FACULTEIT GENEESKUNDE EN GEZONDHEIDSWETENSCHAPPEN

HIP RANGE OF MOTION AS A RISK FACTOR FOR LOWER EXTREMITY INJURIES IN ELITE MALE HOCKEY PLAYERS: A RETROSPECTIVE AND PROSPECTIVE APPROACH

Aline Mollemans

Alexandra Vantieghem

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Promotor: Prof. Dr. Damien Van Tiggelen

Copromotor: Dorothée Gaeremynck

A dissertation submitted to Ghent University in partial fulfillment of the requirements for the degree of Master of science in Rehabilitation Sciences and Physiotherapy.

Academic year: 2019-2020

UNIVERSITEIT GENT

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1. List of figures and tables

2. List of abbreviations

ROM: range of motion

°: degree

IR: internal rotation

ER: external rotation

TT: Thomas Test

MTT: Modified Thomas Test

FMS: Functional Movement Screen

FADIR-test: Flexion-Adduction-Internal rotation test

FAI: femoroacetabular impingement

IG: injured group

UG: uninjured group

OR: odds ratio

Nagelkerke R^2: Nagelkerke's coefficient of determination

ROC: receiver operating characteristic

SD: standard deviation

y: years

cm: centimeters

kg: kilograms

BMI: body mass index

kg/cm^2: $kilogram/centimeter^2$

r_s: Spearman correlation coefficient

ACL: anterior cruciate ligament

κ: Cohen Kappa coefficient

3. Abstract

3.1 Abstract in English

Background: Field hockey is a team sport with increased worldwide popularity. It consists of a high amount of running, cutting maneuvers, asymmetrical movements and player/equipment contact. This makes field hockey a sport with a high risk of injury. In field hockey, little is known about hip range of motion (ROM) as an intrinsic risk factor predisposing an athlete to injuries.

Objective: The purpose of the study was to identify hip ROM as an intrinsic risk factor for lower limb musculoskeletal injuries in elite male youth hockey players.

Study design: Retrospective and prospective cohort study.

Methods: Ninety-three male field hockey players, part of the U16, U18 or U21 Belgian national team underwent the testing protocol and were prospectively followed for six months. Injury history data, anthropometrical measurements, the Flexion-Adduction-Internal rotation test, the Deep Squat and hip ROM values were recorded. Univariate hypothesis testing was conducted to assess differences between the injured group and the non-injured group. Multivariate logistic regression modelling was used to identify risk factors contributing to the development of musculoskeletal lower limb injuries.

Results: Forty-one out of 93 athletes (44.1%) retrospectively reported at least one injury to the lower limb. A positive and negative significant correlation was found respectively between attackers (Spearman correlation coefficient (r_s) = +0.220) and goalkeepers (r_s = -0.272) and the development of lower limb injuries. During the prospective follow-up, 36 out of 73 athletes (49.3%) reported at least one injury to the lower limb. Multivariate logistic regression modelling showed a decrease in hip rotation differences in seated position and lower M. Quadriceps flexibility measured with the Modified Thomas Test (MTT) as risk factors contributing to the development of traumatic injuries and lower limb injuries in general. Besides, hip internal rotation (IR) in supine position was found as a risk factor for overuse injuries and lower limb injuries in general. Decreased hip IR in seated was found as a predictor for traumatic injuries.

Conclusion: A decrease in both hip IR, M. Quadriceps flexibility and hip rotation differences were found as risk factors in field hockey and need to be considered in the development of prevention programs.

Key words: field hockey; risk factor; lower limb; injury; hip range of motion; injury prevention

3.2 Abstract in Dutch

Achtergrond: Veldhockey is een teamsport met wereldwijd een groeiende populariteit. Lopen, plotse richtingsveranderingen, asymmetrische bewegingen en regelmatig contact tussen spelers/materiaal beslaan een groot aandeel van deze sport. Dit maakt hockey tot een sport met een hoog risico op letsels. Er is weinig geweten omtrent de heup range of motion (ROM) als intrinsieke risicofactor voor het oplopen van letsels bij hockeyspelers.

Doelstelling: Het doel van deze studie was om de heup ROM te identificeren als intrinsieke risicofactor voor onderste lidmaat letsels aan het musculoskeletaal stelsel in mannelijke elite jeugd hockeyspelers.

Onderzoeksdesign: Retrospectief en prospectief cohortonderzoek.

Methode: Drieënnegentig mannelijke hockeyspelers uit het U16, U18 of U21 Belgisch nationaal hockeyteam werden onderworpen aan het testprotocol en rapporteerden vervolgens gedurende zes maanden alle opgelopen letsels. Dit testprotocol bestond uit een bevraging naar de medische voorgeschiedenis van de afgelopen twee seizoenen, een antropometrisch onderzoek, de Flexie-Adductie-Interne rotatie test, de Deep Squat en heup ROM metingen. Univariate hypothesetesten werden uitgevoerd om het verschil tussen de letsel groep en de niet-letselgroep te onderzoeken. Multivariate logistische regressie werd toegepast om na te gaan welke variabelen risicofactoren zijn voor het oplopen van een musculoskeletaal letsel aan het onderste lidmaat.

Resultaten: Eenenveertig van de 93 atleten (44.1%) rapporteerden retrospectief minimaal één letsel aan het onderste lidmaat. Een positieve en negatieve significante correlatie werd gevonden respectievelijk tussen aanvallers (Spearman correlation coefficient (r_s) = +0.220) en doelmannen (r_s = -0.272) en het oplopen van letsels aan het onderste lidmaat. Tijdens de follow-up periode liepen 36 van de 73 atleten (49.3%) minimaal één letsel aan het onderste lidmaat op. Logistische regressieanalyse toonde een daling in heup rotatieverschillen en verminderde M. Quadriceps flexibiliteit gemeten met de Modified Thomas Test (MTT) aan als risicofactoren voor het oplopen van zowel een traumatisch letsel als een letsel aan het onderste lidmaat in het algemeen. Daarenboven werd heup interne rotatie (IR) in ruglig gevonden als een risicofactor voor het oplopen van een overbelastingsletsel en een letsel aan het onderste lidmaat in het algemeen. Verminderde heup IR in zit werd als voorspeller gevonden voor het oplopen van een traumatisch letsel.

Conclusie: Een vermindering van heup IR, flexibiliteit van de M. Quadriceps en heup rotatieverschillen werden gevonden als risicofactoren in veldhockey en zouden mee in rekening gebracht moeten worden in de ontwikkeling van preventieprogramma's.

Trefwoorden: veldhockey; risicofactor; onderste lidmaat; letsel; heup range of motion; letselpreventie

4. Introduction

Field hockey is an Olympic sport which is played worldwide. The fact that there are 137 national associations of field hockey shows its global popularity (International Hockey Federation, 2020). Despite the increase in popularity and the well-known health benefits of the sport, field hockey is associated with a certain risk of injury.

During games, contact between players or with equipment are not rare. Besides, there is an intense use of the full body: the lower quadrant must withstand forces generated from accelerations, side-cutting maneuvers and changes of direction while the upper body and trunk are used to control and distribute the ball by high motion swings (Feeley et al. 2019; Johnston et al. 2016). This makes field hockey a team sport with a high risk of injury. Considering the injury rate during the 2004 Athens Olympic games, field hockey took third place compared to other team sports (Junge et al. 2006). During 2008 Beijing (Junge et al. 2009), 2012 London (Engebretsen et al. 2013) and 2016 Rio Olympic games (Soligard et al. 2017), field hockey took respectively the third, sixth and 12th place compared to all other sports held during the Olympic games.

In general, sport injuries are highly associated with large medical and social costs, psychological problems, decreased performance and comprised team's success over a season (Brewer et al. 1994; Eirale et al. 2013; Van Mechelen et al. 1992). In sports, injury prevention programs consisting structured exercises may inhibit prospective injuries (Thorborg et al. 2017). Therefore, injury prevention programs are of great importance. Identification of the extent of the injury problem is the start towards effective injury prevention (Van Mechelen et al. 1992).

Various studies have been carried out to investigate the locations, types and mechanisms of injuries in field hockey. Barboza et al. (2018a) reviewed all prospective literature and found the lower limb as most affected body part, followed by the head, upper limb and trunk. Retrospective publications extended these findings (Eggers-Ströder et al. 1994; Murtaugh et al. 2001). Contact and non-contact injuries are the two main types of field hockey injuries. Contact injuries are injuries due to contact with a ball, stick, other players or playing surface as non-contact injuries are characterized by acute or chronic injuries associated with increased internal stress (Rose et al. 1981). Non-contact injuries seem to be predominant in field hockey (Barboza et al. 2018a; Lynall et al. 2018; Rishiraj et al. 2009). Muscle/tendon/ligament sprains/strains, tendinitis, contusions, concussions, haematoma and lacerations are the most frequent injuries as consequence of the earlier described mechanisms (Barboza et al. 2018a; Barboza et al. 2018b; Lynall et al. 2018). The injury incidence seems to be higher in competition than in practice as it is ranged between 2.50 and 3.70 per 1000 practice hours compared to 7.87 to 12.30 per 1000 match hours (Barboza et al. 2018b; Dick et al. 2007; Hollander et al. 2018). Also, men are more likely to sustain an injury (Hollander et al. 2018, Murtaugh et al. 2009; Theilen et al. 2015). During the 2004 Olympic games, men had approximately a four-fold higher risk to sustain any injury as well as a time-loss injury (Junge et al. 2006).

The second step of injury prevention is to determine the factors playing a part in the occurrence of sport injuries. Those entities which contribute to the occurrence of an athletic injury are called risk factors and can be divided into intrinsic or extrinsic factors (Maffey et al. 2007; Meeuwisse et al. 1991). Intrinsic risk factors are person-related and are part of the athlete themself. These factors include e.g. fatigue, range of motion (ROM) and strength. In contradiction with the latter are extrinsic risk factors environment-related and have an influence on all athletes while performing their sport like weather, rules and field conditions (Arnason et al. 2004; Meeuwisse et al. 1991). Risk factors can be further identified as modifiable and non-modifiable. Modifiable risk factors can potentially be revised in order to decrease the injury risk (Maffey et al. 2007).

During the years, the game of field hockey had been subjected to various changes to promote a faster, more continuous and more entertaining game. Advancements in the stick (material composition) occurred to manipulate the ball with more power and accuracy, the surface has changed from grass to a water-based artificial surface and new rules were initiated such as the self-pass, the permission to play high balls and the elimination of the off-side rule (Murtaugh et al. 2001; Rishiraj et al. 2009; Rossiter et al. 2017; Theilen et al. 2015). These were considered as extrinsic risk factors as publications indicated that these influenced the injury rates (Barboza et al. 2018a; Hollander et al. 2018; Lynall et al. 2018; Murtaugh et al. 2001; Rishiraj et al. 2009; Rossiter et al. 2017; Theilen et al. 2015; Tully et al. 2003).

