Injury prediction in male field hockey players: screening with the ‘Functional Movement Screen’ and an agility protocol.

Masterproef deel 2 voorgelegd tot het behalen van de graad van Master of Science in de Revalidatiewetenschappen en Kinesitherapie

Motmans Jeroen, Nyckees Daan en Merckx Nicky

Promotor:
Prof. Dr. Van Tiggelen
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**Dankwoord**

Wij zouden graag onze promotor Prof. Dr. Damien Van Tiggelen bedanken voor al de tijd en moeite die hij in ons en ons werk heeft gestoken. Ook zouden wij alle trainers, afgevaardigden en spelers van de deelnemende hockeyploegen willen bedanken voor de samenwerking. Zonder hen zou dit niet mogelijk zijn.

Daan Nyckees, Jeroen Motmans en Nicky Merckx
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Abbreviation list

BMI  body mass index
e.g.  exempli gratia (for example)
et al.  Et alii (and others)
etc.  et cetera (and so on)
FIH  international hockey federation
FMS  functional movement screen
Hz  Hertz
i.e.  id est (which means)
kg  kilograms
m  Meters
N  Amount
SD  Standard deviation
SDT  sprint and dribble test
SE  Standard error
sec  Seconds
sig.  Significance
Abstract

Background: Interest in the role of injury prediction has developed in recent years as a growing factor of sport business. An example of such an injury prediction protocol is the FMS. The FMS is a movement screen containing 7 movement tests which could identify a higher risk of sustaining an injury. Additionally, little research has been conducted on the relationship between injury and agility tests.

Objectives: The goal of this study is to evaluate the effect of the FMS and an agility protocol on injury prediction concerning male hockey players.

Study design: Prospective cohort study.

Methods: 80 healthy male hockey players were tested. Performance of the FMS and the agility protocol occurred during preseason. Subsequently, a fatigue protocol was assessed before retesting the Illinois to view the effect of fatigue. Injury data was collected from September 2015 until the end of May 2016 in the season of 2015-2016.

Results: Binary logistic regression shows significant differences in the hurdle step, rotary stability and Illinois fatigue in sustaining an injury (p = 0,028; 0,043 and 0,009). There were also significant differences in the hurdle step, active straight leg raise, rotary stability and Illinois fatigue in sustaining an overuse injury (p = 0,012; 0,018; 0,023 and 0,006). No sum score was indicative in preventing injuries.

Conclusion: Results shows the injury predictive value of single tests of the FMS instead of the use of a sum score. Additionally, results indicate an important role of fatigue in injury prevention in male hockey players. Further research is warranted on the effect of agility and fatigue on injury prediction.

Key-words: Injury prediction, Functional Movement Screen, agility, fatigue
**Samenvatting**

**Achtergrond:** In de laatste jaren is er een toegenomen interesse voor de voorspelling van blessures in de sportwereld. Een voorbeeld hiervan is de FMS. De FMS is een screeningsprotocol dat ‘beweging’ screent op basis van 7 testen, en kan een verhoogd risico op het krijgen van blessures identificeren. Hiernaast is er slechts weinig onderzoek gedaan over de relatie tussen blessures en behendigheidstesten.

**Doel:** Het doel van deze studie is het effect te evalueren van de FMS en een protocol bestaande uit behendigheidstesten op het voorspellen van blessures bij mannelijke hockey spelers.

**Onderzoeksdesign:** Prospectieve cohort studie.


**Resultaten:** De hurdle step, rotary stability en Illinois fatigue werden significant bevonden voor het oplopen van een blessure (p = 0,028; 0,043 en 0,009). De hurdle step, active straight leg raise, rotary stability en Illinois fatigue werden significant bevonden voor het oplopen van een overbelastingsblessure (p = 0,012; 0,018; 0,023 en 0,006).

**Conclusie:** De resultaten wijzen op de rol van aparte testen van de FMS in de voorspelling van blessures in plaats van het gebruik van een totaalscore. Een belangrijke rol van vermoeidheid en de predictie van blessures werd ook aangetoond in de resultaten. Verder onderzoek is nodig om het effect van behendigheid op het voorspellen van blessures te achterhalen.

**Sleutelwoorden:** Blessure voorspelling, Functional Movement Screen, behendigheid, vermoeidheid
1 Introduction

With 127 countries affiliated to the international hockey federation (FIH), hockey is a popular sport particularly in Western Europe, India and Australia. Although there is limited data known related to injuries or injury prevention, Theilen et al. (2015) did research on injury occurrence in field hockey on elite and international level. They concluded that most of the injuries were traumatic injuries caused by the hockey ball, the hockey stick or by collisions. Next to these traumatic injuries, there is also a big part and a growing awareness of the importance of overuse injuries. The emphasis of this study will be on the overuse injuries, which still represent a major part in injuries.

The aim of prevention is to identify and to modify or treat the risk factors to which an individual is exposed. These risk factors can be divided in intrinsic and extrinsic risk factors (Meeuwisse et al., 2007). In addition, it has been hypothesized that the presence of both intrinsic and extrinsic risk factors contribute to a higher risk of sustaining an injury, but sustaining an injury is only plausible after an injury inducing moment (Bahr et al., 2005). Thus sustaining an injury is based on a multifactorial origin. Musculoskeletal screening focuses on modifiable intrinsic risk factors, meaning risk factors associated with the athlete himself e.g. strength, flexibility etc. The FMS focuses on the intrinsic risk factor ‘movement’. Cook et al. (2010) defines the term movement by motions in which the body participates as a whole, with flexibility, motor control and core stability at its base. The principle behind this is the erroneous emphasizing of rehabilitation, screening and training of separate, isolated body parts, while the body should move functional, i.e. as a whole (Cook et al., 2010). More attention should be paid at the body as a whole and how the body adjusts at different situations and movements. Therefore, Cook et al. (2006) hypothesizes that progressions such as strength, endurance, explosive power etc. can be added to a training program only if the physical estate of the participant is sufficient, i.e. basic movement patterns. The word ‘functional’ in the abbreviation of the FMS implies that it involves movements which occur during activities an athlete performs at practices or games. The FMS itself consists of 7 simple tests and is designed as an easy on the field screening tool to evaluate the movement patterns that are thought to be injurious.

Is the whole greater than the sum of its parts? This is the main question that should be taken in account regarding the FMS.

Results of research on the subject of the correlation of injury prevention and the FMS remain controversial. Although the majority of the current research (Chorba et al., 2010; Cosio-Lima et al., 2014;
Garrison et al., 2015; Kiesel et al., 2007, 2014; Letafatkar et al., 2014; Lisman et al., 2013; O’Connor et al., 2011) found a link between injury prevention and a FMS total score, it is contradicted by other research papers claiming there is no link whatsoever (Bushman et al., 2016; Dorrel et al., 2015; Dossa et al., 2014; Hotta et al., 2015; Kodesh et al., 2015; Sorenson et al., 2009; Warren et al., 2014). Some studies only showed a correlation between some tests of the FMS and injury (Hotta et al., 2015; Warren et al., 2014) or a correlation between pain on tests with greater risk of injury (Bushman et al., 2016).

These contradictory findings could be caused by the use of limited populations in the reviews, assessments of various sports, an overall low methodological quality of the studies, the lack of differentiation between genders and the lack of distinction in the nature of injury e.g. contact or non-contact injuries or acute and chronic injuries.

In contrast to the high amount of research concerning the FMS and injury prediction, there is limited research on the relationship between agility and injury. One of the causes is perhaps a lack of consensus about the term agility. Agility is a rapid whole-body movement with change of velocity or direction in response to a stimulus (Sheppard et al., 2006). Making agility a more functional movement type for soccer, hockey and other sports that fit those criteria of movement. This can possibly hypothesize the importance of agility assessment for injury prediction in athletes.

Agility is therefore an exercise form used by coaches, athletes, performance trainers because of its functionality. The combination of perceptual and decision-making factors, speed, strength, the change of direction and many other factors makes it functional for a wide variety of sports such as soccer, hockey, basketball, tennis etc. (Sheppard et al., 2006). The functionality and wide use of agility is based on an empirical foundation and further research is warranted on the relationship between agility and athletic performance in various sports and sport situations. Additionally, agility tests are widely used in order to screen specific sport related performance in diverse sport settings.

