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Functional Movement Screen and lower body mobility limitations in Ice Hockey

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Abstract

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This product oriented thesis considers how Functional Movement Screen can be used to recognize limitations in ice hockey player's basic movements. The product for this thesis is a "Guide for lower mobility and stability movements to help prevent lower extremity injuries". The guide was made for ice hockey coaches to recognize limitations in basic movements and that way be able to prevent some of the injuries that occur in ice hockey.

Functional Movement Screen (FMS) was created to recognize asymmetries and quality of fundamental movement patterns. The guide is based on the results of previous FMS and FMS related movement tests performed by ice hockey players, and the results of previously done injury researches. FMS is simple and reliable product that screens movement abilities, asymmetries and limitations. By using FMS based test movements the limitations that ice hockey players might have in their movements can be screened and the possible injuries prevented.

Ice Hockey is a high speed collision sport, with high risk of injuries. Injuries in Ice Hockey have been researched in many studies, but injury studies mostly concentrate on collecting information about what type of injuries occur in Ice Hockey and why the injuries occur.

By going through previously done ice hockey injury researches the lower extremity injuries and the prevention of the injuries was selected for the subject for the guide. From FMS test pattern Deep Squat-test, Inline Lunge-test and Active Straight Leg-test was selected to the guide for test movements.

The outcome of this thesis is a 29-page guide with 3 test movements and 21 corrective movements. The goal of the guide is to help coaches recognize the limitation in movement and give possible solutions how to fix the problems.

Keywords
Functional Movement Screen, Ice hockey, Injuries, lower extremity

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Appendix 1. Guide for lower body mobility and stability movement to help prevent lower extremity injuries.

1 Introduction

Proper movement abilities in lower extremities are in most sports requirement for generation of power, and also requirement for general wellbeing. Still, unfortunately often the movements and muscle maintenance are neglected until problems start to build up, power generation and performance start to weaken and this can finally lead to injuries. With proper actions all of this is possible to be prevented.

Sports and injuries go hand to hand. While trying to achieve better results one also gains bigger risk to get injury. Asymmetries in body have been studied to be a major risk factor for injuries (Knapick et al. 1991; Nadler et al. 2001). Even in our daily routines we have a chance to hurt ourselves if we have problems in the basic movements. While science and medical care can fix the injuries faster, it can also create a problem. Maybe enough focus is not given to the basic movement patterns that create the base for all movement?

Ice hockey is a fast contact sport with high risk of injuries. The game is played on a frozen surface, and collisions, fast pace and rapid changes of direction predispose the players for injuries. The higher level of the game, the higher risk to get injured. The physical and technical aspect of the game expose players to injuries. For example, skating is a demanding movement for hip, knee and ankle, and neglecting the lower body mobility, muscle stability and muscle force can cause injuries. This thesis goes through the most common injuries in ice hockey, and the product based on this thesis gives suggestions how these injuries might be able to be avoided.

This study uses Functional Movement Screen (later FMS) as a tool to recognize the problems in ice hockey player's movement, and view the possible connections between the injuries in ice hockey and FMS tests. FMS is one tool that can be used to recognize possible risks of injuries. FMS doesn't give straight answer to avoid injuries, but it might give guidelines how to plan practicing to a way that decreases a risk to gain injury.

The outcome of this thesis is a 29-page guide for lower body injury prevention. The guide uses three FMS test to recognize problems in movement and mobility, and gives 21-movements to improve lower body mobility and muscle stability.

2 Sport analysis Ice hockey

Ice hockey as a game

Ice Hockey is played in a hockey rink on a frozen surface. Ice hockey rink is limited with boards, and the size of the rink is 56-61 metres long and 26-30 metres wide. The game is played between two teams, both having max. 21 players. Both teams have maximum 6 players on ice at the same time, one goaltender and five players, and combined there are twelve players on the ice same time. (International Ice Hockey Federation 2014)

The pace of the game is determined by the level of the game, being highest on the National Hockey League (NHL) or International game (Olympic Games, World Championships etc.). The maximum speeds that ice hockey players achieve have been measured to be above 45 kilometres per hour. (International Ice Hockey Federation 2014)

Ice Hockey game consist from three 20-minute periods and from a possible overtime and shootout competition if the game is tied, overall game time being 65 minutes. However, depending on the rules the game can be played in overtime as long as other team scores, making the longest games to be over 176 minutes. The time that one player is on ice varies from 30-80 seconds, average shift being approximately 45 seconds. (International Ice Hockey Federation 2010)

Ice hockey demands versatile set of skills from a player. Technical, tactical, physical and psychological skills are needed to play the game. Technical skills can be divided into four categories: Skating, passing, shooting and stick-handling. Skating can be considered as the most important technical skill in Ice Hockey. (Laaksonen 2011a, 10.)