Field hockey consists of symmetrical movements like running but is as well a sport with asymmetric and unilateral characteristics. Due to the use of a stick for hitting and pushing and the semi-crouched position during the games, one side of the body dominates the other side. This specific movement pattern can result in sport specific adaptations in ROM. Significantly higher lumbar bending asymmetry was found in field hockey players compared to non-athletes. Thoracic and lumbar right rotation movement and lumbar side bending were also found significantly different (Krzykala et al. 2018). Studies about these adaptations on the development of lower extremity musculoskeletal injuries in a specific population of field hockey players are lacking. Other publications with a wider population of not only field hockey players indicated that increased subtalar eversion and inversion ROM and increased talar tilt sets hockey players at higher risk in the development of an ankle injury (Baumhauer et al. 1995; Beynnon et al. 2001). The risk of lower leg injuries is also increased when the right leg hip extension flexibility is 15% higher than the other leg (Knapik et al. 1991).

Studies concerning risk factors and the set-up of prevention programs should be divided by gender as literature suggested differences in the anatomical locations and the type of sport injuries between male and female athletes (Matzkin et al. 2019; Ristolainen et al. 2009). Besides, physical and physiological changes make the adolescent athletes highly susceptible to sport injuries in relation to both injury risk and severity and more vulnerable for injuries than adults. (Eapen et al. 2014; Mukherjee et al. 2016). Therefore, the population of the present study concerns male hockey players playing in the U16, U18 and U21 Belgian national teams.

To our knowledge, there are no publications about ROM as an intrinsic risk factor in a specific population of male field hockey players. Therefore, the purpose of the study is to perform a retrospective and prospective investigation of hip ROM as an intrinsic risk factor for injuries concerning the lower quadrant in elite male youth hockey players.

5. Methods

This study was carried out in the context of a larger study undertaken to identify risk factors for injuries in elite Belgian hockey players. The study design is a combination of a retrospective and prospective cohort study. The prospective part involves a longitudinal research with a baseline assessment followed by a six months injury registration. The investigation was approved by the Ethics Committee of the Ghent University Hospital.

5.1 Study population

The U16, U18 and U21 male Belgian national hockey teams were invited for this study. Ninety-three hockey players volunteered and took part in the baseline assessment. All participants were briefed about the methods and aims of the study. Participants were excluded if a present injury or disease prevented them from completing the baseline measurements.

5.2 Baseline assessment

During the preseason screening, the players were submitted to baseline physical assessment. Every participating team was attributed to a specific screening day to guarantee that all team members were assessed on the same day. All subjects wore sportswear to prevent limitations in the performance of the tests. Each participant completed a questionnaire in which following items were enquired: team, player position, hand and leg dominance and special remarks regarding chronic injuries, complaints and malformations (Appendix 1). In addition, anthropometric measurements (height, weight and leg length) were taken.

The preseason screening consisted of 11 different testing stations and the sequence was randomly assigned. In total, 24 different assessors were enabled to execute the tests. ROM measurements, Deep Squat and Flexion-Adduction-Internal rotation test (FADIR-test) were investigated in this study.

5.2.1 Range of motion measurements

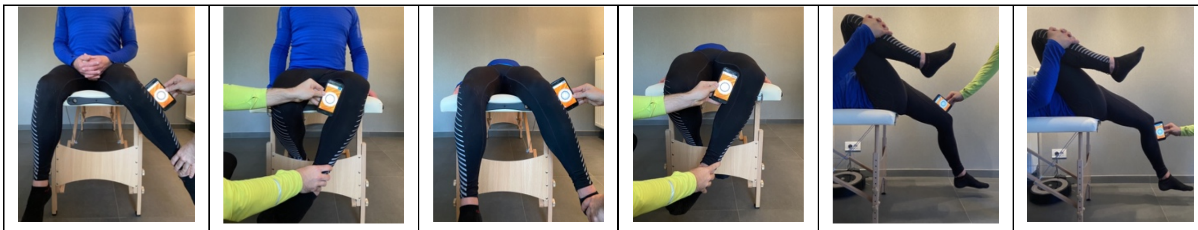
Hip joint ROM was assessed with a digital protractor (Fowler 54-950-315 Pro-360) and a smartphone application (Rotating Sphere clinometer) which both provided measurements to 0.1 degrees (°). Following variables were measured: internal rotation (IR) in supine and seated position, external rotation (ER) in supine and seated position, Thomas Test (TT) and Modified Thomas Test (MTT).

Internal and external rotation in seated position

The hip IR and ER were tested with the participant seated on an examination table with the hips and knees flexed at 90° (Figure 1). For the assessment of hip IR ROM, the inclinometer was placed on the lateral side of the calf at the level of the tibial tuberosity. For the measurement of hip ER ROM, the inclinometer was placed at the same level but on the medial side of the calf. During ER movement, the contralateral leg was flexed more than 90° to avoid obstruction of motion. For both movements, the examiner passively moved the lower leg to the end-ROM, defined as the highest range without the occurrence of compensatory movements. Before each measurement, the inclinometer was zeroed to the vertical line.

Internal and external rotation in supine position

The hip IR and ER were tested with the participant in supine position on an examination table with the hips in a neutral position and knees flexed at 90° over the edge of the table (Figure 1). The position and calibration of the inclinometer and the execution of the tests were similar to the previous described measurements in seated position.



Hip internal rotation seated	Hip external rotation seated	Hip internal rotation supine	Hip external rotation supine	Thomas Test	Modified Thomas Test

Figure 1: Execution of the hip rotation range of motion measurements

Thomas Test and Modified Thomas Test

The TT and MTT are clinical examinations to assess respectively M. Iliopsoas and M. Quadriceps flexibility. Figure 1 illustrates the testing position for the TT and MTT. The participant took place at the edge of the examination table and pulled the contralateral knee to the chest to guarantee posterior tilt of the pelvis. The examiner guided the participant to a supine position with the tested leg lowered towards the floor. The tested leg was relaxed to make sure a passive end-ROM was attained by the impact of gravity. From this starting position, two angles were recorded: the angle between the subject's thigh and the horizontal line (TT) and the angle of knee flexion (MTT). Therefore, the inclinometer was placed for the TT and MTT respectively above and below the patella. The inclinometer was zeroed to the horizontal line before each measurement.

5.2.2 Deep Squat

The Deep Squat is a clinical examination that is part of the Functional Movement Screen (FMS). The execution, scoring system and the investigation of the reliability are described in Appendix 2.

5.2.3 Flexion-Adduction-Internal rotation test

Figure 2: Execution of the Flexion-Adduction-Internal rotation test

FADIR-test is a provocative test used in the diagnosis of femoroacetabular impingement (FAI) syndrome. The participant was placed in supine position on the examination table. The examiner moved the hip passively to maximal hip flexion, adduction and IR with visual monitoring for compensatory movements (Figure 2). From this position, overpressure was applied on the knee in the direction of the femur. When athletes reported any pain in the groin region, the test was considered positive. Both sides were tested.

5.3 Registration of injuries

An injury questionnaire regarding the limitations in participation, localisation, description, onset and the affection on performance was set up by the team physiotherapists to follow-up the sustained injuries during the season. The complete form can be found in Appendix 3. During the injury surveillance period, the questionnaire was filled in by the athletes every Sunday using the online platform 'tophockey' from the Belgian national hockey federation.

5.4 Injury definition

An injury was defined as any traumatic event or overuse impairment concerning the lower limb that occurred during practice or competition which resulted in the presence of pain or physical discomfort.

5.5 Statistical analysis

All statistical analysis were conducted using SPSS Statistics version 26.0 (SPSS Inc, Chicago, Illinois). To compare possible differences between the injured group (IG) and the uninjured group (UG), the independent continuous variables were run through a descriptive analysis. For all tests, the level of significance was set at 0.05. Data distribution was assessed for normality using the Shapiro-Wilk test. To perform univariate hypothesis testing for between-group analysis, the independent Student *t*-test was applied in case the data were normally distributed and the Mann-Whitney *U*-test was used if the data were not normally distributed. Categorical data were studied using Chi-square analysis. If the criteria for the Chi-square test were not fulfilled, the Fisher's exact test was used. The described analysis was conducted on both retrospective and prospective data.

To assess potential risk factors for both lower limb injuries, traumatic injuries and overuse injuries, a multivariate logistic regression analysis was performed on the prospective data. Variables were considered eligible for inclusion if the p-value was below 0.20. The multivariate logistic regression model was built by using the backward likelihood ratio selection. After this elimination process, odds ratios (OR) along with 95% confidence intervals were calculated for the remaining variables.

Nagelkerke's coefficient of determination (Nagelkerke R^2) was used to investigate the usefulness of the logistic model by defining the extent in which the model can explain the variance in the outcome variables. The fit of the model was assessed using the Hosmer and Lemeshow Goodness-of-fit-test. Sensitivity and specificity were determined using the receiver operating characteristic (ROC) curve analysis. Sensitivity, also defined as the true positive rate, is the percentage of injured athletes that were genuinely identified as such. Specificity, also defined as true negative rate, is the percentage of uninjured athletes that were genuinely identified as such. Based on the ROC curve analysis, cutoff values at 85% sensitivity were defined.

6. Results

6.1 Retrospective approach

6.1.1 Population and injury data

Injury data from 93 male hockey players were obtained in this retrospective study. From the participants, 41 (44.1%) reported at least one injury to the lower limb during the last two seasons. In total, 51 injuries were registered. Twenty-four (47.1%) injuries occurred at the knee which makes the knee the most affected body part. Seventeen (33.3%) injuries incurred at the lower leg, ankle or foot. Ten (19.6%) injuries were located at the hip or the upper leg region.

Players' characteristics at the baseline assessment are presented in Table 1. The UG had a mean ± standard deviation (SD) age of 16.4 ± 1.46 years (y), with a mean height of 176.55 ± 8.327 centimeters (cm) and mean body weight of 64.74 ± 9.834 kilograms (kg) as the IG had a mean age of 16.1 ± 1.57 y, a mean height of 175.20 ± 9.441 cm and a mean body weight of 65.92 ± 11.472. Body mass index (BMI) was calculated as weight/height² resulting in a mean BMI of 20.67 ± 2.075 kilogram/centimeter² (kg/cm²) for the UG and 21.34 ± 2.392 kg/cm² for the IG. The mean right leg length for the UG was 94.09 ± 4.997 cm and for the IG 93.85 ± 6.214 cm. Statistical analysis did not reveal any significantly different p-values for the anthropometric variables.

The study population consisted of 28 attackers, 24 midfielders, 29 defenders and 12 goalkeepers. Based on the distribution of player positions on the field, weighted percentages were calculated. Attacker seemed to be the most vulnerable position during field hockey as 39.0% of all injuries were sustained by attackers. Respectively 28.8%, 26.8% and 5.4% of the injuries were sustained by defenders, midfielders and goalkeepers. A significantly different p-value was found between the IG and the UG for player position (p = 0.024). The Spearman correlation test showed a significant correlation between attackers (p = 0.034) and goalkeepers (p = 0.007) and the development of a lower limb injury. The Spearman correlation coefficient (r_s) for attackers and goalkeepers were respectively +0.220 and -0.277.