Our research involves testing the FMS and its relationship to injury prediction in male hockey players. Furthermore, an agility protocol will be performed to find a similar relationship and additionally to research the influence of fatigue on agility scores and injury prediction.
2 Methods

2.1 Population

80 healthy male hockey players participated in this prospective cohort study. 5 hockey teams volunteered for this study. Participants were invited to participate by email through their team coach. Male hockey players between 16 and 36 years old were included. Exclusion criteria were (1) participants did not sustain any musculoskeletal injury in the past 6 weeks that prevented the athlete from participating in practice and/or competition, (2) participants did not have any surgery or fracture in the last year, or (3) participants did not have a history of knee surgery. Informed consent (see appendix 1) was obtained from all participants and ethical approval was received from the Ethical Committee of Ghent University.

2.2 Data collection/Testing procedure

Data was collected at the team’s practice facility. All participants were asked to fill out a questionnaire containing their medical history, anthropometric data and sports related questions. Following topics were included in the questionnaire (see appendix 2): age, team, hand dominance, injury history, hours of training, player position, other leisure activities, etc. Two parameters, height and weight, were measured before the testing.

Participants were tested prior to the start of their competitive sport season. The tests were conducted on the artificial turf before training sessions. 63 players were tested on a water-based field, while 17 players on a sand-dressed field. Players performed the tests with own shoes and clothing with the aim of stimulating the training and competition situation as closely as possible.

Tests were conducted and scored by three independent investigators.

If desired, the players could obtain information about the results of their tests at all times.

2.2.1 The Functional Movement Screen (FMS)

The FMS (see appendix 3) consists of seven movement tests, described by Cook et al. (2006), that include: Deep Squat, Hurdle Step, In-line Lunge, Shoulder Mobility, Active Straight Leg Raise, Trunk Stability Push-up and Rotary Stability.

Each player was given three trials on each of the seven sub-tests and received a score from zero to three on each sub-test (Cook et al., 2006). The highest score from the three trials was recorded. The lowest
score of both sides was used for sub-tests that were assessed bilaterally. The tests were scored separately and a total score with a maximum of 21 was calculated.

2.2.2 Agility tests
After a standardized warm-up procedure, supervised by one tester, the testing started.

2.2.2.1 Warming-up procedure
A field was marked out of 20 meters in length. A start and run-out zone was made by dividing the field into 2 parts.

Firstly, participants had to run one length back and forth. Next, the players had to perform the following exercises one length back and forth: heel buttocks, high knees, lateral shuffle and finally one legged jumps.

Afterwards, the participants started with the stretching (see appendix 4). This involved dynamic stretching exercises upon a length of 10 meters interspersed with jogging upon 10 meters.

2.2.2.2 Agility tests
The agility tests were executed after a warming-up procedure. 3 agility tests were conducted consecutively: Modified T-test, Shuttle run and Illinois test (see appendix 5). The Illinois test was conducted two times. One time before, and a second time after a fatigue protocol (see 2.2.2.3).

The tests were measured with a stopwatch, results were expressed in seconds (with an accuracy of 0,01 seconds).

2.2.2.3 Fatigue protocol
The fatigue protocol consisted of 2 tests: Shuttle Sprint and Dribble test (Shuttle SDT), and Slalom Sprint and Dribble test (Slalom SDT) (Lemmink et al., 2004) (see appendix 6). The tests were conducted successively without rest between the two tests.

2.2.2.3.1 Shuttle SDT
This test consisted of three maximal sprints of 32 m while carrying a hockey stick and three maximal sprints of 32 m while dribbling a hockey ball.

The Shuttle SDT was recorded with a camera, while time scores were calculated with Kinovea.
The following variables were measured in the test (with an accuracy of the camera of 0.04 seconds (25Hz)):

- Sprint times = individual sprint times
- Dribble times = individual dribble times
- Mean sprint time = mean sprint time of the three sprints
- Mean dribble time = mean dribble time of the three dribbles

2.2.3.2 Slalom SDT

This test consisted of three maximal slalom sprints of 30 m while carrying a hockey stick and three maximal slalom dribbles of 30 m while dribbling a hockey ball.

The Slalom SDT was measured with a stopwatch, results were expressed in seconds.

The following variables were measured in this test (with an accuracy of the stopwatch of 0.01 seconds):

- Slalom sprint times = individual sprint times
- Slalom dribble times = individual dribble times
- Mean slalom sprint time = mean sprint time of the three sprints
- Mean slalom dribble time = mean dribble time of the three dribbles

2.2.3 Follow up

Injury data was collected from September 2015 until the end of May 2016 in the season of 2015-2016. Injury information was collected every week by oral communication with the players. Injury reports were filled by each player who had suffered an injury. This injury report (see appendix 7) contained the following information: date, diagnosis, cause and location of the injury. A differentiation was made between traumatic and overuse chronic injuries. Overuse injury was defined as any pain or discomfort that was not directly associated with a traumatic event and which was different from the normal aches and pain associated with competitive hockey (Clarsen et al., 2010). Injury was defined as a physical condition which occurred during a game or practice which resulted in missing at least one game or practice.
2.3 Statistical analysis

SPSS version 23.0 was used for statistical analysis. Descriptive statistics (see table 2 and 3) were calculated for the physical characteristics, total FMS scores, the three agility tests and the Shuttle and Slalom SDT.

Normality of distribution was checked for all the dependent variables. Mann-Whitney U tests (absence of normal data distribution) and independent-samples T-tests (normal data distribution) were used to compare differences in the injury group and non-injury group. Statistical significance was accepted at the level of p ≤ 0.05.

Paired Sample T-test was used to identify the effect of fatigue in the Illinois test.

After Mann-Whitney U tests and independent-samples T-tests, all variables with a p value of < 0.20 were investigated in a multivariate analysis (Nilstad et al., 2014). Multivariate analysis was performed using binary logistic regression analysis to identify the predictive factors for injuries, overuse injuries and traumatic injuries in male hockey players. Statistical significance was accepted at the level of p ≤ 0.05 for the final analysis.

3 Results

Injury data from 65 male hockey players from 5 different teams from 2 different clubs were obtained. First squad and reserves from Gantoise Hockey club played in the Belgian premier league, while the first squad, reserves of Indiana and the first squad of Leopard were active in the third league of Belgian hockey competition.

![Flowchart](Image)

*Figure 1. Flowchart*.
41.5% of these players were injured over the course of the season. 40% of the injuries were of a traumatic nature (both contact and non-contact), while 60% had an overuse aetiology.

Prevalence of injury and anthropometric data can be found in table 1 and 2. The FMS and the agility protocol were taken in the preseason.

27 players reported an injury accounting for 30 injuries in total. The majority of injuries affected the lower limb and were overuse. Only 3 injuries affected the upper limb and 2 the spine. The mean FMS score for those sustaining an injury was $15.96 \pm 2.175$ and $16.21 \pm 2.220$ for those who remained injury free.

Table 1. Prevalence of injuries.

<table>
<thead>
<tr>
<th>Injury</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury</td>
<td>No</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>27</td>
</tr>
<tr>
<td>Overuse injury</td>
<td>No</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>18</td>
</tr>
<tr>
<td>Traumatic injury</td>
<td>No</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>12</td>
</tr>
<tr>
<td>Lower Limb injury</td>
<td>No</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>25</td>
</tr>
<tr>
<td>Upper Limb injury</td>
<td>No</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>3</td>
</tr>
<tr>
<td>Spine injury</td>
<td>No</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 2. Anthropometric data.

<table>
<thead>
<tr>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>65</td>
<td>24,6</td>
<td>5,69</td>
</tr>
<tr>
<td>Length (m)</td>
<td>65</td>
<td>1,8</td>
<td>0,06</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>65</td>
<td>78,5</td>
<td>11,36</td>
</tr>
<tr>
<td>BMI</td>
<td>65</td>
<td>23,8</td>
<td>3,23</td>
</tr>
<tr>
<td>Training hours (hours/week)</td>
<td>65</td>
<td>6,2</td>
<td>2,95</td>
</tr>
<tr>
<td>Years of hockey (year)</td>
<td>65</td>
<td>17,1</td>
<td>5,87</td>
</tr>
</tbody>
</table>
No significant differences (p > 0,05) in age, length, weight, BMI, training hours, years of hockey, FMS, deep squat, hurdle step, inline lunge, shoulder mobility, active straight leg raise, trunk stability push up, modified T-test, shuttle run, Illinois, mean shuttle SDT sprint, mean Shuttle SDT Dribble, mean Slalom SDT Sprint and mean Slalom SDT Dribble were found between the players who sustained an injury, overuse injury or traumatic injury and those who did not.