Ice Hockey is physically demanding game. Aerobic and anaerobic energy output systems need to be well trained to meet the demands of the game. To be effective anaerobic energy output require good aerobic capacity. Ice hockey also requires enough lean mass and exceptional muscular strength and force output. (Laaksonen 2011a, 10.)

Both aerobic and anaerobic energy output systems are involved in every shift. Anaerobic glycose is responsible for producing 60-70% of the energy needed in one shift. This percentage can be higher or lower, depending on the level of the game (regular seasons, playoffs), the intensity of the game, role of the player and physical condition of the player. For maximal efforts, for example acceleration and shooting, high-energy phosphates (ATP, CP) are required. This energy output system only last approximately 5-6 second per time. Aerobic energy output system is responsible for player recovery after shift. (Tiikkaja 2002; Huovinen 2009; Hirvonen et al. 1987)

There are three different basic types of skating: Forward skating, backward skating and crossover skating. The core elements in all of the skating types are posture, kick, glide and return. Forward skating is the most common type of skating in ice hockey. (Laaksonen 2011a, 10.)

Skating is a demanding movement for hip, knee and ankle. Therefore, the maintenance of lower extremity joints and muscles is important. Skating biomechanical studies have shown that one forward skating kick phase consists from hips extension and outer rotation, knee extension and ankle plantarflexion. Return phase consist from hip flexion and inner rotation, knee flexion and ankle dorsiflexion. Gluteus maximus is mainly responsible to produce force for skating movement. The fast extension of knee joint is produced by fast activation of rectus femoris and vastus medialis. (Pearsall et al. 2000)

3 Functional Movement Screen

Functional Movement Screen (FMS) was created to recognize asymmetries and quality of fundamental movement patterns. By evaluating the movement patterns the risk to obtain injury can be screened. FMS has seven basic movement tests to screen the movement and three clearing tests to indicate pain. FMS screen examines the movement and motoric control in movements that doesn't require any specific skills. Tests are scored using a scale ranging from 0 to 3, 21 points being the highest score after the test are calculated together (Cook et al. 2010, 73). Studies have shown that total score lower than 14 points indicate that risk to be injured is higher compared to total score above 14 points. (Kiesel et al. 2007)

FMS patterns use movements that place tested person in position where weaknesses, imbalances, asymmetries and limitations become noticeable. The movements are simple and practical to perform, but still challenging with basic, manipulative and stabilizing movements. (Cook et al. 2010, 73.)

FMS tests are used in several professional sport leagues, including National Football league, National Basketball Association and also in National Hockey League. FMS test have been attached to NHL combine tests, where top 100+ 17-19-year-old ice hockey players are tested in different physical and medical tests.

3.1 Functional Movement Screen tests

Functional Movement Screen tests include seven movements that test fundamental movement patterns, and three clearing tests that test if the participant suffers pain in upon the movement. The seven tests that test fundamental movement patterns are deep squat, hurdle step, inline lunge, shoulder mobility reaching, active straight leg raise, trunk stability push up and rotary stability test. Three clearing test are used to examine if participant suffers pain upon different movement. Clearing test are impingement clearing test, spinal extension clearing test and spinal flexion clearing test. (Cook et al. 2010, 87.)

3.1.1 Deep Squat

The deep squat pattern is used to examine participant's extremity mobility, postural control and pelvic and core stability. While performed correctly deep squat demonstrates fully coordinated extremity mobility and core stability, while hips and shoulder are functioning in symmetrical positions. (Cook et al. 2010, 90-91.)

Deep squat is not often required in everyday life, but its functions create base to many other movement patterns, and the basic components of deep squat are required in many other movements. Deep squat test is used to test bilateral, symmetrical, functional mobility and stability of the hips, knees and ankles. (Cook et al. 2010, 90-91.)