Table 1: Analysis of anthropometric data to compare injured and uninjured subjects using the independent Student t-test and the Mann-Whitney U-test

	Uninjured		Injured		p-value
	Mean	SD	Mean	SD	
Age (y)	16.4	1.46	16.1	1.57	0.277 ^{U}
Body height (cm)	176.55	8.327	175.20	9.441	0.466
Body weight (kg)	64.74	9.834	65.92	11.472	0.595
Body mass index (kg/cm²)	20.67	2.075	21.34	2.392	0.151
Right leg length (cm)	94.09	4.997	93.85	6.214	0.838

^{U}: Mann-Whitney *U*-test

6.1.2 Between group analysis for lower limb injuries

Means, SD and p-values for the ROM measurements are presented in Table 2. The mean values for hip IR in seated position, hip ER in supine position, TT and MTT were lower in the IG for both left and right side. For hip IR in supine position were the mean values also lower in the IG but only on the left side. In contradiction to this, the mean hip ER in seated position was higher in the IG compared to the UG for both sides. Nevertheless, none of the tests reached the level of significance.

Lower mean absolute differences between both sides were found in the IG in comparison with the UG for hip IR in seated and supine position, hip ER in seated position, TT and MTT (Table 3). A higher side to side difference was seen in the IG for hip ER in supine position. For all variables, p-values did not reach the level of significance.

Table 4 shows the mean absolute differences between ER and IR movements of the hip. In general, more symmetrical values were seen in the IG except for right hip rotations in supine position. Nevertheless, none of these differences were significantly different.

Using Chi-square analysis to compare the IG and UG, the FADIR-test was not found to be significantly different for both left (p = 0.601) and right side (p = 0.560). Neither the Deep Squat was found to be significantly different (p = 0.860, Fisher's exact test).

Table 2: Analysis of range of motion data to compare injured and uninjured subjects using the independent Student t-test and the Mann-Whitney U-test

	Uninjured		Injured		p-value
	Mean	SD	Mean	SD	
Hip IR seated					
Left	45.8	6.32	44.9	7.70	0.522
Right	48.0	6.81	46.5	6.65	0.278
Hip ER seated					
Left	43.2	9.03	43.8	10.39	0.917 ^{U}
Right	42.4	9.74	42.7	10.89	0.886
Hip IR supine					
Left	41.8	7.63	40.3	6.92	0.351
Right	42.4	6.40	43.1	8.18	0.659
Hip ER supine					
Left	46.9	9.54	45.4	11.80	0.499
Right	45.5	9.86	42.8	11.12	0.226
TT					
Left	-18.7	9.42	-18.1	7.49	0.886 ^{U}
Right	-18.8	9.55	-17.5	7.39	0.495 ^{U}
MTT					
Left	70.7	8.29	70.1	9.49	0.730
Right	72.0	8.44	71.3	8.97	0.620 ^{U}

IR, internal rotation; ER, external rotation; TT, Thomas Test; MTT, Modified Thomas Test.
^{U}: Mann-Whitney *U*-test

Table 3: Analysis of side to side differences to compare injured and uninjured subjects using the Mann-Whitney U-test

	Uninjured		Injured		p-value
	Mean	SD	Mean	SD	
Hip IR seated	5.9	5.00	4.8	3.62	0.586
Hip ER seated	5.4	4.41	5.1	5.63	0.321
Hip IR supine	5.0	3.63	4.7	4.07	0.508
Hip ER supine	5.6	4.12	6.9	5.17	0.304
TT	4.1	3.46	3.8	3.01	0.882
MTT	5.8	4.95	5.2	3.33	0.969

IR, internal rotation; ER, external rotation; TT, Thomas Test; MTT, Modified Thomas Test.

Table 4: Analysis of rotation differences to compare injured and uninjured subjects using the Mann-Whitney U-test

	Uninjured		Injured		p-value
	Mean	SD	Mean	SD	
Hip seated					
Left	8.7	6.96	8.4	5.67	0.801
Right	10.0	8.35	9.2	7.79	0.548
Hip supine					
Left	10.6	6.73	9.7	7.46	0.354
Right	8.9	7.08	11.6	7.63	0.062

6.2 Prospective approach

6.2.1 Lower limb injuries

Population and injury data

Twenty of the 93 initial participants dropped out during the follow-up period. Four dropped out because of reduced exposure due to an upper limb injury, six dropped out because of insufficient injury data and 10 athletes were deselected from the national team. Of the 73 athletes who completed the study, 36 athletes reported a total of 60 injuries. Only an athlete's first sustained injury was used in the statistical analysis to prevent interference between the first injury and the subsequent injuries. Twenty (55.6%) injuries were located at the hip or the upper leg, six injuries (16.7%) incurred at the level of the knee and 10 injuries (27.8%) occurred at the lower leg, ankle or foot.

Anthropometric characteristics at baseline assessment are presented in Table 5. The UG had a mean (± SD) age of 16.1 ± 1.28 y, with a mean height of 175.15 ± 8.259 cm and mean body weight of 65.53 ± 9.296 kg as the IG had a mean age of 16.6 ± 1.71 y, a mean height of 176.76 ± 9.295 cm and a mean body weight of 68.11 ± 9.913. A mean BMI of 20.28 ± 1.913 kg/cm² was found for the UG and 21.72 ± 2.135 kg/cm² was found for the IG. The mean right leg length for the UG was 94.02 ± 5.260 cm and for the IG 94.36 ± 5.802 cm. Body weight and BMI between the IG and the UG were significantly different.

The study population counted 22 attackers, 19 midfielders, 22 defenders and 10 goalkeepers. The p-value for player position was not considered statistically significant ($p = 0.085$).

Table 5: Analysis of anthropometric data to compare injured and uninjured subjects using the independent Student t-test and the Mann-Whitney U-test

	Uninjured		Injured		p-value
	Mean	SD	Mean	SD	
Age (y)	16.1	1.28	16.6	1.71	0.215 [U]
Body height (cm)	175.15	8.259	176.76	9.295	0.436
Body weight (kg)	65.53	9.296	68.11	9.913	0.016 [a]
Body mass index (kg/cm²)	20.28	1.913	21.72	2.135	0.003 [a]
Right leg length	94.02	5.260	94.36	5.802	0.794

[a] : significant at $p < 0.05$
[U] : Mann-Whitney *U*-test

Between group analysis

ROM data are presented in Table 6. Overall, lower left and right mean IR values were found in the IG for both seated and supine position. Statistical analysis between both groups showed a significantly different p-value for hip IR in supine position for the right side. Lower mean values for the MTT were found in the IG but these were only statistically significant for the right side.

The Fisher's exact test and the Chi-square test revealed no statistically significant p-values respectively for the Deep Squat ($p = 0.251$) and the FADIR-test on both left ($p = 0.258$) and right side ($p = 0.818$).

Table 6: Analysis of range of motion data to compare injured and uninjured subjects using the independent Student t-test and the Mann-Whitney U-test

	Uninjured		Injured		p-value
	Mean	SD	Mean	SD	
Hip IR seated					
Left	46.3	6.01	45.7	7.19	0.725
Right	48.4	6.83	46.3	6.80	0.192
Hip ER seated					
Left	43.7	10.38	42.5	9.35	0.597
Right	42.0	10.78	43.6	10.70	0.531
Hip IR supine					
Left	43.1	6.73	39.8	7.75	0.054
Right	45.0	6.58	40.0	7.38	0.003 [a]
Hip ER supine					
Left	47.7	10.39	45.2	11.52	0.321
Right	43.2	10.53	45.7	10.62	0.320
TT					
Left	-18.1	10.11	-20.2	7.40	0.084 [U]
Right	-18.5	10.63	-18.6	7.24	0.551 [U]
MTT					
Left	71.6	9.24	68.5	7.92	0.133
Right	74.0	8.57	68.9	7.96	0.011 [a]

IR, internal rotation; ER, external rotation; TT, Thomas Test; MTT, Modified Thomas Test.
[a] : significant at $p < 0.05$
[U] : Mann-Whitney *U*-test

Higher mean absolute side to side differences were found in the UG compared to the IG for all variables except for the TT. None of these differences were statistically significant (Table 7).

Table 7: Analysis of side to side differences to compare injured and uninjured subjects using the Mann-Whitney U-test

	Uninjured		Injured		p-value
	Mean	SD	Mean	SD	
Hip IR seated	5.6	4.88	5.5	4.24	0.947
Hip ER seated	5.9	5.21	5.5	5.23	0.546
Hip IR supine	5.4	4.06	4.4	3.68	0.296
Hip ER supine	6.9	5.33	5.8	4.02	0.615
TT	3.8	3.12	4.3	3.55	0.681
MTT	5.9	4.93	5.6	4.18	0.987

IR, internal rotation; ER, external rotation; TT, Thomas Test; MTT, Modified Thomas Test.

Mean absolute differences between ER and IR movements of the hip are shown in Table 8. Higher mean values were found in the UG for all variables except for right hip rotation in supine position in which the mean value was lower. None of the p-values did reach the level of significance.

Table 8: Analysis of rotation differences to compare injured and uninjured subjects using the Mann-Whitney U-test

	Uninjured		Injured		p-value
	Mean	SD	Mean	SD	
Hip seated					
Left	10.0	7.19	7.3	5.67	0.096
Right	10.8	8.83	9.1	8.18	0.364
Hip supine					
Left	10.9	7.21	10.8	7.34	0.947
Right	10.1	7.15	10.8	8.12	0.838

Risk factors

Nine variables were found eligible to incorporate in the multivariate logistic regression to analyse the relationship between the outcome variables and potential risk factors. Backward stepwise elimination resulted in the following three variables: hip IR supine right, MTT right and hip rotation differences seated left. These independent predictors of lower limb injuries are presented in Table 9.

For each 1° increase in hip IR ROM, the risk of sustaining a lower limb injury decreased with 9.9%. For each 1° increase on the MTT on the right side (i.e. increasing M. Quadriceps flexibility) and each 1° increase in left hip rotation asymmetry, the lower limb injury risk decreased respectively with 8.0% and 9.5%.

Table 9: Risk model for the prediction of lower limb injuries obtained by the multivariate logistic regression

Predictive variable	B	SE	OR	95% CI		p-value
				Lower	Higher	
Hip IR supine right	-0.104	0.042	0.901	0.831	0.978	0.012
MTT right	-0.083	0.036	0.920	0.858	0.987	0.019
Hip rotation differences seated left	-0.100	0.049	0.905	0.822	0.995	0.040

IR, internal rotation; MMT, Modified Thomas Test; B, regression coefficient; SE, standard error; OR, odds ratio; 95% CI, 95% confidence interval.