Significant differences (p ≤ 0,05) were found in rotary stability in injuries and in Illinois fatigue in injuries and overuse injuries.

Means, standard deviations and range of the tested variables are shown in table 3. P values are shown in table 4.

Table 3. Descriptive statistics.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMS</td>
<td>65</td>
<td>16,1</td>
<td>2,19</td>
<td>10,00 - 21,00</td>
</tr>
<tr>
<td>Deep Squat</td>
<td>65</td>
<td>2,2</td>
<td>0,52</td>
<td>1,00 - 3,00</td>
</tr>
<tr>
<td>Hurdle step</td>
<td>65</td>
<td>2,4</td>
<td>0,50</td>
<td>2,00 - 3,00</td>
</tr>
<tr>
<td>Inline lunge</td>
<td>65</td>
<td>2,9</td>
<td>0,40</td>
<td>1,00 - 3,00</td>
</tr>
<tr>
<td>Shoulder mobility</td>
<td>65</td>
<td>2,0</td>
<td>0,82</td>
<td>0,00 - 3,00</td>
</tr>
<tr>
<td>Active straight leg raise</td>
<td>65</td>
<td>2,3</td>
<td>0,77</td>
<td>1,00 - 3,00</td>
</tr>
<tr>
<td>Trunk stability push up</td>
<td>65</td>
<td>2,3</td>
<td>0,83</td>
<td>0,00 - 3,00</td>
</tr>
<tr>
<td>Rotary stability</td>
<td>65</td>
<td>2,1</td>
<td>0,50</td>
<td>0,00 - 3,00</td>
</tr>
<tr>
<td>Modified T-test (sec)</td>
<td>65</td>
<td>10,4</td>
<td>0,58</td>
<td>9,20 - 11,87</td>
</tr>
<tr>
<td>Shuttle Run (sec)</td>
<td>65</td>
<td>10,2</td>
<td>0,60</td>
<td>9,08 - 12,06</td>
</tr>
<tr>
<td>Illinois (sec)</td>
<td>65</td>
<td>15,5</td>
<td>0,89</td>
<td>13,92 - 18,11</td>
</tr>
<tr>
<td>Illinois fatigue (sec)</td>
<td>65</td>
<td>17,0</td>
<td>1,14</td>
<td>14,36 - 19,98</td>
</tr>
<tr>
<td>Mean Shuttle SDT Sprint (sec)</td>
<td>65</td>
<td>8,1</td>
<td>0,48</td>
<td>7,10 - 10,24</td>
</tr>
<tr>
<td>Mean Shuttle SDT Dribble (sec)</td>
<td>65</td>
<td>9,5</td>
<td>0,79</td>
<td>8,50 - 12,37</td>
</tr>
<tr>
<td>Mean Slalom SDT Sprint (sec)</td>
<td>65</td>
<td>17,1</td>
<td>1,27</td>
<td>14,30 - 20,86</td>
</tr>
<tr>
<td>Mean Slalom SDT Dribble (sec)</td>
<td>65</td>
<td>20,3</td>
<td>1,84</td>
<td>15,48 - 26,86</td>
</tr>
</tbody>
</table>
Table 4. *p* value independent t-tests. *a* = Mann-Whitney U test.

<table>
<thead>
<tr>
<th></th>
<th><em>p</em> value injury</th>
<th><em>p</em> value overuse injury</th>
<th><em>p</em> value traumatic injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>0.775*</td>
<td>0.615</td>
<td>0.548*</td>
</tr>
<tr>
<td>Length (m)</td>
<td>0.889</td>
<td>0.270</td>
<td>0.495</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>0.807</td>
<td>0.874</td>
<td>0.261</td>
</tr>
<tr>
<td>BMI</td>
<td>0.904</td>
<td>0.437</td>
<td>0.127</td>
</tr>
<tr>
<td>Training hours (hours/week)</td>
<td>0.829</td>
<td>0.578*</td>
<td>0.238</td>
</tr>
<tr>
<td>Years of hockey (year)</td>
<td>0.259</td>
<td>0.295</td>
<td>0.728*</td>
</tr>
<tr>
<td>FMS</td>
<td>0.657</td>
<td>0.210</td>
<td>0.118</td>
</tr>
<tr>
<td>Deep Squat</td>
<td>0.567</td>
<td>0.550</td>
<td>0.799</td>
</tr>
<tr>
<td>Hurdle step</td>
<td>0.103*</td>
<td>0.052*</td>
<td>0.992</td>
</tr>
<tr>
<td>Inline lunge</td>
<td>0.339*</td>
<td>0.876</td>
<td>0.189*</td>
</tr>
<tr>
<td>Shoulder mobility</td>
<td>0.859</td>
<td>0.210</td>
<td>0.103</td>
</tr>
<tr>
<td>Active straight leg raise</td>
<td>0.538</td>
<td>0.154*</td>
<td>0.301</td>
</tr>
<tr>
<td>Trunk stability push up</td>
<td>0.621</td>
<td>0.255</td>
<td>0.120</td>
</tr>
<tr>
<td>Rotary stability</td>
<td>0.040</td>
<td>0.092</td>
<td>0.282</td>
</tr>
<tr>
<td>Modified T-test (sec)</td>
<td>0.968</td>
<td>0.256</td>
<td>0.119</td>
</tr>
<tr>
<td>Shuttle Run (sec)</td>
<td>0.891</td>
<td>0.556</td>
<td>0.314</td>
</tr>
<tr>
<td>Illinois (sec)</td>
<td>0.109</td>
<td>0.151</td>
<td>0.972</td>
</tr>
<tr>
<td>Illinois fatigue (sec)</td>
<td>0.029</td>
<td>0.009</td>
<td>0.797</td>
</tr>
<tr>
<td>Mean Shuttle SDT Sprint (sec)</td>
<td>0.773</td>
<td>0.949</td>
<td>0.184</td>
</tr>
<tr>
<td>Mean Shuttle SDT Dribble (sec)</td>
<td>0.943</td>
<td>0.403</td>
<td>0.170</td>
</tr>
<tr>
<td>Mean Slalom SDT Sprint (sec)</td>
<td>0.855</td>
<td>0.483</td>
<td>0.294</td>
</tr>
<tr>
<td>Mean Slalom SDT Dribble (sec)</td>
<td>0.488</td>
<td>0.725</td>
<td>0.140</td>
</tr>
</tbody>
</table>

Paired sample T-test shows a significant difference (*p* ≤ 0.05) in the test results of the Illinois test and the Illinois test after a fatigue protocol (see table 5).

Table 5. Paired sample T-test.

<table>
<thead>
<tr>
<th>Paired differences</th>
<th>95% confidence interval of the difference</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>SE</td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>Illinois (sec) – Illinois fatigue (sec)</td>
<td>-1.462</td>
<td>1.0211</td>
<td>0.126</td>
<td>-1.715</td>
<td>-1.209</td>
</tr>
</tbody>
</table>
All variables with a p value of < 0.20 were investigated in binary logistic regression (Nilstad et al., 2014). Binary logistic regression analysis did not reveal a significant difference (p > 0.05) in Illinois between players who sustained an injury or an overuse injury and those who did not. There was also no significant difference in BMI, FMS, inline lunge, shoulder mobility, trunk stability push up, modified T-test, mean Shuttle SDT sprint, mean Shuttle SDT dribble and mean Slalom SDT Dribble between players who sustained a traumatic injury and those who did not. On the other hand, there was a significant difference (p ≤ 0.05) in hurdle step, rotary stability and Illinois fatigue in those who sustained an injury and those who did not (p = 0.028; 0.043 and 0.009). There was also a significant difference in hurdle step, active straight leg raise, rotary stability and Illinois fatigue in those who sustained an overuse injury and those who did not (p = 0.012; 0.018; 0.023 and 0.006). Table 6 and 7 represents the risk models for the prediction of an injury or an overuse injury.

Table 6. Risk model for the prediction of an injury versus no injury.