The dowel held on overhead calls on bilateral, symmetrical mobility and stability of the shoulders, scapular region and the thoracic spine. The Pelvis and core must establish stability and control throughout the entire movement to achieve the full pattern. (Cook et al. 2010, 90-91.)

Deep Squat 3 Front View

Deep Squat 3 Side View

3.1.2 Hurdle Step

The hurdle step movement test participant's locomotion and acceleration abilities. Hurdle step challenges the body's step and stride mechanics while exposing asymmetries or compensation in stepping functions. Balance, coordination and stability in a single-leg stance are required while performing stepping motion. (Cook et al. 2010, 92-93.)

The proper movement requires coordination and stability between the hips when one is bearing the load of the body while other is moving freely. Excessive upper body movement is not seen when proper mobility, stability, posture and balance are available and functioning. Excessive upper body movement can be taken as a compensation. (Cook et al. 2010, 92-93.)

Hurdle Step 3 Front View


Hurdle Step 3 Side View

3.1.3 Inline Lunge

The inline lunge movement tests body's functioning in deceleration and direction change movements that occurs in many activities and sports. Although more movement in the inline lunge test takes place than what takes place in normal activities, the test gives a good look to body's left-right functions in the basic pattern. The Inline lunge pattern tests balance in narrow position, continued dynamic control of the pelvis and core within an asymmetrical hip position equally sharing the load. (Cook et al. 2010, 94-95.)

The Inline lunge pattern repeats the natural counterbalance where lower and upper extremities complements each other, lower extremities being in a split-stance position while upper extremities are in opposite or reciprocal pattern. The inline lunge test also challenges hip, knee, ankle and foot mobility and upper extremities multi-articular muscles. (Cook et al. 2010, 94-95.)

Inline Lunge 3 Front View

Inline Lunge 3 Side View

3.1.4 Shoulder mobility reaching

The shoulder mobility reaching pattern tests upper-extremity shoulder movements in each of the segments range of active control while leaving very little room for compensation. When the compensation is removed the movement ability of upper extremity can be clearly seen. (Cook et al. 2010, 96-97.)

The shoulder mobility reaching pattern observes bilateral shoulder range of motion. Extension, internal rotation and adduction can be viewed in one extremity, and flexion, external rotation and abduction can be viewed in the other. (Cook et al. 2010, 96-97.)

Shoulder Mobility 3 Right

Shoulder Mobility 1 Right

3.1.5 Impingement clearing test

The impingement clearing test only test participants pain response to movement. If pain is produced in this movement the score of zero is given to the entire shoulder reach test. (Cook et al. 2010, 96-97.)

Active Scapular Stability (Shoulder Clearing Test)

3.1.6 Active straight-leg raise

The active straight leg-raise pattern identifies the active mobility of the flexed hip and the available extension of the alternate hip. Active straight leg-raise also includes the initial and continuous core stability. (Cook et al. 2010, 98-99.)

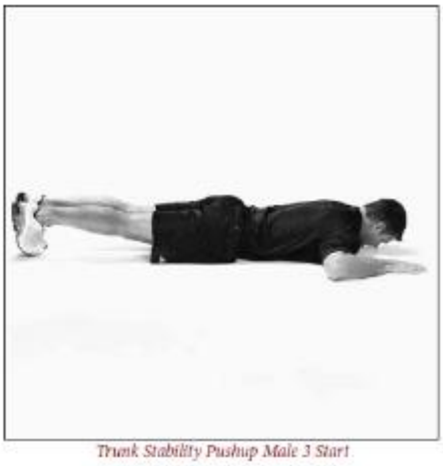
Gluteus maximus/iliotibial band complex and the hamstring are usually the structures where flexion limitations can be seen, and iliopsoas and other muscles of pelvis are structures where extension limitations usually can be seen. With active straight leg-raise the ability to dissociate the lower extremities while maintaining stability in the pelvis and core can be challenged and observed. Also, active hamstring and gastroc-soleus flexibility while maintaining a stable pelvis and active extension of the opposite leg can be challenged and observed. (Cook et al. 2010, 98-99.)