According to the Nagelkerke R² measure, 30.6% of the variance in the outcome variable was declared by the logistic regression model. Furthermore, the p-value of the Hosmer and Lemeshow Goodness-of-fit-test was not significant, indicating the competence of the model in fitting the data (Table 10). Cutoff values for these predictors of lower limb injuries were determined at 85% sensitivity (Table 11). The cutoff values of right hip IR in supine position, MTT on the right side and left hip rotation differences in seated position were respectively 31.0° (specificity: 2.7%), 60.5° (specificity: 2.7%) and 1.5° (specificity: 5.4%).

Table 10: Nagelkerke R² and Hosmer and Lemeshow Goodness-of-fit-test

	Nagelkerke R²	Hosmer and Lemeshow Goodness-of-fit-test (p-value)
Lower limb injury	0.306	0.171

Table 11: Cutoff values and specificity for the risk factors at 85% sensitivity

Parameter	85% Sensitivity	
	Cutoff (°)	Specificity (%)
Hip IR supine right	31.0	2.7
MTT right	60.5	2.7
Hip rotation differences seated left	1.5	5.4

IR, internal rotation; MTT, Modified Thomas Test.

6.2.2 Overuse injuries

Between group analysis

An overuse injury was defined as an injury that came up gradually and did not originate of a specific and identifiable event. In total 21 out of the 36 injuries (58.3%) were overuse injuries. Statistical analysis of the independent variables to compare players who sustained an overuse injury with players who did not sustain an overuse injury resulted in the p-values listed in Table 12. A significantly different p-value for right hip IR in supine position was found.

Table 12: The p-values for the independent variables for overuse and traumatic injuries using the independent Student t-test, the Mann-Whitney U-test and the Chi-square test

	p-value	
	Overuse	Traumatic
Age (y)	0.257 [U]	0.791 [U]
Body height (cm)	0.580	0.111
Body weight (kg)	0.411	0.041 [a]
Body mass index (kg/cm²)	0.069	0.131
Right leg length (cm)	0.415	0.313
Position	0.593 [X]	0.370 [F]
Deep Squat	0.486 [F]	0.811 [F]
FADIR-test		
Left	0.324 [F]	1.000 [F]
Right	0.530 [F]	0.493 [F]
Hip IR seated		
Left	0.846	0.513
Right	0.921	0.083
Hip ER seated		
Left	0.688	0.268
Right	0.278	0.662

Hip IR supine		
Left	0.382	0.165
Right	0.030 [a]	0.248
Hip ER supine		
Left	0.595	0.530
Right	0.241	0.935
TT		
Left	0.068 [U]	0.924 [U]
Right	0.198 [U]	0.482 [U]
MTT		
Left	0.797	0.116
Right	0.415	0.027 [a]
Hip side to side differences		
IR seated	0.816 [U]	0.859 [U]
ER seated	0.907 [U]	0.537 [U]
IR supine	0.360 [U]	0.789 [U]
ER supine	0.409 [U]	0.763 [U]
TT	0.560 [U]	0.246 [U]
MTT	0.365 [U]	0.300 [U]
Hip rotation differences		
Left seated	0.529 [U]	0.175 [U]
Right seated	0.486 [U]	0.732 [U]
Left supine	0.956 [U]	0.886 [U]
Right supine	0.396 [U]	0.229 [U]

FADIR-test, Flexion-Adduction-Internal rotation test; IR, internal rotation; ER, external rotation; TT, Thomas Test; MTT, Modified Thomas Test.
[a] : significant at $p < 0.05$
[F] : Fisher's exact test
[U] : Mann-Whitney *U*-test
[X] : Chi-square test

Risk factors

Four variables were considered further in a backward stepwise multivariate logistic regression model to evaluate potential predictors for overuse injuries. The elimination resulted in one predictor which is presented in Table 13. The risk to sustain an overuse injury decreased with 8.1% with every 1° of higher hip IR ROM in supine position.

Table 13: Risk model for the prediction of overuse lower limb injuries obtained by the multivariate logistic regression

Predictive variable	B	SE	OR	95% CI		p-value
				Lower	Higher	
Hip IR supine right	-0.084	0.040	0.919	0.850	0.994	0.035

IR, Internal rotation; B, regression coefficient; SE, standard error; OR, odds ratio; 95% CI, 95% confidence interval.

Table 14 presents the Nagelkerke R^2 and the p-value of the Hosmer and Lemeshow Goodness-of-fit-test. The logistic model declares 9.4% of the variance in overuse lower limb injuries. The Hosmer and Lemeshow p-value was not significant which demonstrated the model's adequacy in fitting the data. Table 15 shows the cutoff value at 85% sensitivity for right hip IR in supine position as a predictor for overuse injuries. This value was determined at 31.0° corresponding with a specificity of 5.8%.

Table 14: Nagelkerke R^2 and Hosmer and Lemeshow Goodness-of-fit-test

	Nagelkerke R^2	Hosmer and Lemeshow Goodness-of-fit-test (p-value)
Overuse injury	0.094	0.263

Table 15: Cutoff value and specificity for the risk factor at 85% sensitivity

Parameter	85% Sensitivity	
	Cutoff (°)	Specificity (%)
Hip IR supine right	31.0	5.8

IR, internal rotation.

6.2.3 Traumatic injuries

Between group analysis

An acute injury was defined as an injury with a sudden onset and which resulted from one specific, traumatic event. In total 15 out of the 36 injuries (41.7%) were acute injuries. Statistical analysis of the independent variables to compare players who sustained a traumatic injury with players who did not sustain a traumatic injury resulted in the p-values listed in Table 12. Significantly different p-values were found for body weight and MTT on the right side.

Risk factors

Eight variables were applied in the multivariate logistic regression model and this resulted in three remaining variables (Table 16). Right MTT (M. Quadriceps flexibility) was identified as a predictor for traumatic injuries. Every 1° of higher right M. Quadriceps flexibility, higher IR ROM in seated and more hip rotation asymmetry resulted in a decreased injury risk of respectively 9.7%, 8.5% and 10.2%.

Table 16: Risk model for the prediction of traumatic lower limb injuries obtained by the multivariate logistic regression

Predictive variable	B	SE	OR	95% CI		p-value
				Lower	Higher	
MTT right	-0.102	0.044	0.903	0.829	0.984	0.019
Hip IR seated right	-0.089	0.052	0.915	0.827	1.012	0.085
Hip rotation differences seated left	-0.108	0.061	0.898	0.797	1.012	0.077

MTT, Modified Thomas Test; IR, internal rotation; B, regression coefficient; SE, standard error; OR, odds ratio; 95% CI, 95% confidence interval.

The logistic regression model revealed 23.9% of the variance in traumatic lower limb injuries (Nagelkerke $R^2 = 0.239$). The Hosmer and Lemeshow Goodness-of-fit-test ($p = 0.885$) demonstrated the model's accuracy in fitting the data (Table 17). Cutoff values for the three predictors of traumatic lower limb injuries were defined at 85% sensitivity (Table 18). The cutoff values of right hip IR in seated position, MTT on the right side and left hip rotation imbalances in seated position were respectively 39.5° (specificity: 12.1%), 59.5° (specificity: 3.4%) and 1.5° (specificity: 8.6%).

Table 17: Nagelkerke R² and Hosmer and Lemeshow Goodness-of-fit-test

	Nagelkerke R^2	Hosmer and Lemeshow Goodness-of-fit-test (p values)
Traumatic injury	0.239	0.885

Table 18: Cutoff values and specificity for the risk factors at 85% sensitivity

Parameter	85% Sensitivity	
	Cutoff (°)	Specificity (%)
Hip IR seated right	39.5	12.1
MTT right	59.5	3.4
Hip rotation differences seated left	1.5	8.6

IR, internal rotation; MTT, Modified Thomas Test.

7. Discussion

7.1 Main findings

In the retrospective approach of this study, the group who sustained an injury was found significantly different to the group who did not sustain an injury with respect to player positions. A positive significant correlation was found between attackers and the development of lower limb injuries. During the last two seasons, 39.0% of the reported lower limb injuries were sustained by attackers. Similar findings were found by Fuller et al. (1990). However, Dick et al. (2007) and Rishiraj et al. (2009) disagreed with this finding and found respectively midfielders and defenders as the most injured player position. Furthermore, a negative significant correlation was found between goalkeepers and lower limb injuries. The goalkeepers sustained the lowest amount of lower limb injuries (5.4%). This result is in agreement with publications by Dick et al. (2007), Fuller et al. (1990) and Rishiraj et al. (2009) as these publications also reported goalkeepers as the least injured player position.

In the prospective approach of this study, a logistic model was obtained in which hip IR, MTT and hip rotation differences were identified as risk factors for lower limb injuries. The IR with a neutral hip was found as a risk factor for both lower limb injuries and overuse injuries. These results are in agreement with several studies (Nakano et al. 2018; Nevin et al. 2014; Yasuda et al. 2016). However, the relationship between IR with a neutral hip and lower limb injuries remained obscure as six publications disagreed with these findings (Gabbe et al. 2005, 2006a, 2006b; Hein et al. 2014; Malliaras et al. 2009; Milgrom et al. 1991). A plausible reason for the difference between our results and others could be due to our focus on lower limb and overuse injuries as a group while the other studies focused on a specific pathology, which also differed between the studies. The cutoff values at 85% sensitivity for lower limb injuries and overuse injuries were both 31°. This suggests that athletes with IR ROM values with a neutral hip below these thresholds were predisposed to the corresponding type of injury. In field hockey, every hit is performed from a lunge position (Figure 3). This indicates that the hip of the posterior leg is extended. In this position, IR values are lower compared to IR with a flexed hip due to higher capsuloligamentous tension (Kapandji, 1982). Restrictions in ROM may result in abnormal kinematics, which can injure the proximal and distal parts of the kinetic chain (Bedi et al. 2014). During a hit, the ground reaction forces are transduced upwards through the kinetic chain to built up energy and hit the ball as hard as possible. An IR of the hip is crucial

Figure 3: Demonstration of the lunge position during field hockey

for optimizing the potential energy transfer in an adequate way. A hip IR ROM restriction might result in a deficit in the kinetic chain indicating compensatory actions of other segments which might predispose the athlete to injuries.