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
<th>95% C.I.for EXP(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>Hurdle step (1)</td>
<td>1.365</td>
<td>0.620</td>
<td>4.848</td>
<td>1</td>
<td>0.028</td>
<td>3.918</td>
<td>1.162</td>
</tr>
<tr>
<td>Rotary stability</td>
<td></td>
<td></td>
<td>4.098</td>
<td>3</td>
<td>0.251</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotary stability (1)</td>
<td>-23.218</td>
<td>40192.970</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rotary stability (2)</td>
<td>-24.072</td>
<td>25071.362</td>
<td>0</td>
<td>1</td>
<td>0.999</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rotary stability (3)</td>
<td>-1.564</td>
<td>0.773</td>
<td>4.098</td>
<td>1</td>
<td>0.043</td>
<td>0.209</td>
<td>0.046</td>
</tr>
<tr>
<td>Illinois Fatigue (sec)</td>
<td>0.793</td>
<td>0.302</td>
<td>6.881</td>
<td>1</td>
<td>0.009</td>
<td>2.210</td>
<td>1.222</td>
</tr>
<tr>
<td>Constant</td>
<td>-13.251</td>
<td>5.135</td>
<td>6.659</td>
<td>1</td>
<td>0.01</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
Table 7. Risk model for the prediction of overuse injury versus no overuse injury.

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
<th>95% C.I. for EXP(B)</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hurdle step (1)</td>
<td>2,307</td>
<td>0,918</td>
<td>6,316</td>
<td>1</td>
<td>0,012</td>
<td>10,046</td>
<td>1,662 60,724</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active straight leg raise</td>
<td>5,698</td>
<td>2</td>
<td>0,058</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active straight leg raise (1)</td>
<td>0,549</td>
<td>1,006</td>
<td>0,298</td>
<td>1</td>
<td>0,585</td>
<td>1,732 0,241 12,442</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active straight leg raise (2)</td>
<td>2,042</td>
<td>0,863</td>
<td>5,591</td>
<td>1</td>
<td>0,018</td>
<td>7,703 1,418 41,838</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotary stability</td>
<td>5,133</td>
<td>3</td>
<td>0,162</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotary stability (1)</td>
<td>-22,434</td>
<td>40192,970</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0 0 .</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotary stability (2)</td>
<td>-26,160</td>
<td>22648,669</td>
<td>0</td>
<td>1</td>
<td>0,999</td>
<td>0 0 .</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotary stability (3)</td>
<td>-2,184</td>
<td>0,964</td>
<td>5,133</td>
<td>1</td>
<td>0,023</td>
<td>0,113 0,017 0,745</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illinois Fatigue (sec)</td>
<td>1,287</td>
<td>0,464</td>
<td>7,701</td>
<td>1</td>
<td>0,006</td>
<td>3,620 1,459 8,983</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-23,631</td>
<td>8,140</td>
<td>8,428</td>
<td>1</td>
<td>0,004</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8. Categorical variables coding injuries.

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Parameter coding</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotary stability</td>
<td>0</td>
<td>1 1 0 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2 0 1 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>51 0 0 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>11 0 0 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hurdle step</td>
<td>2</td>
<td>38 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>27 0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9. Categorical variables coding overuse injuries.

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Parameter coding</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotary stability</td>
<td>0</td>
<td>1 1 0 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2 0 1 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>51 0 0 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>11 0 0 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active straight leg raise</td>
<td>1</td>
<td>12 1 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>22 0 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>31 0 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hurdle step</td>
<td>2</td>
<td>38 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>27 0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.1 Injuries

The Illinois fatigue was identified as a significant predictor of an injury.

The chi-square test shows that this model fits with this data (significance of 0.002).

\[ \text{Table 10. Chi-square test.} \]

<table>
<thead>
<tr>
<th>Chi-square</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step</td>
<td>18,778</td>
<td>5</td>
</tr>
<tr>
<td>Block</td>
<td>18,778</td>
<td>5</td>
</tr>
<tr>
<td>Model</td>
<td>18,778</td>
<td>5</td>
</tr>
</tbody>
</table>

\[ \text{Table 11. Model Summary injuries.} \]

<table>
<thead>
<tr>
<th>-2 Log likelihood</th>
<th>Cox &amp; Snell R Square</th>
<th>Nagelkerke R Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>69,461</td>
<td>0,251</td>
<td>0,338</td>
</tr>
</tbody>
</table>

The function of the best fitting model is as follows:

\[ P(x) = (-13,251) + [1,365 \times \text{(Hurdle step})] + [(-1,564) \times \text{(Rotary stability (3)})] + [0,793 \times \text{(Illinois fatigue)}]. \]

After logit transformation, the following model predicts the likelihood of sustaining an injury:

\[ \pi(x) = \frac{e^{P(x)}}{1 + e^{P(x)}} \]

The outcomes ranged from 0 to 1. An outcome of 0 represents that there is no risk for an overuse injury and a 1 is the highest possible risk for an overuse injury.

3.2 Overuse injuries

The Illinois fatigue was identified as a significant predictor of an overuse injury.

The chi-square test shows that this model fits with this data (significance of < 0.001).

\[ \text{Table 12. Chi-square test.} \]

<table>
<thead>
<tr>
<th>Chi-square</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step</td>
<td>27,609</td>
<td>7</td>
</tr>
<tr>
<td>Block</td>
<td>27,609</td>
<td>7</td>
</tr>
<tr>
<td>Model</td>
<td>27,609</td>
<td>7</td>
</tr>
</tbody>
</table>

\[ \text{Table 13. Model Summary overuse injuries.} \]

<table>
<thead>
<tr>
<th>-2 Log likelihood</th>
<th>Cox &amp; Snell R Square</th>
<th>Nagelkerke R Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>49,094</td>
<td>0,346</td>
<td>0,500</td>
</tr>
</tbody>
</table>
The function of the best fitting model is as follows: \( P(x) = (-23,631) + [2,307 \times \text{(Hurdle step})] + [2,042 \times \text{(Active straight leg raise (2)])} + [(-2,184) \times \text{(Rotary stability (3)])} + [1,287 \times \text{(Illinois fatigue})]. \)

After logit transformation, the following model predicts the likelihood of sustaining an overuse injury:

\[
\pi(x) = \frac{e^{P(x)}}{1 + e^{P(x)}}
\]

The outcomes ranged from 0 to 1. An outcome of 0 represents that there is no risk for an overuse injury and a 1 is the highest possible risk for an overuse injury.

### 3.3 Traumatic injuries

No significant differences were found in binary logistic regression between players who sustained a traumatic injury and those who did not.
4 Discussion

Results from different studies linking injury prediction to the FMS were controversial. A possible cause for those discrepancies may be the differences in tested populations, the test selection, the ability of the sum score to predict injury and the functionality of the tests. Additionally, there was little research linking agility to injury prediction.

Therefore, the purpose of this study was to investigate the predictive value of the FMS, agility and fatigue on the development of injuries in male hockey players.

The results of this study revealed no significant relationship between any of the measured anthropometrical characteristics and the occurrence of an injury, overuse injury or traumatic injury.

Next to all variables that are discussed, the psychological estate and the positioning on the tables of the league could have an influence on the prevalence of injuries. For example, Leopard had a terrific season and will be promoted to the 2nd league next year. This in contrast to the first team of Gantoise, who will be relegated next season to the 2nd league. This difference in team spirit can possibly have an important influence. Further research about this hypothesis is necessary.

4.1 FMS and injuries

Data analysis revealed that a cutoff score for the FMS total score was not significant related to the likelihood of the prediction of an injury. Few findings suggest a positive link between injury prediction and the mechanism of the sum score of the FMS (Chorba et al., 2010; Garrison et al., 2015; Kiesel et al., 2007, 2014; Letafatkar et al., 2014; Lisman et al., 2013; O’Connor et al., 2011), whereas some did not find any link between the use of a cutoff total score and injury prediction (Dossa et al., 2014; Sorenson et al., 2009). Differences in population provided the most discrepancy between studies. The research that disapproves the use of a cutoff score for the FMS was done on hockey players and basketball players. While the research that backs the use of a cutoff score was primarily done on students who primarily participated in different sports (Chorba et al., 2010; Garrison et al., 2015; Letafatkar et al., 2014) or military personnel (Lisman et al., 2013, O’Connor et al., 2011) or performed on male professional American football players (Kiesel et al., 2007, 2014). Additionally, most studies did not make a difference in gender or age.
Statistical analysis (independent-samples-T-tests and Mann-Whitney U tests) of the separate FMS tests, agility tests and fatigue protocol revealed significant differences ($p \leq 0.05$) in the rotary stability for injuries and the Illinois fatigue for injuries as well as overuse injuries. These results indicate a difference between the injured and non-injured group for the previous factors i.e. these factors can contribute in sustaining an injury. However, after binary logistic regression, a score of 2 on the hurdle step or the rotary stability test and the Illinois fatigue were predictive factors of injuries. A score of 2 for the hurdle step, the rotary stability or the active straight leg raise and the Illinois fatigue were predictive factors of overuse injuries.