The active straight leg-raise is an evaluation of the ability to separate the lower extremities in an unloaded position more than the flexion of a hip on the one side. (Cook et al. 2010, 98-99.)

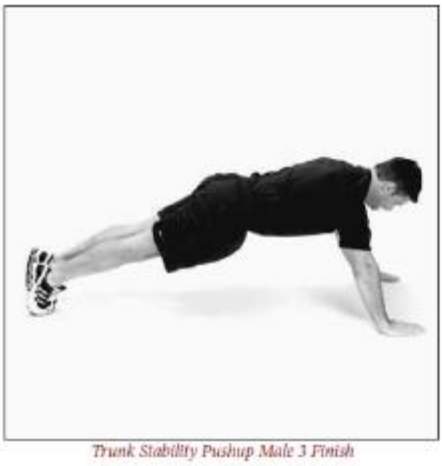
Active Straight-Leg Raise 3

3.1.7 Trunk stability push up

The push-up movement pattern tests the ability to stabilize the spine in the sagittal plane during the closed kinetic chain, upper body symmetrical pushing movement. The trunk stability push-up pattern tests core stabilization more than it tests upper body strength. In the trunk stability push-up, the purpose is to initiate movement with upper extremities without allowing movement in the spine or hips. The ability to stabilize the spine in the sagittal plane during closed kinetic chain in upper body symmetrical pushing movement can be evaluated in the trunk stability push-up pattern. (Cook et al. 2010, 100-101.)



Trunk Stability Pushup Male 3 Start



Trunk Stability Pushup Male 3 Finish

3.1.8 Spinal extension clearing test

At the end of the trunk stability push-up test the participant performs a spinal extension clearing exam. The clearing exam is not scored, only pain response is observed. If the movement produces pain response to the participant the score of zero is given to the entire press-up test. (Cook et al. 2010, 100-101.)

Spinal Extension Test

3.1.9 Rotary stability

The rotary stability pattern observes multi-plane pelvis, core and shoulder girdle stability during a combined upper- and lower-extremity movement. This pattern is complex, requiring proper neuromuscular coordination and energy transfer through the torso. It has as its roots the creeping pattern that follows basic crawling in our development sequence. The test has two important implications. It demonstrates reflex stabilization and weight shifting in the transverse plane, and it represent the coordinated efforts of mobility and stability observed in fundamental climbing patterns. (Cook. et al. 2010, 102-103.)

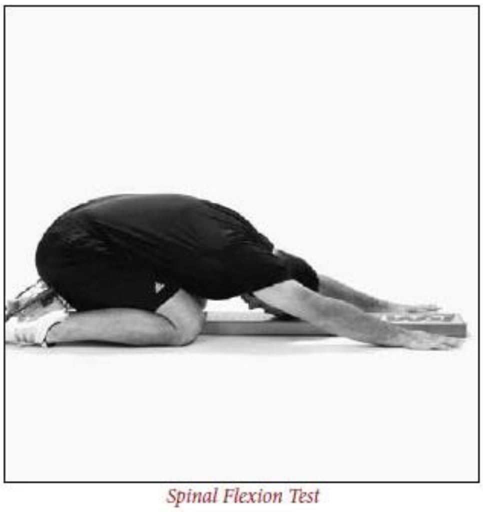
The rotary stability pattern requires proper neuromuscular coordination, balance and energy transfer through the torso. The weight shifting and reflex stabilization in the transverse plane can be seen in this test. Also, the coordinated efforts of mobility and stability in fundamental climbing patterns can be observed. The rotary stability pattern is a complex, combined upper- and lower-extremity movement. Multi-plane pelvis, core and shoulder girdle stability can be observed during the test. (Cook. et al. 2010, 102-103.)

Rotary Stability 3 Extension

Rotary Stability 3 Flexion

3.1.10 Spinal flexion clearing test

At the end of the rotary stability test the participant performs a spinal flexion clearing exam. The clearing exam is not scored, only pain response is observed. If the movement produces pain response to the participant the score of zero is given to the entire press-up test. (Cook et al. 2010,102-103.)



Spinal Flexion Test

4 Injuries in ice Hockey

Ice hockey is high speed collision sport, with high risk of injuries. Injuries in ice hockey may occur by collision (hit, stick, puck, surface) or the injury can be non-contact injury. Injuries in ice hockey have been researched in many studies, but injury studies mostly concentrate on collecting information about ”what and why” type of injuries occur in ice hockey. The physiological reason behind the injury is not often studied.