In this study, hip IR in seated position was found as a risk factor for traumatic injuries. In agreement with the current study, two publications found hip IR in seated position as a risk factor for traumatic injuries (Bedi et al. 2014; Nakano et al. 2018). However, an equal amount of publications disagreed with this finding (Milgrom et al. 1991; Schuermans et al. 2017). The different outcomes of the studies could possibly explain the discrepancies in the literature. Again, the present study evaluated risk factors for traumatic injuries in general as others examined a specific injury. The cutoff value at 85% sensitivity for traumatic injuries was respectively 39.5°. This suggests that athletes with hip IR ROM values below this threshold were predisposed to the corresponding type of injury. The higher cutoff value for traumatic injuries in comparison with the earlier described cutoff values for lower limb and overuse injuries could be explained by the position in which the test was evaluated. Higher ROM values were obtained with a flexed hip due to the fact that all ligaments are more relaxed in this position, indicating increased demands of muscles and joint capsules (Kapandji, 1982). Field hockey is played in a semi-crouched position, a prolonged hip flexion that facilitates anterior pelvic tilt, which produces an asymmetrical force couple between the hip flexors and the gluteal muscle resulting in muscle imbalances (Ellapen et al. 2014). In this forward-flexed position many cutting-maneuvers are performed by the athletes. Restriction of hip IR ROM in a flexed position may require compensatory movements in the kinetic chain to successfully complete the maneuver (Bedi et al. 2014). This implies that players with a hip IR deficit in the semi-crouched position might be at higher risk for injury.

Field hockey is a high-demanding sport that requires large ROM movements of the hip. These types of sports predispose the athlete to direct contact between the femur and the acetabulum (Keogh et al. 2008) which may lead to reactive bone formation and the development of FAI syndrome. Therefore, the FADIR-test was used in this study to assess its relationship with lower extremity injuries but the IG was not found to be significantly different from the UG for both traumatic, overuse and lower limb injuries. Looking at the literature, no publications studied the FADIR-test as a risk factor that may predispose the athlete to injuries. However, Bedi et al. (2014) found that football players diagnosed with FAI syndrome were more vulnerable to sustain an anterior cruciate ligament (ACL) injury. The result of our study might be explained by the results found by Philippon et al. (2008) that FAI occurred in young patients but often remained asymptomatic until adulthood. This indicates that FAI is a subclinical deformity at young age and need to be observed for a longer period of time. Another possible reason given by Casartelli et al. (2018) is that the FADIR-test is an inadequate test for detecting

FAI-deformities due to the large amount of false positives. FAI syndrome may lead to a decrease in the ROM, particularly the hip IR ROM measured with a flexed hip (Ganz et al 2003; Philippon et al. 2007). Therefore, Pålsson et al. (2020) suggests to combine the FADIR-test with the measurement of hip IR in flexed position to increase the diagnostic accuracy of FAI. Since, he suggested that a negative FADIR-test may be eligible to rule out patients from the FAI-diagnosis, while a decreased IR measurement can be used to rule in patients with FAI syndrome. The importance of hip IR ROM in combination with the diagnosis of FAI was also studied by Bedi et al. (2014) who found that a decrease in hip IR due to abnormal hip morphology may lead to a compensatory greater range of IR of the tibia during cutting and pivoting and thus more stress on the ACL. In this study, both tests were assessed independent from each other. Further research should focus on the risk to develop a lower limb injury when an athlete has a positive result on both tests.

The MTT for determining M. Quadriceps flexibility has been found as a risk factor for sustaining an injury. A decreased risk for a lower limb or traumatic injury was associated with a greater M. Quadriceps flexibility. The cutoff values at 85% sensitivity for lower limb and traumatic injuries were respectively 60.5° and 59.5°, predisposing an athlete to the corresponding type of injury if the ROM values were below these thresholds. A previous prospective study by Gabbe et al. (2005) supported these findings, describing a similar relationship between the MTT and hamstring injuries. The least flexible Australian football athletes were more likely to complete their sportive season with a hamstring injury. These findings are in contrast with conclusions drawn by previous studies (Gabbe et al. 2004; Schuermans et al. 2017) as these found no association between the MTT and the occurrence of a lower limb injury respectively in Australian football and soccer. A possible reason for contradiction could be that muscle flexibility should be analysed on a sport specific basis (Harvey et al. 1998). In field hockey, Kawalek et al. (2013) found that in 63% of the elite hockey players the M. Quadriceps was shortened caused by the semi-crouched position that players have to maintain during this sport. Looking at the different hitting techniques (i.e. the drag flick, the push and the flats), a large amount of muscle flexibility is required due to the deep lunge position in which the hits are played. Deficits in flexibility might result in improper technique and therefore lead to an increased risk for injuries. These findings implicate that muscle flexibility of the M. Quadriceps should be taken into account in the development of prevention programs in a field hockey population.

In our study, the difference between hip IR and hip ER has been found as a risk factor for sustaining lower limb and traumatic injuries. A lower risk for an injury was associated with more asymmetrical ipsilateral hip rotations. The cutoff values at 85% sensitivity for lower limb injuries and traumatic injuries were both 1.5°, predisposing an athlete for injury if the difference between IR and ER of the hip was below these thresholds. These findings are in contrast with the conclusions of previous studies which postulated that asymmetry in hip rotation is related to various musculoskeletal injuries (Cibulka et al. 1998; Cibulka & Threlkeld-Watkins 2005; Ellison et al. 1990; Gelberman et al. 1987; Pitkow et al. 1975; Swanson et al. 1963). To our knowledge, this is the first study that investigated hip rotation asymmetry in an athletic population. Selye et al. (1956) set up the specific adaptation to imposed demand principle, also known as the SAID-principle. During sports activities, all athletes develop physiological adaptations in response to the athletic demands. Depending on the characteristics of the sport, these adaptations will be more of less prominent (Liebenson, 2014). Multiple publications investigated the sport specific adaptations in baseball players and it was apparent that each athlete adapted in a similar pattern specific for this sport (Borsa et al. 2005; Crockett et al. 2002; Osbahr et al. 2002; Reagan et al. 2002; Wilk et al. 2010; Wilk 2004). Publications about functional adaptations in field hockey are lacking. Ng et al. (2018) executed a kinematic analysis on a forehand hit and a drag flick and found in every technique different patterns for hip IR movements compared to hip ER movements. Therefore, it is possible that an asymmetry develops based on the execution of the hitting techniques. These adaptations may help the athlete and the athlete's body to meet the demands of the sport and therefore prevent injury. This could possibly explain the findings in this study suggesting that more asymmetry in ipsilateral hip rotation is associated with a decreased risk for lower limb and traumatic injuries. In this study, no differentiation was made in the patterns of asymmetry (i.e. ER exceeding IR or IR exceeding ER). This implies that further research should focus on the different types of asymmetry in field hockey and its influence on the development of lower limb musculoskeletal injuries.

For lower limb and traumatic injuries, analysis of anthropometrical characteristics revealed that body weight was significantly different between the IG and the UG. These results does not fit in the framework of the literature as Baumhauer et al. (1995), Bennell et al. (1996), Beynonn et al. (2001), Kannus & Niittymäki (1994), Lysens et al. (1984), McKay et al. (2001), Ostenberg et al. (2000), Twellaar et al. (1997) and Wiesler et al. (1996) did not found an association between body weight and the development of injuries. On the first sight, Moss et al. (1992) did agree with the findings in our study but the population consisted of female athletes. Therefore, the results cannot be extrapolated to a male population as Lin et al. (2018) reviewed sex-differences in sports injuries and found variations between female and male athletes respectively for injury incidence, injury mechanisms and risk factors. Nevertheless, body weight might be relevant in our study population as the results found in our study might be explained by a biomechanical analysis. During the game of field hockey, heavier athletes produce higher gravity forces due to the higher body mass and therefore also higher ground reaction forces. Thus, higher demands of the muscles are required to neutralise the increased external moment created by the gravity forces and ground reaction forces. Due to the higher load, the fatigue will set in faster which can lead to a loss of proper technique. There is a tendency that improper technique leads to an increased risk of injury in field hockey (Ng et al. 2016).

7.2 Limitations

The results of the current study should be interpreted considering several limitations.

During preseason, three testing days (one for each team) with an interval of one week were organised. This indicates that players who were tested on the last screening day had experienced two more weeks of training and thus, might be in a different shape at the baseline measurements.

For the retrospective part, the injury history data were self-reported. Thus, the athletes were potentially subjected to recall bias. This implies that the accuracy of the injury tracking method was not ideal as some injuries might be missed due to the inattentiveness of the athletes. Besides, in case more injuries were reported, the order in which the injuries were sustained was unknown. Therefore, only a differentiation between athletes who sustained a lower limb injury and those who did not could be made.

As earlier described, this study was carried out in the context of a larger study. In total, 24 examiners took part in the administration of the tests. The large amount of different examiners might have impacted the reliability. However, moderate interrater reliability was found for the FADIR-test according to the Cohen Kappa coefficient (κ) reference values set by Landis et al. (1977) (Robroy & Sekya 2008). Intraclass correlation coefficients were evaluated based on the benchmarks set by Cichetti et al. (1994). Fair reliability was found for hip IR in supine position (Tak et al. 2018), good reliability was found for hip IR and hip ER in seated position (Norris et al. 2016) and excellent reliability was found for hip ER in supine position, TT and MTT (Cleffken et al. 2007; Doinn et al. 2018; Tak et al. 2018). Furthermore, all examiners had little to no experience in the assessment of the performed tests. For that reason, all examiners received a clear explanation from a more experienced examiner together with a copy consisting of the execution and the scoring system of the tests.

Every athlete had to report the sustained injuries by using the weekly injury tracking questionnaire. Despite a one week interval between the baseline measurements of the different teams, the injury registration started on the same day namely two weeks after the last screening day. This indicates that every team did not report injuries during the first weeks.

During the follow-up period, the athletes had to indicate, in case of injury, if the injury was accompanied with full participation, reduced participation or missing at least one training or game. A description of the reduction or the total amount of time missed from participation was not recorded within this study, indicating that the severity of injuries could not be used in the analysis. Furthermore, the location is well known for every injury but only a few injuries were investigated by a doctor or team physiotherapist. This implies that a specific diagnosis was missing as the affected structure was unknown. Consequently, categorisation based on the type of injury became impossible. Therefore, all injuries were included in a general group of lower limb injuries. Hence, this involved a limitation as every injury has its own injury mechanism and factors that contribute to the development of the injury. Only a sub-categorisation could be made based on the onset of the injuries.

7.3 Strengths

All subjects were part of the Belgian national team and played at a local field hockey club. Generally, all players had approximately the same training regimen consisting of three trainings and one game every week. Besides, all the tests were conducted on male athletes. Focusing on a male population in field hockey was a well-considered choice as men and women are not comparable due to sex-specific differences in flexibility, ROM, injury incidence, biomechanics, injury mechanism and factors contributing to injury (Czuppon et al. 2017; Davis et al. 2008; Hollman et al. 2003; Hwang et al. 2015; Lin et al. 2018; López De Subijana et al. 2010; Marshall et al. 2014; Miyamoto et al. 2018; Simoneau et al. 1998).