The overall easiness of scoring and the difficulty of assessing multiple aspects of a movement from one vantage point makes the FMS vulnerable to missing vital parts that could contribute to the problem (Whiteside et al., 2016). Occasionally there is a compensation of isolated body parts in order to perform the movement correctly. This puts an excessive load on certain bodily structures. Therefore, a person is more sustainable for injury, but this is not noticeable only by using the FMS. E.g. a distinct lordosis in the lumbar spine to keep the dowel overhead during the deep squat. Additionally, recent research showed that the ambiguity of the scoring criteria could interfere with the test results. An additional performance instruction significantly changed FMS scores (Frost et al., 2013; Whiteside et al., 2016). These concerns raise significant questions regarding the validity of the FMS (Bonazza et al., 2016). Further research is warranted due to the lack of internal consistency of the FMS (Bonazza et al., 2016; Kazman et al., 2014). The influence of pain on the scoring should also be questioned. Some studies hit upon little difference between scoring with a pain score of 0 or without a 0-score (Kazman et al., 2014).

The tests are initially hypothesized to be fundamental for athletes. However, there is no difference made in gender, type of sport, age etc. as mentioned above. The presumption that all sports and all athletes make the same functional movements during daily life, during training, during matches etc. is controversial as well. The goal of screening for movement is to look at the body as a whole instead of looking at the work of isolated body parts. This theory is in discrepancy with most of modern literature where assessment of isolated tissue is warranted. However, this does not make it incorrect. Additionally, to perform a certain functional movement properly does not imply an automatic use of those movements in daily live. Meaning that certain movement may not be functional to every single human being because of personal differences in movement in a population. Therefore research should focus on a different FMS protocol for different sports, different ages and different genders. We need to step away
from the ‘one size fits all’ strategy and there should be a shift in focus to sport specific, gender specific and age specific functional testing batteries.

The individual FMS tests have an extreme focus on the fundamentals of movement such as neuromuscular control, flexibility and core stability where stamina, strength and overall aerobic endurance are neglected. Some of those factors could play a major part in injury prediction but are not assessed in the screening. Literature suggest that a combination of poor scores on a 3 mile run test and a FMS cutoff score of 14 or less increases the predictive value on all injury classifications (Lisman et al., 2013). Additionally, O’Connor et al. (2011) stated that candidates with low physical fitness scores are 2.2 times more likely to have FMS scores of 14 or less, and are more likely to sustain an injury across all types of injuries.

Only a few research papers discussed the link between isolated tests of the FMS in relation to injury prediction in specific sports (Hotta et al., 2015; Warren et al., 2014). Most criticism was addressed to the fact that the risk of injury rises when the athlete scores below a certain threshold, this without consideration of the individual test scores. By ignoring the individual test scores, it is possible that certain test subjects succeed to cover their major flaws due to excellent scores in other testing parts. As mentioned before, a wide variance in tested populations or the ignorance of gender or age could be at the root of these discrepancies.

Hotta et al. (2015) was able to correlate individual tests of the FMS to running injuries. Poor flexibility and deficit in neuromuscular coordination in the deep squat can cause running injuries (Hotta et al., 2015), as well as limited flexibility of the hamstrings, which is needed for a good active straight leg raise ability (Butler et al., 2013; Hotta et al., 2015). Additionally, there is some evidence that a score of 2 on the inline lunge could mean a decreased likelihood in sustaining a non-contact injury in comparison to a score of 3 (Warren et al., 2014).

From the combination of our results, with the low validity, the lack of internal consistency and the contradictory findings of the FMS score, we can assume that the FMS should not be considered as a standalone screening, but should be used in combination with various other screenings assessing the factors the FMS did not evaluate. Subsequently there was a discrepancy of when the tests should be taken. Should the FMS be conducted with the athlete at rest or should there be a sport specific fatigue protocol prior to the testing? We did not address fatigue in our FMS testing. However, it could be hypothesized that fatigue, aerobic and anaerobic endurance could be crucial factors in sustaining an
injury because most athletes tend to compensate in functional patterns when they reach a certain point of fatigue. Further research should be taken into account if the FMS should be assessed in a resting state of the athlete, or if a sport specific fatigue protocol must precede, exposing the tester to fatigue before the initiation of testing. Further research should be conducted on the timing of the assessment, as well as the influence of the separate tests on injury prediction.

In recent years, there has been done much research on the likelihood of the FMS predicting injury, whereas less attention has been paid to the link of the FMS and athletic performance. The strength of the FMS is to discover faulty movement patterns in a short period of time. Making it perhaps a better tool for athletic performance screening than for injury prediction. Only one study performed with golfers found no link between athletic performance and the FMS (Parchmann et al., 2011). This study used the 1RM value as a reference for strength and different athletic performance tests. Little research is done on the link between the FMS and athletic performance and there has been no consensus on what section of athletic performance, i.e. endurance, strength, agility etc., has a correlation with the FMS (Lisman et al., 2013; Lockie et al., 2014, 2015; O’Connor et al., 2011; Okada et al., 2011; Rowan et al., 2015). In spite of that, some correlations have been found. A thorough research should be conducted whether the FMS is more valid as an athletic performance screen or an injury prediction protocol.

4.2 Agility, fatigue and injuries

As shown in Table 4, there was no significant difference (p < 0.05) for any of the three agility tests (Modified T-test, Shuttle run and Illinois test) between players who sustained an injury and players who remained injury free. These results could indicate a non-functional relationship between the chosen agility tests and injury prediction. No research is known on the relationship between agility and injury prediction in field hockey and further research is warranted.

Agility is used by sport practitioners as a functional way of measuring athletic performance. Many types of exercises are already available for different sports. However, there is not yet a protocol supported by literature that is significant in the prediction of injuries in hockey, both overuse, traumatic and overall. In the design of the protocol we made a combination of the most common agility based exercises in hockey, with an added fatigue protocol (Lemmink et al., 2004).

Assessment should also consider playing minutes and physical labour in correlation to injury prediction. It could be hypothesised that players who have higher test scores on functional sport exercises such as
the agility tests, get more playing minutes or show an increased physical labour during matches, trainings etc. This higher exposure could be indicative to a higher risk of sustaining an injury. Further research should address the link between test scores, athletic performance, exposure in correlation with the risk of sustaining an injury i.e. an integration of playing minutes, physical labour, agility and injury prediction.

Due to the lack of results from our study correlating agility tests with injury prediction, perhaps the focus of the use of agility tests should not be on the prediction of injuries, but on the prediction or quantification of athletic performance as it is nowadays used on an empirical base.

Data analysis shows the effect of fatigue on the Illinois test (paired sample t-test) and shows a link in injury and overuse injury prediction and fatigue. The results indicate a difference between the injured and non-injured group in the Illinois fatigue i.e. this factor can contribute to sustaining an injury. This was statistically significant as shown in the binary logistic regression.

Fatigue has become the source of discussion in recent years. The UEFA injury study (Ekstrand et al., 2011) showed an increase in injury incidence towards the end of each half. This higher incidence of injury may be the result of fatigue. No literature is available on the effect of fatigue on field hockey players. Further research should address the link between fatigue and injuries in hockey.

It must be taken into account that the fatigue in this study was fatigue from a standardized fatigue hockey protocol, which tries to simulate a hockey specific fatigue. However, this is still not a training or game specific fatigue. Further research is warranted to find out the effect of training and game specific fatigue in injury prediction. Additionally, the role of a fatigue protocol prior to the FMS and injury prediction should also be researched.

5 Limitations

Our population contained players from different teams from different levels. We tested players who play in 1st Belgian division, in 3th Belgian division and also reserve squads. Additionally, squads who were higher ranked, had more training hours.

Testing was assessed on artificial turf, where trainings and matches were conducted. Differences in quality and type of artificial turf (sand-dressed or grass) could be at the base of different outcomes on the tests.
Testing was performed during preseason. Due to the duration of testing, we were obliged to take the tests in different stages of season preparation. Some players were tested in the beginning of preseason, where only a few training hours preceded. While we had to test others in the mid and late stage of the preseason, who had undergone more training hours and therefore hypothetically had a physical advantage over the ones who had to take the tests in the first weeks of preseason.

When players did not perform an exercise or test adequate, retesting occurred at the same time on the spot. Those who had to redo a test, were in a relatively more fatigued state than who had not. This could interfere with test results.

There was a wide range in age and experience between players.

