusion of strength and balance exercise elements for the hip/groin in this program without additional exercise elements, e.g. agility, stretching, plyometrics. This decision is based on our previous umbrella review, which showed that muscle strength and balance exercises should be prioritized in lower extremity injury prevention programs for team-sport athletes because these elements were most effective in preventing these injuries.[23] Furthermore, the program needs to be quick and

easy to perform with little additional equipment,[16] which is difficult to apply for agility and plyometric exercises. Agility training usually needs a long hallway often set up with additional equipment such as cones; and plyometric exercises require different jump heights usually created with boxes. Agility and plyometrics are nonetheless included in regular ice hockey training sessions (Brunner et al. 2018, unpublished data). Another reason for focusing on strength and balance for injury prevention is that these elements form the basis of every activity on the ice such as shooting, skating, and checking.[39]

There is no increase in the risk of adverse events when all athletes perform the prevention program compared to only those screened as high-risk candidates.[14] Neither severe nor moderate, e.g. muscle strain/pull, musculoskeletal adverse events are expected. Only minor musculoskeletal adverse events related to the testing of hip muscle strength (involving maximal-intensity contractions) might occur, e.g. muscle soreness. In this case, the symptoms will not last more than 2 to 3 days and will not affect the general physical condition of the players. Although a long-term follow-up has not been planned for the feasibility study, a 6-month follow-up should be planned to evaluate the long-term effectiveness of the intervention if the study is conducted on a larger scale.

Adherence to completing the OSTRC questionnaire over a long study period is expected to be challenging as experienced in our previous investigation.[6] However, the questionnaire will be filled out for the feasibility study by smartphone application targeting only the hip/groin area to increase long-term adherence.

By applying the proposed injury prevention program to youth ice hockey players, traumatic and overuse injuries of the hip/groin are expected to decrease, although traumatic injuries during games are difficult to address because of the environmental conditions. To prevent injuries, a player needs to be best prepared physically, especially the specific muscles that are prone to injuries, e.g. hip adductors, which is vital for a

high-speed, high-collision sport such as ice hockey.[38] Overuse injuries are expected to decrease especially in youth ice hockey players who have less or not yet occurring degenerative changes; the results are nonetheless expected to lack any statistical significance due to the relatively small sample size. Calculations based upon these approximations would lead to an underestimation of results.[59]

Limitations

One limitation of the feasibility study might be the risk of contamination bias stemming from the control team, since this group receives the same study information as that of the intervention team prior to randomization.[60] The athletic trainer might therefore need to consider placing the focus on prevention exercises to also target the specific area. This issue will be addressed by applying attention control to the participants, i.e. the study coordinator (RB) will provide general information about different injury prevention strategies, e.g. sleep, recreation, training, that can be analyzed.

There is also a risk of recall and reporting bias,[60] as underreporting of traumatic hip/groin injuries may arise due to only one person being responsible for data gathering. However, the study coordinator (RB) will be in close contact with the person responsible for data collection and provide weekly reminders by e-mails/phone. A final limitation is the lack of detailed diagnostic information derived from the OSTRC questionnaire[53] and in the case of program effectiveness, the classification of overuse hip/groin problems will therefore remain unknown.

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