8. Conclusion

This research was conducted to examine the risk factors contributing to the development of lower limb, overuse and traumatic injuries. The injured athletes were found to be significantly different to the uninjured athletes with respect to player position, BMI and body weight. The multivariate logistic regression analysis suggested decreased hip IR in supine position as a risk factor for lower limb and overuse injuries while decreased hip IR in seated position was found as a risk factor for traumatic injuries. In addition, a decreased M. Quadriceps flexibility measured with the MTT and lower hip rotation imbalances were identified as predictors for lower limb and traumatic injuries. Multiple limitations and strengths should be considered when interpreting the results. Therefore, further research should set up study designs to assess risk factors for injuries without these limitations. Nevertheless, the risk factors found in this study should be implicated in the development of prevention programs in field hockey.

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10. Abstract in Layman's terms

Achtergrond: Veldhockey is een teamsport met wereldwijd een groeiende populariteit. In deze sport wordt er veel gelopen, van richting veranderd en voornamelijk asymmetrisch bewogen. Veldhockey is een contactsport dat gespeeld wordt met een stick en een bal. Dit maakt hockey een sport waarbij het risico om een letsel op te lopen hoog is. Tot op heden werd weinig onderzoek verricht naar de invloed van de beweeglijkheid van de heup op het oplopen van letsels bij hockeyspelers.

Doelstelling: Het doel van deze studie was om na te gaan of de beweeglijkheid van de heup een risicofactor kan zijn voor het oplopen van een letsel van het onderste lidmaat bij mannelijke jeugd hockeyspelers, waardoor deze vatbaarder zijn voor het oplopen van een letsel.

Onderzoeksdesign: Dit onderzoek bestond uit twee onderdelen. Deel één is gebaseerd op de gegevens voor het moment dat de groep getest werd. Deel twee is gebaseerd op gegevens verkregen in een vastgelegde periode na het testmoment.

Methode: Drieënnegentig mannelijke hockeyspelers uit het U16, U18 of U21 Belgisch nationaal hockeyteam ondergingen verschillende testen. Letsels die opgelopen waren in de laatste twee seizoenen werden bevraagd. Grootte, gewicht en beenlengte werden opgemeten en verschillende testen om de beweeglijkheid van hun heup na te gaan werden uitgevoerd. Nadien moesten de atleten alle letsels rapporteren die ze opliepen in de zes maanden volgend op het testmoment.

Resultaten: Voor het eerste deel van deze studie rapporteerden 41 van de 93 (44.1%) atleten minimum één letsel. Er werd een recht evenredig verband gevonden tussen een aanvaller als speler positie en het oplopen van een letsel. Een omgekeerd evenredig verband werd gevonden tussen het zijn van een doelman en het oplopen van een letsel. Voor het tweede deel van de studie liepen 36 van de 73 (49.3%) atleten minimum één letsel op. Twintig atleten vielen uit omdat ze niet gedurende de volledige periode konden opgevolgd worden. Uit het onderzoek bleek dat hoe symmetrischer de heup rotatie bewegingen zijn en hoe minder flexibel de spier aan de voorzijde van de dij is, hoe meer kans een atleet heeft op het oplopen van een traumatisch letsel en een onderste lidmaat letsel in het algemeen. Daarenboven werd in ruglig heup interne rotatie, een beweging waarbij met een geplooide knie de voet naar buiten wordt gebracht waardoor de heup naar binnen draait, gevonden als een voorspeller voor het oplopen van een overbelastingsletsel en een letsel aan het onderste lidmaat in het algemeen. Voor het oplopen van een traumatisch letsel werd een verminderde heup interne rotatie gemeten in zit gevonden als voorspeller.

Conclusie: Verminderde heup interne rotatie en flexibiliteit van de spier aan de voorzijde van de dij evenals meer symmetrie in heuprotatie werden gevonden als risicofactoren voor het

oplopen van een letsel in veldhockey. Deze factoren zouden bij het opstellen van preventieprogramma’s in rekening gebracht moeten worden.
Trefwoorden: veldhockey; risicofactor; onderste lidmaat; letsel; heup range of motion; letselpreventie

11. Proof of submission to the Ethics Committee

UZ Universitair Ziekenhuis Gent

UNIVERSITEIT GENT

Afz: Commissie voor Medische Ethiek

COMMISSIE VOOR MEDISCHE ETHIEK

Voorzitter:
Prof. Dr. D. Matthys
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	2016/1126	24-okt-16	Zie "CC"

BETREFT

Advies voor monocentrische studie met als titel:
De voorspellende waarde van bewegingspatronen en behendigheid voor letsels in de hockeysport.

Belgisch Registratienummer: B670201629662

* Adviesaanvraagformulier dd. 27/09/2016 (volledig ontvangen dd.29/09/2016)
* Begeleidende brief dd. 27/09/2016
* (Patiënten)informatie- en toestemmingsformulier
  - voor volwassenen (dd.15/09/2016)
  - voor jongeren ouder dan 12jaar (dd.22/09/2016)
  - voor de ouders van de jonge deelnemer (dd.08/09/2016)
* Diverse
  - scoringscriteria FMS (dd.22/09/2016)
  - scoringsformumlier FMS sine dato

Advies werd gevraagd door:
Prof. dr. D. VAN TIGGELEN ; Hoofdonderzoeker

BOVENVERMELDE DOCUMENTEN WERDEN DOOR HET ETHISCH COMITÉ BEOORDEELD.
ER WERD EEN POSITIEF ADVIES GEGEVEN OVER DIT PROTOCOL OP 20/10/2016. INDIEN DE STUDIE NIET WORDT OPGESTART VOOR 20/10/2017, VERVALT HET ADVIES EN MOET HET PROJECT TERUG INGEDIEND WORDEN.
Vooraleer het onderzoek te starten dient contact te worden genomen met Bimetra Clinics (09/332 05 00).

THE ABOVE MENTIONED DOCUMENTS HAVE BEEN REVIEWED BY THE ETHICS COMMITTEE.
A POSITIVE ADVICE WAS GIVEN FOR THIS PROTOCOL ON 20/10/2016. IN CASE THIS STUDY IS NOT STARTED BY 20/10/2017, THIS ADVICE WILL BE NO LONGER VALID AND THE PROJECT MUST BE RESUBMITTED.
Before initiating the study, please contact Bimetra Clinics (09/332 05 00).

DIT ADVIES WORDT OPGENOMEN IN HET VERSLAG VAN DE VERGADERING VAN HET ETHISCH COMITE VAN 15/11/2016
THIS ADVICE WILL APPEAR IN THE PROCEEDINGS OF THE MEETING OF THE ETHICS COMMITTEE OF 15/11/2016

- *Het Ethisch Comité werkt volgens 'ICH Good Clinical Practice' - regels*
- *Het Ethisch Comité beklemtoont dat een gunstig advies niet betekent dat het Comité de verantwoordelijkheid voor het onderzoek op zich neemt. Bovendien dient U er over te waken dat Uw mening als betrokken onderzoeker wordt weergegeven in publicaties, rapporten voor de overheid enz., die het resultaat zijn van dit onderzoek.*
- *In het kader van 'Good Clinical Practice' moet de mogelijkheid bestaan dat het farmaceutisch bedrijf en de autoriteiten inzage krijgen van de originele data. In dit verband dienen de onderzoekers erover te waken dat dit gebeurt zonder schending van de privacy van de proefpersonen.*
- *Het Ethisch Comité benadrukt dat het de promotor is die garant dient te staan voor de conformiteit van de anderstalige informatie- en toestemmingsformulieren met de nederlandstalige documenten.*
- *Geen enkele onderzoeker betrokken bij deze studie is lid van het Ethisch Comité.*
- *Alle leden van het Ethisch Comité hebben dit project beoordeeld. (De ledenlijst is bijgevoegd)*

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	2016/1126	24-okt-16	Zie "CC"

Vervolg blz. 2 van het adviesformulier betreffende project EC UZG 2016/1126

- *The Ethics Committee is organized and operates according to the 'ICH Good Clinical Practice' rules.*
- *The Ethics Committee stresses that approval of a study does not mean that the Committee accepts responsibility for it. Moreover, please keep in mind that your opinion as investigator is presented in the publications, reports to the government, etc., that are a result of this research.*
- *In the framework of 'Good Clinical Practice', the pharmaceutical company and the authorities have the right to inspect the original data. The investigators have to assure that the privacy of the subjects is respected.*
- *The Ethics Committee stresses that it is the responsibility of the promotor to guarantee the conformity of the non-dutch informed consent forms with the dutch documents.*
- *None of the investigators involved in this study is a member of the Ethics Committee.*
- *All members of the Ethics Committee have reviewed this project. (The list of the members is enclosed)*

Namens het Ethisch Comité / On behalf of the Ethics Committee
Prof. dr. D. MATTHYS
Voorzitter / Chairman

CC: De heer T. VERSCHOORE - UZ Gent - Bimetra Clinics
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12. Appendices

12.1 Appendix 1: Questionnaire for players' identification

<u>Questionnaire for players' identification</u>

1) First and last name

____

2) National team
    - U16
    - U18
    - U21

3) Player position
    - Goalkeeper
    - Defender
    - Midfielder
    - Attacker

4) Hand dominance
    - Left
    - Right

5) Leg dominance
    - Left
    - Right

6) Special remarks
(chronic injuries – complaints – malformations)

____

12.2 Appendix 2: Reliability of the Deep Squat

Intra- and interrater reliability of the Deep Squat

1. Background

In the context of prevention programs, a screening tool consisting of multiple valid tests was set up by the University of Ghent to follow-up the national hockey teams. The U16, U18, U21 and the elite male and female national teams participate in the testing protocol twice a year. One of the performed tests is the Deep Squat, which is part of the FMS. The Deep Squat was not scored by one, two or three as usual but a modified scoring system of the test was utilized in order to get an applicable score to determine the intra- and interrater reliability.

2. Method

2.1 Participants

Eight healthy subjects, equally divided by gender, volunteered for this study. All participants are physically active on a recreational level. The subjects received an invitation and agreed to perform the test. The mean (± SD) age, height and weight of the subjects were respectively 21.8 ± 0.89 y, 178.63 ± 8.927 cm and 77.13 ± 13.464 kg. None of the subjects reported lower limb musculoskeletal or other current injuries at the time the test was conducted.

2.2 Rater characteristics

Two raters (A and B) were used in this study. Both were final master year physiotherapy students at Ghent University. The raters obtained the same instructions by the physiotherapists of the national hockey teams in Belgium. Nevertheless, both assessors had a varied experience in conducting the test. Rater A completed over 100 testing procedures of the Deep Squat. Rater B had no previous experience in assessing the Deep Squat.

2.3 Procedure

Two examiners scored separately and independently the performance of the eight subjects. The sequence of the volunteers was randomized. The participants were invited to perform the test twice with an interval of one week. At the beginning of the test, the subjects needed to remove their shoes and socks before standing on the testing surface. No warming-up or exercise trials were allowed. The participants took place with the heels on the red line and placed the second toe on the blue line corresponding with the zero degree line. A stick was hold straight above the head (Figure 1). From this starting position the subjects bend the knees slowly, as deep as possible without losing heel contact. The test was executed three times.