6 Conclusion

The results of this study indicate that the use of a sum score of the FMS is not a predictive variable for the prediction of injuries in male hockey athletes. Some separate tests of the FMS were predictive for injuries as well as the Illinois fatigue tests. Further research on the role of fatigue and separate tests of the FMS on injury prediction is warranted. Additionally, the role of agility in injury prediction should be assessed in further research.
7 References


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Functional Movement Screen: A Comparison of Manual (Real-Time) and Objective Methods. J 
8 Abstract in lekentaal

Achtergrond: In de laatste jaren is er een toegenomen interesse voor de voorspelling van blessures een in de sportwereld. Een voorbeeld van zo een protocol om blessures te voorspellen is de FMS. Dit is een combinatie van 7 testen die een verhoogd risico op blessures proberen te identificeren. Hierbij aansluitend is de rol van behendigheid en vermoeidheid in blessures is nog onvoldoende onderzocht.

Doelstelling: Proberen blessures te voorspellen bij mannelijke hockey spelers.

Onderzoeksdesign: Groepen opvolgen over een bepaalde tijdspanne.


Resultaten: 1 van de testen uit de FMS en de Illinois test na vermoeidheid waren indicatief. Na het uitvoeren van een statistische vergelijking, werd er gevonden dat de hurdle step, rotary stability en de Illinois test na vermoeidheid iets konden zeggen over de kans op blessures in de toekomst. De hurdle step, active straight leg raise, rotary stability en de Illinois test na vermoeidheid zeggen iets over de kans op een overbelastingsblessure in de toekomst. Voor de totale score op de FMS werd geen verband gevonden tussen de groep met blessures en de groep zonder blessures.

Conclusie: De resultaten wijzen op de rol van aparte testen van de FMS in de voorspelling van blessures in plaats van het gebruik van een totaalscore. Een belangrijke rol van vermoeidheid en de voorspelling van blessures werd ook aangetoond in de resultaten. Verder onderzoek is nodig om het effect van behendigheid op het voorspellen van blessures te achterhalen.

Sleutelwoorden: Blessure voorspelling, Functional Movement Screen, behendigheid, vermoeidheid
9 Proof of submission to the ethics committee

Afz. Commissie voor Medische Ethiek

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DATUM
11-feb-16

2016/2011

KOPIE

Di "CC"

BETREFF

Advies voor monencoertische studie met als titel:

Titel hoofdstuk: Identificatie van risicofactoren op lekken bij voetbal

Titel (differentiation in hockey: Screening with the Functional Movement Screen - Jeroen Moetmans

Belgisch Registratienummer: 096/2016/28894

* Adviesaanvraagformulier dd. 21/09/2015, (volledig ontvangen dd. 03/09/2015)
* Begeleidende brief dd. 31/08/2015
* (Patiënten)informatie- en toestemmingssformulier dd. 17/072015
* Diverse - Bijlage A met de illustraties testen
* Adviesaanvraagformulier dd. 29/10/2015, (document E)
* Begeleidende brief dd. 4/12/2015

Advies werd gevraagd door:

Prof. dr. B. CAGNIE ; Houdtonderzoeker

BOVENVERMELDE DOCUMENTEN WERDEN DOOR HET ETISCH COMITÉ BEoordeld.

EN WERD EEN POSITIEF ADVIES GEGEVEN OVER DIT PROTOCOL OP 18/2/2016, INDIEN DE STUDIE NIET WORDT OPGEGROND VOOR

15/02/2017, VERVALT HET ADVIES EN MOET HET PROJECT DEERG INGEDEED WORDEN.

Voorleg het onderzoek te starten dient contact te worden genomen met Bimeta Clinica (09/332 05 00).

THE ABOVE MENTIONED DOCUMENTS HAVE BEEN REVIEWED BY THE ETHICS COMMITTEE.

A POSITIVE ADVICE WAS GIVEN FOR THIS PROTOCOL ON 18/02/2016, IN CASE THIS STUDY IS NOT STARTED BY 15/02/2017, THIS

ADVICE WILL BE NO LONGER VALID AND THE PROJECT MUST BE RESUBMITTED.

Before initiating the study, please contact Bimeta Clinica (09/332 05 00).

DIT ADVIES WORDT OPGEPOMEN IN HET VERSLAG VAN DE VERGADERING VAN HET ETISCH COMITÉ VAN 19/02/2016.


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* 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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Namens het Ethisch Comité / On behalf of the Ethics Committee

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11-feb-16
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COMMISSIE VOOR MEDISCHE
ETHIEK,
Voorzitter:
Prof. Dr. D. Matthys
Secretaris:
Prof. Dr. J. Decruyenaere

BETREFF
Advies voor moncentrische studie met als titel:
Titel hoofdstudie: Identificatie van risicofactoren op leeftijd bij veldhockey
Titel scriptie: Injury prevention in hockey: Screening with the Functional Movement Screen - Scriptie Daan Nykens
Belgisch Registratienummer: B6702016386939

* Adviesaanvraagformulier dd. 21/05/2015, (volledig ontvangen dd. 03/09/2015)
* Begeleidende brief dd. 31/06/2015
* (Patienten)informatie- en toestemmingsformulier dd. 17/07/2015
* Diverse:
  * Bijlage A met de illustraties testen
  * Adviesaanvraagformulier dd. 05/11/2015, (document E)
  * Begeleidende brief dd. 04/12/2015

Advies werd goedgekeurd door:
Prof. dr. B. CAGNIE; Hoofdonderzoeker

BOVENVERMELDE DOCUMENTEN WERDEN DOOR HET ETHISCH COMITÉ BEOORDEELD.
ER WERD EEN POSITIEF ADVIES GEGEVEN OVER DIT PROTOCOL OP 16/01/2016. INDIEN HET STUDIE NIET WORDT OPENSTAAT VOOR 16/01/2017, VERVALT HET ADVIES EN MOET HET PROJECT TERUG INGEDIENEN WORDEN.

Voorafgaand het onderzoek te starten diert contact te worden genomen met Bimeta 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 16/01/2016. IN CASE THIS STUDY IS NOT STARTED BY 16/01/2017, THIS ADVICE WILL BE NO LONGER VALID AND THE PROJECT MUST BE RESUBMITTED.

BEFORE INITIATING THE STUDY, PLEASE CONTACT BIMETA CLINICS (09/332 05 00).

 Dit advies wordt opgenomen in het verslag van de vergadering van het ethisch comité van 18/01/2016

THEMEETING OF THE ETHICAL COMMITTEE ON 18/01/2016

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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.

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* Geen enkel onderzoek, betrokken bij deze studie is lid van het Ethisch Comité.
* Alle leden van het Ethisch Comité hebben dit project beoordeeld. (De ledenlijst is bijgevoegd)

* 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

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Voorzitter / Chairman

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BETREFT
Advies voor monochteron studie met als titel:
Titel hoofdstudie: Identificatie van risicofactoren op letseba bij voetschijf
Titel subtitel: Injury prevention in hockey: Screening with the Functional Movement Screen - Scriptie Nicky Merckx
Belgisch Registratienummer: B570201629965
* Adviesaanvraagformulier dd. 21/08/2015, (volledig ontvangen dd. 03/09/2015)
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* Diverse: Bijlage A met de illustraties testen
* Adviesaanvraagformulier dd. 28/10/2015, (document E)
* Begeleidende brief dd. 4/12/2015

Advies werd gevraagd door:
Prof. dr. B. CAGNIE: Hoofdonderzoeker

BOVENVERMELDE DOCUMENTEN WERDEN DOOR HET ETHISCH COMITÉ BEORDOELD.
ER WERD EEN POSITIEVE ADVIES GEGEVEN OVER DIJT PROTOCOL OP 16/01/2016. INDIEN DE STUDIE NIET WORDT OPEGESTART VOOR 16/01/2017, VERVALT HET ADVIES EN MOET HET PROJECT TERUG INGEDEED WORDEN.
VOORALEER HET ONDERZOEK TE STARTEN DIENDE CONTACT TE WORDEN GEDUREN MET BIMETRA CLINICS (09/332 06 06).

THE ABOVE MENTIONED DOCUMENTS HAVE BEEN REVIEWED BY THE ETHICS COMMITTEE.
A POSITIVE ADVICE WAS GIVEN FOR THIS PROTOCOL ON 16/01/2016. IN CASE THIS STUDY IS NOT STARTED BY 15/01/2017, THIS ADVICE WILL BE NO LONGER VALID AND THE PROJECT MUST BE RESUBMITTED.
BEFORE INITIATING THE STUDY, PLEASE CONTACT BIMETRA CLINICS (09/332 06 06).