The most common injury location and type of injury cannot be determined because of different results in different injury study. Different injury studies have different results depending on the level of participation, player position, game versus practice exposure, protective equipment, violent behavior, and personal susceptibility due to pre-existing injury and style of play.

Tuominen et al. (2014) studied men’s international hockey during a seven-year period. Data was collected from International Ice Hockey Federation World Championship Tournaments and Olympic Winter Games. Tuominen’s study shows that 528 injuries were recorded. From these 162 cases (30.7%) were lower extremity injuries and 115 cases (21.8%) were upper extremity injuries. 210 cases (39.8%) were located to head and face, but from these 210 cases 74.3% were lacerations caused by a stick and therefore easily prevented by full face protection.

According to Tuominen’s (2014) study, from lower body injuries the knee was the most common injury site. 49.6% of the 162 lower body injury cases affected the knee. Ankle and thigh injuries were second and third common lower extremity injuries. Shoulder was the most common upper extremity injury. Approximately 50% of upper extremity injuries were located to shoulder. (Tuominen et al. 2014)

Studies have also shown that professional ice hockey and soccer players are predisposed also to adductor muscle strain, 10% to 11% of all injuries being groin strain. Hip muscle weakness, previous injuries in lower extremities, preseason practicing and level of experience have been linked to these injuries. By identifying the weaknesses in movement the injuries might be able to be prevented. (Tyler et al. 2010)

Contact-related injuries occur most often in games and in second period. Different results have been collected in different studies, but lower limb injuries appear to be in majority in injuries. (Tuominen et al. 2014)

Listola (2013, 12) have collected statistics about non-contact injuries in ice hockey, which is shown in Table 1.

Table 1. Ice Hockey injury studies, where overuse and non-contact injuries have been descripted in percentages of all injuries. (Listola 2013, 12.)

Study	Country, Level	Overuse and Non-contact injuries
Daly et al. (1990)	Summary	Non-contact injuries 17,9 %
Dick (1993)	USA (University)	Non-contact injuries 20 %
Stuart ja Smith (1995)	USA (17-20 y.)	Repetitive strain injuries 9 %
Voaklander ym. (1996)	Canada (amateur hockey)	Non-contatc injuries 14 %
Pinto ym. (1999)	USA (16-20 y.)	Repetitive strain injuries 13 %, Non-contact injuries 8 %
Ferrara ja Schurr (1999)	USA (University)	From all injuries (n=113), Repetitive strain- or Non-contact injuries 40 % (n=45),
Gröger (2001) Saksa	A/B National Teams	Non-contact injuries 3,4 %
Flik ym. (2005)	USA (University)	Repetitive strain injuries 8 % (Third common injurymechanism)
Agel ym. (2007)	USA (University)	9,7 % from game injuries and 32 % from practice injuries Non-contact injuries
Kuzuhara ym. (2009)	Japani	From Injuries during practice 40 % (n=52) Rishiraj et al. (2009) Canada (University) Repetitive strain injuries 8 %

OP-Pohjola's insurance statistics show, that overall 2144 accident cases were compensated in Finnish ice hockey in 2012. 851 of these were located in lower limbs and 733 were located in upper limbs. 651 of these were muscle- or tendon strain, 372 were contusions, 361 were bone fractures and 180 were joint sprains. OP-Pohjola's insurance statistics are shown in Table 2. and Table 3.

Table 2. OP-Pohjola insurance company's statistic about compensated injuries in 2012. (Koski. Feb 2016)