The performances were assessed by the researchers based on the following well-defined criteria: (1) the upper body is parallel with the tibia or toward vertical, (2) the upper leg is below the horizontal line, (3) both stick and knees can not pass the imaginary line, vertically drawn from the most anterior point of the subject's toes. Each time the performer was not able to meet the criteria after three times, the subject must replace the second toe 10 degrees wider and received three more attempts. When fulfillment of the criteria was impossible with the second toe at 50 degrees, a zero-score was attributed.

Figure 1: Demonstration of the Deep Squat

2.3 Statistical analysis

SPSS Statistics version 26.0 (SPSS Inc, Chicago, Illinois) was used for the statistical analysis. The κ for both inter- and intrarater reliability was calculated. The interpretation of κ was based on the benchmarks proposed by Landis and Koch (1977): below zero as poor, zero to 0.20 as slight, 0.21 to 0.40 as fair, 0.41 to 0.60 as moderate, 0.61 to 0.80 as substantial and 0.81 to 1.0 indicating almost perfect agreement.

3. Results

The interrater and intrarater reliability is shown in Table 1.

3.1 Interrater reliability

The percentage of exact agreement between the two assessors was 75.0%. In two cases the raters disagreed on the scoring. The κ was 0.619, corresponding with a substantial score.

3.2 Intrarater reliability

Between the two trials, rater A gave an equal score for six out of eight cases related to an agreement of 75.0%. Identical to rater A, rater B had an exact agreement of 75.0%. The κ for the intrarater reliability for rater A and B were respectively 0.610 and 0,660 which is substantial.

Table 1: Intra- and interrater reliability

Measurement	Intrarater reliability rater A	Intrarater reliability rater B	Interrater reliability
κ	0.610	0.660	0.619

κ : kappa coefficient

4. Conclusion

The results of this study suggest that the earlier described procedure of the Deep Squat can be reliably performed both by the same rater as by different raters in healthy subjects. Varying experience in completed tests seems not to influence the reliability. Further research is needed to support these results in different study populations.

5. References

1. Landis J.R, Koch G.G. The measurement of observer agreement for categorical data. Biometrics 1977; 33: 159-174.

12.3 Appendix 3: Medical Registration Form

<u>Medical Registration Form</u>

Weekly questionnaire to follow up medical status (complaints – problems – injuries)
* required

1) First and last name

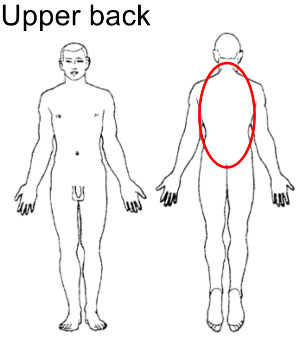
____

2) Participation at training/game *
(problems= refers to pain, ache, stiffness, swelling, instability/giving away, locking or other complaints related to a body part)

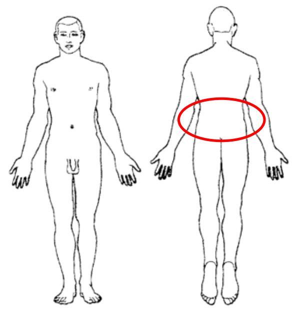
   - Full participation without problems (if you select this option you are done with the registration for today)
   - Full participation with problems
   - Reduced participation due to problems
   - Couldn't participate to at least one training session/game due to problems

3) Localisation of the problem

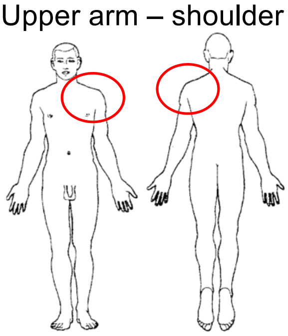
   - Upper back



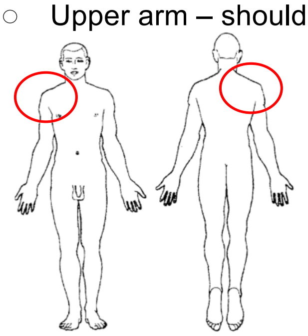
   - Lower back



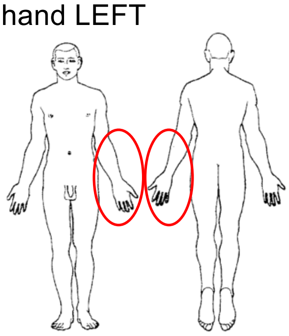
   - Upper arm – shoulder LEFT



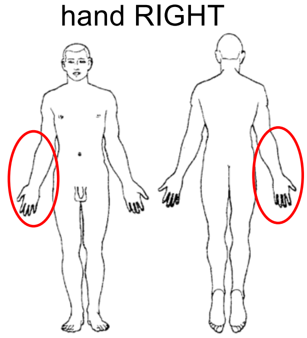
   - Upper arm – shoulder RIGHT



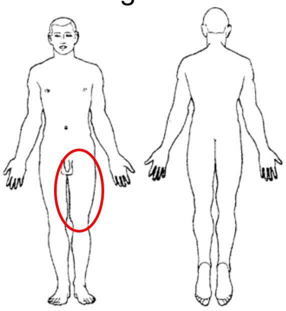
   - Elbow – lower arm – wrist – hand LEFT



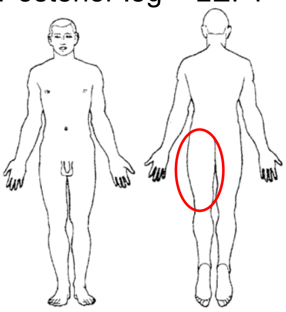
   - Elbow – lower arm – wrist – hand RIGHT



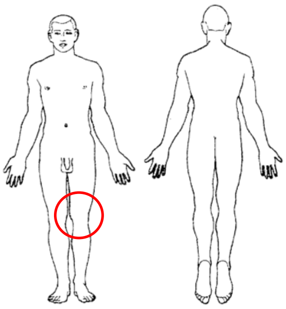
- Frontal leg – LEFT



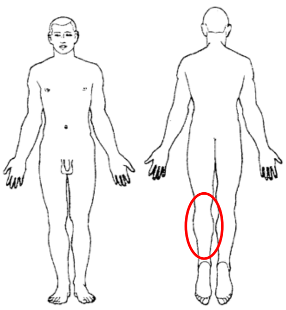
- Posterior leg – LEFT



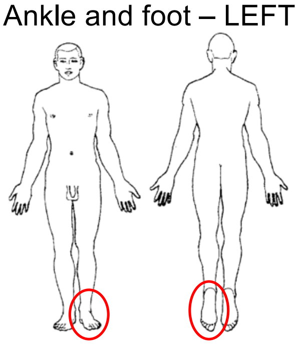
- Knee – LEFT



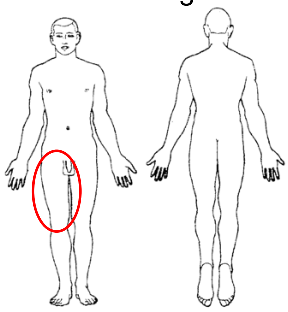
- Calf – LEFT



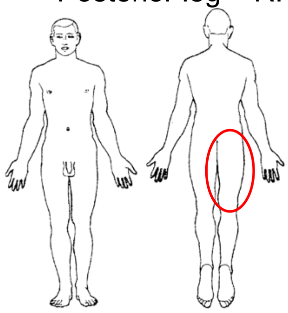
- Ankle and foot – LEFT



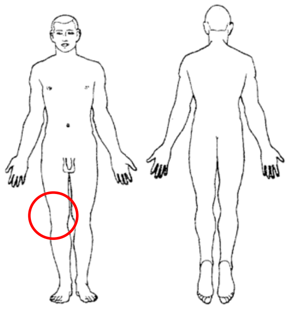
- Frontal leg – RIGHT



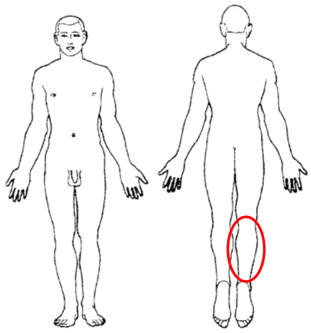
- Posterior leg – RIGHT



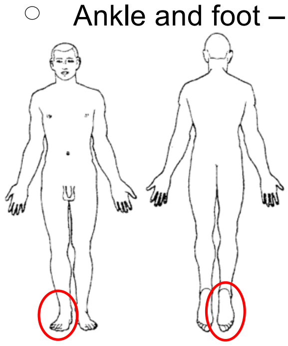
- Knee – RIGHT



- Calf - RIGHT



- Ankle and foot – RIGHT



4) Onset/start of the problem

- The pain/problem gradually came up
- The pain suddenly started (you remember a specific moment when the pain started)

5) Limitation in participation

- @ club – physical training
- @ club – hockey training
- @ club – game
- @ national team – physical training
- @ national team – hockey training
- @ national team – game

6) Affection on performance

	1	2	3	4	
Problem had no affection on performance	○	○	○	○	Problem had major affection on performance

7) Important note? (describe shortly your problem)

____

12.4 Appendix 4: Confidentiality and assignment of rights

GHENT UNIVERSITY

VERTROUWELIJKHEID & OVERDRACHT VAN RECHT EENZIJDIGE VERKLARING

NDA-EV	

Deze Verklaring wordt afgelegd ten aanzien van

Universiteit Gent, openbare instelling met rechtspersoonlijkheid, waarvan de bestuurszetel gevestigd is te 9000 Gent, Sint-Pietersnieuwstraat 25, gekend onder ondernemingsnummer 0248.015.142 voor wie optreedt bij delegatie ingevolge het besluit van de Raad van Bestuur, prof. dr. Rik Van de Walle, rector ("UGent")

Door:

Holleman Aline	
Student, ingeschreven aan UGent in de richting:	Revalidatiewetenschappen en Kinesitherapie

Project:	Hip range of motion as a risk factor for lower extremity injuries in elite male hockey players: A retrospective and prospective approach.

In het kader van zijn/haar opleiding aan UGent, zal ondergetekende kennis krijgen van bepaalde vertrouwelijke informatie toebehorend aan UGent of door derden toevertrouwd aan UGent.

Ondergetekende verbindt er zich toe om de aan hem/haar in het kader van het Project ter beschikking gestelde informatie op geen enkele manier publiek bekend te maken zonder voorafgaande uitdrukkelijke schriftelijke toelating van UGent. Deze verbintenis geldt voor een duur van **tien (10) jaar** te rekenen vanaf de datum van deze Eenzijdige Verklaring.

Ondergetekende draagt eveneens al zijn/haar rechten op onderzoeksresultaten behaald in het kader van het Project over aan UGent.

Ondergetekende garandeert de mensenrechten te zullen respecteren.

Deze Eenzijdige Verklaring vervangt alle schriftelijke en mondelinge overeenkomsten die de partijen eerder zijn aangegaan met betrekking tot haar voorwerp en omvat de enige en volledige overeenkomst ter zake tussen de partijen.