DIT ADVIES WORDT OPGEPOMEN IN HET VERBLAG VAN DE VERGADERING VAN HET ETHISCH COMITÉ VAN 19/01/2016

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Namens het Ethisch Comité / On behalf of the Ethics Committee

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INFORMED CONSENT DEELNAME FMS-TESTING

U bent uitgenodigd om deel te nemen aan een masterscriptie, uitgevoerd door Jeroen Motmans, Nicky Merckx, Daan Nyckees en promotor Prof. Dr. Van Tiggelen van de Universiteit uit Gent.
Als u besluit om deel te nemen, zal u een vragenlijst moeten invullen omtrent de leeftijd, gewicht, lengte, etc.
Wat gaat er gebeuren? U zal geëvalueerd worden bij het uitvoeren van de Functional Movement Screen (FMS) en daarbij 3 behendigheidstesten.

De FMS bevat 7 testen:
1. Deep squat
2. In-Line Lunge
3. Hurdle step
4. Active Straight leg raise
5. Shoulder mobility test
6. Push-up
7. Core stability test

De 3 behendigheidstesten zijn:
1. Modified T-Test
2. Shuttle run
3. Illinois test

Doorheen het hockey seizoen, zal er bijgehouden worden hoeveel spelers er op training en wedstrijd aanwezig zijn. Indien er spelers afwezig zijn omwille van blessures die zijn opgelopen op een training of wedstrijd, zal er een blessurerapport worden opgesteld. Dit rapport zal informatie bevatten over de blessure (datum, plaats van het letsel, diagnose, oorzaak,...).
Het blessurerapport zal uw naam en blessuregegevens bevatten, maar met uw goedkeuring stelt u deze informatie vrij enkel voor ons.
Alle informatie die via deze studie verworven wordt en naar u kan verwezen worden, is strikt vertrouwelijk. U kan altijd uw resultaten inkijken. De verwerking van de resultaten zal verder anoniem gebeuren.
Er zijn geen risico’s verbonden met de deelname aan deze studie.
Uw deelname en medewerking is vrijwillig en vrijblijvend. Als u beslist om deel te nemen, kan u ten allen tijden uit dit onderzoek stappen. Dit zonder enige consequenties.
Als u nog vragen heeft, aarzel niet om ons persoonlijk te contacteren of via de coach van het team.
Uw handtekening geeft aan dat u dit gelezen en goedgekeurd heeft, alle bovenstaande informatie begrijpt, en instemt om deel te nemen. Het geeft ook aan dat u instemt om blessure informatie mee te delen aan de coach, en aan ons (Nicky, Jeroen en Daan) tijdens het hockeyseizoen van 2015-2016.
10.2 Appendix 2. Questionnaire

Vragenlijst deelnemers Masterproef

Deze informatie is strikt vertrouwelijk en wordt uitsluitend binnen het kader van dit onderzoek gebruikt.

1. Administratieve gegevens
   - Naam en voornaam:
   - Geslacht: m [ ] v [ ]
   - Geboortedatum:
   - Lengte: cm
   - Gewicht: kg
   - Voorkeurshand: links / rechts (omcirkelen wat past)

2. Sport
   1) Hockey:
     - aantal trainingsuren per week: u/week
     - spelpositie:
     - aantal jaren: jaar
   2) Andere sporten:
     - sport:
     - aantal trainingsuren per week: u/week
     - spelpositie (indien van toepassing):
     - aantal jaren: jaar

3. Medische gegevens
   - Heeft u momenteel een blessure?
     Ja [ ] Neen [ ]
     \[Indien ja:
     Welke blessure?
     Duur?
     Eventuele behandeling:
- Heeft u in het verleden blessures gehad?
  Ja ☐ Neen ☐
  → Indien ja:
    Welke blessure?
    Duur?
    Eventuele behandeling (operatie?):

- Algemene gezondheidstoestand:
  - Lijdt u momenteel aan een lichamelijke aandoening?
    Ja ☐ Neen ☐
    → Indien ja:
      Welke ziekte?
      Duur?
      Eventuele behandeling:

  - Heeft u in het verleden ernstige lichamelijke aandoeningen gehad?
    Ja ☐ Neen ☐
    → Indien ja:
      Welke ziekte?
      Duur?
      Eventuele behandeling:

Bedankt voor uw medewerking!
10.3 Appendix 3. Functional Movement Screen (FMS)

The Functional Movement Screen (FMS) consists of seven fundamental movement patterns (7 tests), that require a balance between 2 components: mobility and stability. These fundamental movement patterns are designed to provide observable performance of basic loco motor, manipulative and stabilizing movements.

It has been shown that many players, who are performing at a high level, may not be able to carry out these movements correctly.

10.3.1 Test 1: Deep Squat

The squat is a movement needed in most athletic events. The deep squat is a test that evaluates total body mechanics and control, when performed properly. It is used to assess symmetrical and functional mobility of the hips, knees and ankles. The symmetrical mobility of both shoulders and mobility of the (thoracic) spine are evaluated when the dowel is lifted above the head.

Description: The participant started in a straight position with the feet aligned in the sagittal plane and at shoulder width. The participant brought the dowel above the head as far as possible. After this, the participant descended slowly into a squat position. This squat position should be performed with the heels on the floor.

10.3.2 Test 2: Hurdle step

The hurdle step is designed to challenge the whole body during a stepping motion. Proper coordination and stability between the hips and torso during the stepping motion as well as single leg stance stability are tested. This test evaluates functional mobility and stability of the hips, knees, and ankles of both legs.

Description: The participant started by placing the feet together and aligning the toes touching the base of the hurdle. The height of the rope is adjusted to the height of the athlete’s tibial tuberosity. The dowel is positioned across the shoulders below the neck. The participant stepped over the rope and touched their heel to the floor while maintaining the stance leg in an extended position. The moving leg is returned to the starting position. The hurdle step should be performed bilaterally.
10.3.3 Test 3: In-line lunge

The in-line lunge places the body in a position that will focus on stresses during rotational, decelerating, and lateral type movements. This test places the lower extremities in a scissor position challenging the body’s trunk and extremities to resist rotation and maintain proper alignment. Hip and ankle mobility and stability, quadriceps flexibility and knee stability are assessed.

Description: The participant placed the dowel behind the back touching the head, thoracic spine and sacrum. The hand opposite to the front foot should be the hand grasping the dowel at the cervical spine. The other hand grasped the dowel at the lumbar spine. The front foot was placed forward with the similar distance as the hurdle step height. The participant lowered the back knee and touched the surface behind the heel of the front foot and returned to starting position. The dowel may not loose contact with the head, thoracic spine and sacrum. The in-line lunge should be performed bilaterally.

10.3.4 Test 4: Shoulder mobility

The shoulder mobility evaluates bilateral and reciprocal shoulder range of motion, combining internal rotation with adduction of one shoulder and external rotation with abduction of the other. This test also requires normal scapular mobility and thoracic spine extension.

Description: The hand length (distance from distal wrist crease to the tip of the third digit) was measured. The participant made a fist with each hand, with the thumb inside of the fist. The participant performed a maximally adducted, extended and internally rotated position with one shoulder and maximally abducted, flexed and externally rotated position with the other shoulder. The fist must be placed on the back in one smooth motion. The shoulder mobility should be performed bilaterally.

10.3.5 Test 5: Active straight leg raise

The active straight leg raise evaluates the ability to dissociate the lower extremity from the trunk while maintaining stability in the torso. Active hamstrings and gastro-soleus flexibility were assessed while maintaining a stable pelvis and core, and active extension of the opposite leg.
Description: The participant lay in supine position with the arms in anatomical position, legs over the FMS board and head flat on the floor. The dowel was placed at the midpoint between the anterior superior iliac spine (SIAS) and the midpoint of the patella. The participant lifted his leg slowly with a dorsiflexed ankle and extended knee. The opposite knee must remain in contact with the ground and the toes pointed upward, and the head in contact with the floor. The position of the malleolus was evaluated in relation to the dowel. The Active straight leg raise should be performed bilaterally.

10.3.6 Test 6: Trunk stability push-up

The trunk stability push-up evaluates the ability to stabilize the core and spine in an anterior and posterior plane during a closed-chain upper body movement. Trunk stability in the sagittal plane while a symmetrical upper extremity push-up motion is performed, is assessed.