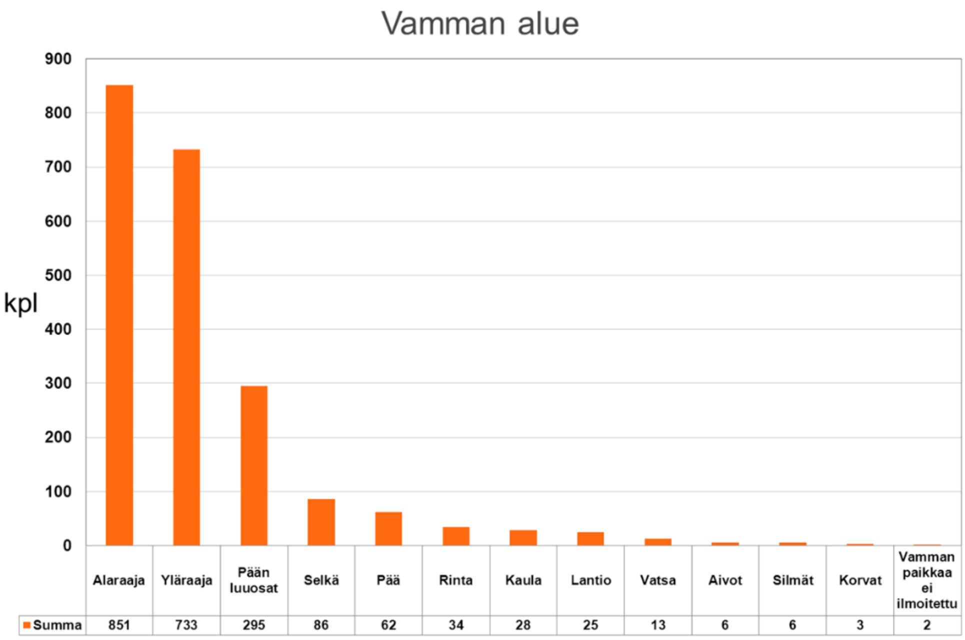
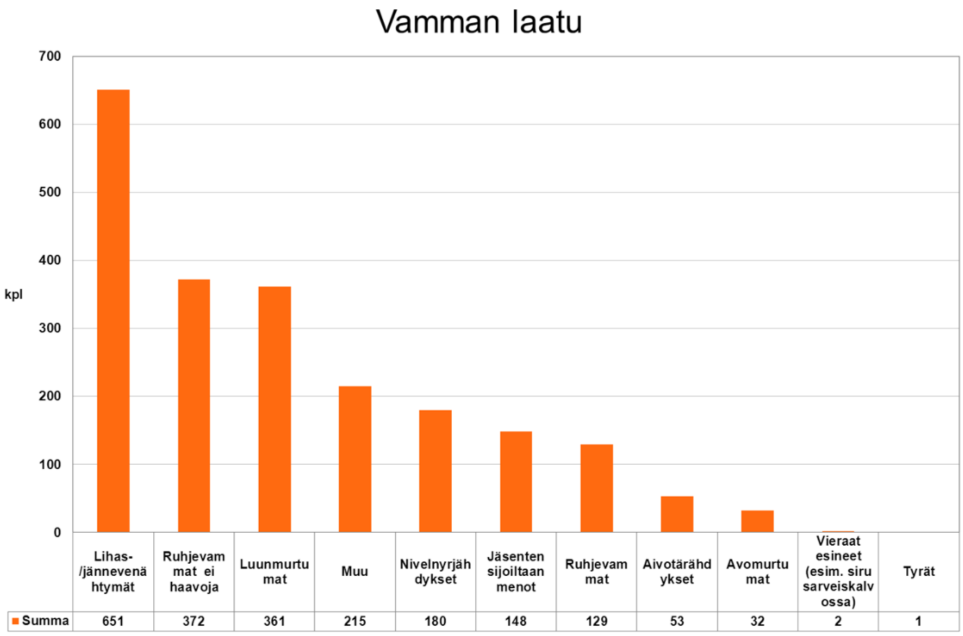


Table 3. OP-Pohjola insurance companys statistic about compensated injuries in 2012. (Koski. Feb. 2016)



4.1 Traumatic Injuries

Traumatic injury occurs usually by contact to other player, puck, stick or ice surface. In traumatic injuries external force usually applies to body, resulting tissue damage. Traumatic injuries are usually unpredictable and therefore the injury mechanism is challenging to study. (Listola 2013, 12.; Fuller et al., 2006)

Most of the injuries in ice hockey are traumatic injuries. Depending on the study, approximately 60-85% of the injuries in ice hockey are traumatic injuries.

4.2 Overuse Injuries

Overuse injuries can be divided to two categories, low-force repetitive stress injuries and Overstress injuries (Listola et al. 2013). Depending on the study, approximately 15-40% of injures in ice hockey are overuse injuries.