Aldus verklaart en tekent voor akkoord:

Naam	Holleman Aline
Handtekening	*Voorafgegaan door handgeschreven vermelding "gelezen en goedgekeurd"* Gelezen en goedgekeurd [signature]
Datum:	15 mei 2020

VERTROUWELIJKHEID & OVERDRACHT VAN RECHT EENZIJDIGE VERKLARING

GHENT UNIVERSITY

NDA-EV	

Deze Verklaring wordt afgelegd ten aanzien van

Universiteit Gent, openbare instelling met rechtspersoonlijkheid, waarvan de bestuurszetel gevestigd is te 9000 Gent, Sint-Pietersnieuwstraat 25, gekend onder ondernemingsnummer 0248.015.142 voor wie optreedt bij delegatie ingevolge het besluit van de Raad van Bestuur, prof. dr. Rik Van de Walle, rector ("UGent")

Door:

Vantieghem Alexandra	
Student, ingeschreven aan UGent in de richting:	Revalidatiewetenschappen en kinesitherapie

Project: Hip range of motion as a risk factor for lower extremity injuries in elite male hockey players: A retrospective and prospective approach.

In het kader van zijn/haar opleiding aan UGent, zal ondergetekende kennis krijgen van bepaalde vertrouwelijke informatie toebehorend aan UGent of door derden toevertrouwd aan UGent.

Ondergetekende verbindt er zich toe om de aan hem/haar in het kader van het Project ter beschikking gestelde informatie op geen enkele manier publiek bekend te maken zonder voorafgaande uitdrukkelijke schriftelijke toelating van UGent. Deze verbintenis geldt voor een duur van **tien (10) jaar** te rekenen vanaf de datum van deze Eenzijdige Verklaring.

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Ondergetekende garandeert de mensenrechten te zullen respecteren.

Deze Eenzijdige Verklaring vervangt alle schriftelijke en mondelinge overeenkomsten die de partijen eerder zijn aangegaan met betrekking tot haar voorwerp en omvat de enige en volledige overeenkomst ter zake tussen de partijen.

Aldus verklaart en tekent voor akkoord:

Naam	Vantieghem Alexandra
Handtekening	*Voorafgegaan door handgeschreven vermelding "gelezen en goedgekeurd"* Gelezen en goedgekeurd
Datum:	17 mei 2020

GHENT UNIVERSITY

VERTROUWELIJKHEID & OVERDRACHT VAN RECHT EENZIJDIGE VERKLARING

NDA-EV	

Deze Verklaring wordt afgelegd ten aanzien van

Universiteit Gent, openbare instelling met rechtspersoonlijkheid, waarvan de bestuurszetel gevestigd is te 9000 Gent, Sint-Pietersnieuwstraat 25, gekend onder ondernemingsnummer 0248.015.142 voor wie optreedt bij delegatie ingevolge het besluit van de Raad van Bestuur, prof. dr. Rik Van de Walle, rector ("UGent")

Door:

Verbraeckel Niels	
Student, ingeschreven aan UGent in de richting:	revalidatiewetenschappen en kinesitherapie

Project:	hip range of motion as a risk factor for lower extremity injuries in elite male hockey players: a retrospective and prospective approach

In het kader van zijn/haar opleiding aan UGent, zal ondergetekende kennis krijgen van bepaalde vertrouwelijke informatie toebehorend aan UGent of door derden toevertrouwd aan UGent.

Ondergetekende verbindt er zich toe om de aan hem/haar in het kader van het Project ter beschikking gestelde informatie op geen enkele manier publiek bekend te maken zonder voorafgaande uitdrukkelijke schriftelijke toelating van UGent. Deze verbintenis geldt voor een duur van **tien (10) jaar** te rekenen vanaf de datum van deze Eenzijdige Verklaring.

Ondergetekende draagt eveneens al zijn/haar rechten op onderzoeksresultaten behaald in het kader van het Project over aan UGent.

Ondergetekende garandeert de mensenrechten te zullen respecteren.

Deze Eenzijdige Verklaring vervangt alle schriftelijke en mondelinge overeenkomsten die de partijen eerder zijn aangegaan met betrekking tot haar voorwerp en omvat de enige en volledige overeenkomst ter zake tussen de partijen.

Aldus verklaart en tekent voor akkoord:

Naam	Verbraeckel Niels
Handtekening	*Voorafgegaan door handgeschreven vermelding "gelezen en goedgekeurd"* gelezen en goedgekeurd Verbraeckel
Datum:	17 mei 2020

12.5 Appendix 5: Research appointments

FACULTEIT GENEESKUNDE EN GEZONDHEIDSWETENSCHAPPEN

Bijlage 10

ALGEMENE ONDERZOEKSAFSPRAKEN

Naam/voornaam student in drukletters: MOLLEMANS ALINE

Project/scriptie: Hip range of motion as a risk factor for lower extremity injuries in elite male hockey players: a retrospective and prospective approach

Promotor en copromotor:
promotor Prof. Dr. Damien Van Tiggelen
copromotor: Dorothée Gaelmynck

- Draag zorg voor het materiaal zowel in het labo als op verplaatsing
- Heb speciale aandacht voor de kabels:
  - Zorg dat er niets op staat
  - Rij er niet over met andere toestellen
  - Zorg dat het verloop van de kabels niet geforceerd wordt (geen 'knik in kabel)
  - Zorg dat de kabels niet op spanning komen te staan tijdens de testing
  - Zorg dat ze netjes opgerold worden bij het beëindigen van de testing
- Indien er een defect is, meld je dit onmiddellijk aan je (co)promotor en aan de onderzoekstechnoloog (OT) en/of ICT Manager
- Meld onregelmatigheden aan je (co)promotor en aan de OT en/of ICT Manager (bv lokaal niet in orde bij het toekomen)
- Zorg dat het transport van het materiaal veilig gebeurt bij het testen buiten het labo
- Bewaar de orde in het labo
- Deponeer alle afval (watjes, elektroden, ...) in de vuilbak, laat niets slingeren
- Breng geen eten en drinken in de labo's, noch voor onderzoekers, noch voor proefpersonen
  (dus eventuele traktaties na de test buiten het labo)
- Indien de voorraad in de studentenkast bijna op is, meld je dit aan de OT
- Bij het beëindigen van de testing:
  - Sluit alle toestellen af en plaats ze terug in de neutrale startpositie
  - Leg alle materiaal terug op zijn plaats en/of in de kast
  - Hang de sleutel van de voorraadkast terug aan het haakje in het labo
  - Vergeet het lokaal niet af te sluiten

Handtekeningen, voorafgegaan door "Gelezen en goedgekeurd":

Gelezen en goedgekeurd

FACULTEIT GENEESKUNDE EN GEZONDHEIDSWETENSCHAPPEN

Bijlage 10

ALGEMENE ONDERZOEKSAFSPRAKEN

Naam/voornaam student in drukletters: VANTIEGHEM ALEXANDRA

Project/scriptie: Hip range of motion as a risk factor for lower extremity injuries in elite male hockeyplayers: a retrospective and prospective approach

Promotor en copromotor:

promotor: Prof. Dr. Van Tiggelen Damien

copromotor: Gaeremynck Dorothée

- Draag zorg voor het materiaal zowel in het labo als op verplaatsing
- Heb speciale aandacht voor de kabels:
  - Zorg dat er niets op staat
  - Rij er niet over met andere toestellen
  - Zorg dat het verloop van de kabels niet geforceerd wordt (geen 'knik in kabel)
  - Zorg dat de kabels niet op spanning komen te staan tijdens de testing
  - Zorg dat ze netjes opgerold worden bij het beëindigen van de testing
- Indien er een defect is, meld je dit onmiddellijk aan je (co)promotor en aan de onderzoekstechnoloog (OT) en/of ICT Manager
- Meld onregelmatigheden aan je (co)promotor en aan de OT en/of ICT Manager (bv lokaal niet in orde bij het toekomen)
- Zorg dat het transport van het materiaal veilig gebeurt bij het testen buiten het labo
- Bewaar de orde in het labo
- Deponeer alle afval (watjes, elektroden, ...) in de vuilbak, laat niets slingeren
- Breng geen eten en drinken in de labo's, noch voor onderzoekers, noch voor proefpersonen (dus eventuele traktaties na de test buiten het labo)
- Indien de voorraad in de studentenkast bijna op is, meld je dit aan de OT
- Bij het beëindigen van de testing:
  - Sluit alle toestellen af en plaats ze terug in de neutrale startpositie
  - Leg alle materiaal terug op zijn plaats en/of in de kast
  - Hang de sleutel van de voorraadkast terug aan het haakje in het labo
  - Vergeet het lokaal niet af te sluiten

Handtekeningen, voorafgegaan door "Gelezen en goedgekeurd":

Gelezen en goedgekeurd

Vantieghem

ALGEMENE ONDERZOEKSAFSPRAKEN

Naam/voornaam student in drukletters: VERBRAEKEL NIELS

Project/scriptie: Hip range of motion as a risk factor for lower extremity injuries in elite male hockey players: a retrospective and prospective approach

Promotor en copromotor: promotor: prof. Dr. Damien Van Tiggelen

copromotor: Dorothée Claeremynck.

- Draag zorg voor het materiaal zowel in het labo als op verplaatsing
- Heb speciale aandacht voor de kabels:
  - Zorg dat er niets op staat
  - Rij er niet over met andere toestellen
  - Zorg dat het verloop van de kabels niet geforceerd wordt (geen 'knik in kabel)
  - Zorg dat de kabels niet op spanning komen te staan tijdens de testing
  - Zorg dat ze netjes opgerold worden bij het beëindigen van de testing
- Indien er een defect is, meld je dit onmiddellijk aan je (co)promotor en aan de onderzoekstechnoloog (OT) en/of ICT Manager
- Meld onregelmatigheden aan je (co)promotor en aan de OT en/of ICT Manager (bv lokaal niet in orde bij het toekomen)
- Zorg dat het transport van het materiaal veilig gebeurt bij het testen buiten het labo
- Bewaar de orde in het labo
- Deponeer alle afval (watjes, elektroden, ...) in de vuilbak, laat niets slingeren
- Breng geen eten en drinken in de labo's, noch voor onderzoekers, noch voor proefpersonen
  (dus eventuele traktaties na de test buiten het labo)
- Indien de voorraad in de studentenkast bijna op is, meld je dit aan de OT
- Bij het beëindigen van de testing:
  - Sluit alle toestellen af en plaats ze terug in de neutrale startpositie
  - Leg alle materiaal terug op zijn plaats en/of in de kast
  - Hang de sleutel van de voorraadkast terug aan het haakje in het labo
  - Vergeet het lokaal niet af te sluiten

Handtekeningen, voorafgegaan door "Gelezen en goedgekeurd":

gelezen en goedgekeurd

Verbraekel