Description: The participant lay in a prone position with the feet together. Hands were placed shoulder width apart at the appropriate position according to the described criteria. Men and woman had different starting arm positions. Men began with their thumbs at the top of the forehead, while women began with their thumbs at chin level. Knees were fully extended and the ankles dorsiflexed. The participant were asked to perform one push-up in this position and the body should be lifted as a unit. If the participant could not perform a push-up in this position, the thumbs were moved to the next, more easy, position, chin level for males and shoulder level for females.

10.3.7 Test 7: Rotary stability

The rotary stability is a complex movement. It requires a proper neuromuscular coordination and energy transfer from one segment of the body to another through the torso. Multi-planar trunk stability during a combined upper and lower extremity motion is assessed.

Description: The participant started in quadruped position, with the shoulders and hips at 90 degrees angles. The FMS board was between their hands and knees. Knees were positioned at 90 degrees and the ankles should be
dorsiflexed. The participant then flexed the shoulder and extended the same side hip and knee. Afterwards, the same shoulder was extended and the knee flexed enough for the elbow and knee to touch. If the participant could not complete this test, he was instructed to perform a diagonal pattern using the opposite shoulder and hip in the same manner as described above. The rotary stability should be performed bilaterally.

10.3.8 Scoring

The scoring was based on four basic criteria. A score of 3 was given if the participant could perform the movement without any compensations according to the established criteria. A score of 2 was given if the participant could perform the movement but must utilize poor mechanics and compensatory patterns to accomplish the movement. A score of 1 was given if the participant could not perform the movement pattern even with compensations. A 0 was given if the individual had pain during any part of the test. There were five tests which should be tested bilaterally. This resulted in two scores for those tests. The lowest score was recorded for the overall score, but both scores were needed for assessment and data collection purposes.
10.4 Appendix 4. Stretching

**Lateral hip muscles:** the participant makes a lunging to a shooter position, with hands on the back. Subsequently, the trunk bowed successively to the left and right. Afterwards they did the next lunge, with the other leg in front.

**Step over and under the fence:** sideward, one over and two under.

**Hip extensors:** the participant brought his left knee as high as possible to the chest, held this position for 3 seconds, and brought the leg back. Then he took two steps, and did the same with the right knee. This was repeated until the end of the defined field.

**Hamstrings:** the participant took one step left and right alternately, by bending the back leg while the front leg was stretched. After that they reached with the arms to the front foot.

**Hip and gluteal muscles:** the participant put a big step forward alternately left and right. At each step the participant crossed the arm of the same side of the front leg below the knee. The opposite arm was raised, while the participant was rotating his torso.

**Hip rotators:** the participant pulled up the left foot towards the groin. Then he putted the foot back, took three steps, and repeated the exercise with the right foot.

**Adductors:** the participant did a lateral lunge. This exercise was performed one time with the right leg and one time with the left leg.

**Accelerations:** the participant made an acceleration of 10 m and ran out quietly.

**Accelerations with changes of direction:** the participant ran forward, turned in the middle of the length along the right side, ran 2 steps backward, and turned back along the left side to continue running forward.
10.5 Appendix 5. Agility tests

10.5.1 Test 1: Modified T-test

This test assesses multidirectional running (forwards, sideways and backwards) and directional changes while running a short distance.

Four cones, with a height of 30 cm, were placed in a T-shape. The three upper cones were placed 4.57 m apart and the lower cone A was placed 9.14 m from the middle upper cone. The test began behind cone A. The participant started on an auditory signal after a 5 second countdown. The participant sprinted from cone A to cone B and touched cone B with the right hand. The participant moved sideways to cone C and touched cone C with the left hand. After this, the participant moved sideways to cone D, touched it with the right hand and returned sideways to cone B. The participant sprinted backwards to cone A, after touching cone B with the left hand. Time stops when the participant passed cone A.

Timing data were measured using a stopwatch, expressed in seconds with an accuracy of 0.01 seconds.

Scoring: The timing data was not valuable if the participant placed his one foot before the other during moving sideways, failed to touch a cone or can't hold his body straight forward during the whole test.

10.5.2 Test 2: Shuttle run

The purpose of this test is to evaluate speed and agility while sprinting between two lines which have been placed 10 m from each other. Body control and the ability to change direction were also evaluated. Two lines have been placed 10 m from each other. The participant started behind line A. Two hockey balls were placed on the other side. The participant started on an auditory signal after a 5 second countdown. The participant sprinted to line B, takes one hockey
ball, and sprinted back to line A. After putting ball one behind line A, the participant sprinted to line B, takes the second hockey ball, and sprinted back over line A. Time stops when the participant passed line A for the second time.

Timing data were measured using a stopwatch, expressed in seconds with an accuracy of 0,01 seconds.

The test was performed again when the participant lost the ball, or throws the ball to line A.

10.5.3 Test 3: Illinois Test

The Illinois test is a commonly performed test to evaluate agility in sporting context.

Cones were placed as shown on the picture, with a total length of 10m and a total width of 5m. The participant started behind the first cone in prone position with the hands next to the shoulders. The participant started on an auditory signal after a 5 second countdown. The participant follows the trail as shown on the picture. Time stops when the participant passed the last cone.

Timing data were measured using a stopwatch, expressed in seconds with an accuracy of 0,01 seconds.
10.6 Appendix 6. Fatigue protocol

This protocol consists of two tests, the Shuttle SDT (Sprint and Dribble Test) and the Slalom SDT (Sprint and Dribble Test). Both described by Lemmink et al., 2004. These tests were carried out successively.

10.6.1 Shuttle SDT

The Shuttle SDT consisted of three maximal sprints of 32 m while carrying a hockey stick and three maximal sprints of 32 m while dribbling a hockey ball with a hockey stick. Each 32 m sprint included a 6 m and a 10 m shuttle sprint.

The participant began the test standing with both feet behind line A, marked with two cones 2 m apart from each other. The participant started on an auditory signal after a 5 second countdown. The participant sprinted 6 m to line B (marked with two cones), touched the line with one foot and returned to line A. The participant then sprinted 10 m to line C (marked with two cones), after touching line A with one foot. The participant touched line C with one foot, and returned to line A. The participant walked back to line A, where the second sprint started exactly 20 seconds after the start of the first sprint. The third sprint started exactly 20 seconds after the start of the second sprint. After 3 sprints with carrying a hockey stick, the participant performed 3 dribble sprints with exact the same protocol as the first 3 sprints.

Timing procedures were used. This meant that the initial and final metres of the sprint were not timed. Data are based on a distance of 30 m. This was recorded with a camera, and the measured times were calculated with Kinovea. Camera was placed at 0,44 m above ground and at 1,0 m behind line A.

The following variables were measured in this test (with an accuracy of 0,04 seconds):

- Sprint times = individual sprint times
- Dribble times = individual dribble times
- Mean sprint time = total sprint time of the three sprints
- Mean dribble time = total dribble time of the three dribbles
10.6.2 Slalom SDT

The Slalom SDT consisted of three maximal sprints of 30 m while carrying a hockey stick and three maximal sprints of 30 m while dribbling a hockey ball with a hockey stick. Twelve cones, with a height of 30 cm, were placed in a zigzag pattern. Start and finish lines (A and B) were each marked by two cones.

The participant began the test with both feet behind line A, and started after an auditory signal after a 5 second countdown. The participant sprinted with a hockey stick around the 12 cones finishing over line B. After the sprint, the participant walked to line B, were the second sprint started after exactly 10 seconds of rest. The third sprint started at line A. After 3 sprints with carrying a hockey stick, the participant performed 3 dribble sprints with exact the same protocol as the first 3 sprints.

Timing data were measured using a stopwatch, expressed in seconds.

The following variables were measured in this test (with an accuracy of 0,01 seconds):

- Slalom sprint times = individual sprint times
- Slalom dribble times = individual dribble times
- Mean slalom sprint time = total sprint time of the three sprints
- Mean slalom dribble time = total dribble time of the three dribbles
10.7 Appendix 7. Injury report

**Blessurerapport**

Naam en voornaam:

Datum:

Club en Ploeg:

Leeftijd:

- Locatie aandoening:

- Wanneer is deze blessure opgetreden?

- Beschrijf de ontaansgeschiedenis:

- Beschrijf de soort pijn:

- Beschrijf wanneer de pijn optreed:

- Heeft u een arts geraadpleegd en/of een andere hulpverlener gecontacteerd? Zoja, welke?

- Wat is de diagnose?


- Heeft u niet kunnen deelnemen aan wedstrijden/trainingen door de blessure? Zoja, voor hoe lang?