4.2.1 Low-force repetitive stress injuries

Low force repetitive stress injuries are usually seen in endurance sports such as running. These type of injuries cause micro trauma which leads to injuries. In ice hockey low force repetitive stress injuries have been occurs off-season when the training environment changes from ice practicing to off-ice practicing. (Listola. 2013, 13.)

4.2.2 Overstress injuries

Overstress injuries occur usually in fast paced sports during a rapid body movement when high force is applied resulting in tissue damage. Knee and groin injuries are common overstress injuries. In ice hockey rapid change of direction is a major risk of injury. According to Listola's (2013, 47.) study, hip/groin injuries were the most common overuse injuries in 15-19 old ice hockey players.

4.3 Lower extremity injuries

Lower extremity injuries occur to be common injury site in ice hockey. Hip, Knee ankle suffer from contact and non-contact related injuries. Common injuries in lower extremities are for example femoroacetabular impingement, hip pointers, quadriceps contusions, medial collateral ligament, anterior cruciate ligament and high and low ankle sprains. (LaPrade et al. 2014, 4-10.)

4.4 Upper extremity injuries

Upper extremity injuries usually occur in contact. Shoulder injuries are most often caused by contact with other player and/or boards. (LaPrade et al. 2014, 4.)

5 FMS in ice hockey

FMS has already been included to some ice hockey programs. Approximately 18 National Hockey League teams utilize FMS in some format, and FMS has been in NHL Entry Draft Combine (NHL Combine) program for past six years.

NHL Combine gathers every year 111 top level junior ice hockey players around the world to be tested in different physical and physiological fitness test, such as medical evaluations. Players also perform FMS tests during the evaluation. In 2013 NHL Combine FMS tests show that the participants mean score in FMS deep squat test was 2.0. 97 players performed the FMS tests, and in deep squat test none of the participants scored the score of zero, 11 participants were evaluated by the score of one, 68 participants were evaluated by the score of two and 9 of the participants were evaluated by the score of 3. These result are similar to the results gathered from Finnish Pohjola-Camp. (Rowan et al 2015; Laaksonen 2016b)

Variation of the deep Squat movement test has also been made for 16-year old players in Finnish Pohjola- camp. In this deep squat test, the ankle, back and shoulder is scored separately from 1-3 points, three being the best. Points are than counted together nine being the overall top score. Test results from 2015 and 2014 Pohjola-camps (Table 4.) show that overall movement in deep squat is slightly above good, test results being 6.68 in 2015 and 7.31 in 2014. Test are not evaluated by professional personnel which affects to the test results. (IIHCE 2015)

Table 4. Finnish Pohjola camp test results (Laaksonen. Jan. 2016b)

Deep Squat test result			2015	2014		mean 2015		mean 2014	
						6.68		7.31	
Etelä 1			5,72	6,76					
Etelä 2			6,19	8					
Keskimaa			6,28	8					
Savo-Karjala			6,82	7,11					
Pohjoinen			6,67	7,56					
Lappi			7,39	6,94					
Kymi-Saimaa			6,18	7,17					
Häme			7,61	6,94					
Länsirannikko			7,33	7,39					

In Parenteau's et al. (2013, 174.) research FMS was noted to be reliable study for young ice hockey players to predict players risk of injury. In this Parenteau's study inter-rater and intra-rater reliability among young ice hockey players was determined. The test results were differ compared to the NHL Combine test results, but Parenteau's study's participants were between 13- to 16-year-old players, whereas NHL Combines test participants are between 17- to 19-year-old ice hockey players.

Table 5. 2013 NHL combine FMS test results and Parenteau's (2013) study's FMS test results.

FMS Test	**NHL Combine (17-19 year old players)**						**Parenteau's et al. research (13-16 year old players**				
	Score						**Score**				
	0	**1**	**2**	**3**	**Mean ± SD**		**0**	**1**	**2**	**3**	**Mean ± SD**
Deep Squat	0	11	68	9	2.0 ± 0.48		6	1	13	8	1.82 ± 1.09
Hurdle Step	0	1	76	11	2.1 ± 0.4		1	0	12	15	2.46 ± 0.69
Active straight leg raise	0	1	59	28	2.3 ± 0.50		5	9	11	3	1.43 ± 0.92
Rotary stability	2	1	84	1	2.0 ± 0.3		1	1	24	2	1.96 ± 0.51
In-Line Lunge	0	0	45	43	2.5 ± 0.5		4	3	9	12	2.04 ± 1.07
Trunk Stability push-up	8	0	20	60	2.5 ± 0.9		15	0	5	8	1.21 ± 1.37
Shoulder mobility	9	12	45	43	2.0 ± 1.0		6	4	10	8	1.71 ± 1.11
FMS Total Score					15.2 ± 2.5						12.64 ± 3.65

Studies have shown that asymmetries and imbalances in body have effect on injuries (Knapick et al. 1991; Nadler et al. 2001). FMS tests can reliably be used to detect the asymmetries and imbalances in athlete's body, and athletes practicing can be planned to direction where non-contact injuries could be more probably avoided. By identifying the most common non-contact injuries in ice hockey and using FMS tests connection between the injuries and problems in ice hockey player's mobility could be found with proper testing. (Cook et al. 2010, 15-17.)

6 Preventing injuries

The best treatment for sport injuries is the prevention. Ice hockey is a dangerous game, and injuries cannot be completely eliminated. The chance to get injury depends on many variables: the level of participation, player position, game versus practice exposure, protective equipment, violent behavior, and personal susceptibility due to pre-existing injury and style of play. Knowledge about injuries, sport-specific conditioning and preventative programs are important for coaches and athletes (Stuart 2003).

Even if the injuries cannot be completely eliminated, the risk of injury can substantially be reduced. Different ways to try to prevent injuries can be used, general physical preparedness being the biggest factor. Muscle weakness, fatigue, limited movement abilities, compensations in movements and asymmetries in body can cause injuries (Kiesel et al. 2009). Screening the player's physical condition can identify existing injuries and undercover deficiencies. To be noted, a screening should be done by experienced athletic trainer or physician.

When considering athlete's health, a sport-specific injury analysis can be used when planning athlete's training program. van Mechelen's (1992) injury analysis consists four sequences:

1. The commonness and severity of the injuries
2. Screening the mechanism and risk factors of the injuries
3. Selecting and initializing the methods to prevent injuries
4. Evaluation of the effectiveness of the chosen methods

(van Mechelen 1992)

Sport-specific injury analysis is a useful tool when improving physical condition. Physical training program is an effective way to decrease risk of injury, but it can also be a risk increasing factor. Training programs should be done by professionals to meet the needs of an individual. Planning the program should start from individual's abilities. Basic movement abilities come first, muscle stabilization comes second and improvement of physical condition and muscle strength comes third. (Cook et al. 2010, 263-269.)

Preparation for the activity plays an important role. Warm-up routines prepares the body for the upcoming activity, and can prevent injuries. Dynamic agility movements can decrease risk of soft tissue injuries such as muscle strains. Sport-specific warm-up routine can improve athlete’s mobility which reflects to athlete’s sport-specific skills. (Wood et al. 2007; Cook et al. 2010, 73.)

Other important factors when preventing the injuries in ice hockey are development and usage of proper equipment, rules of the game and general sportsmanship in the game. Educating the coaches, players and parents to respect the game can reduce injuries.

Ice hockey injuries are a researched field, and the results should be taken under view to understand the risks better and implement the preventative measures. Equipment development prevents some injuries, but might also be a causing factor. More research is needed about the injuries, especially contact based injuries, to find the preventative measures.

7 The aim of the project

The study view for this project was to try to show the connection between ice hockey player's movement abilities and injuries in ice hockey. By going through previously done ice hockey injury studies (Tuominen et al. 2014; Tegner & Lorentzon 1991; Petterson & Lorentzon 1993; Listola 2013; LaPrade et al. 2014; Koski 2016; Fuller et al., 2006) and comparing the most common injury locations to movement tests performed by ice hockey players a possible connection between movement and injuries could be found, and a preventative guide for lower body mobility could be made. The preventative guide for lower body mobility was based on FMS.

7.1 The planning of the project

The idea for the project became from HAAGA-HELIA Degree programme in Sports and Leisure Management teacher Mika Vähälummukka during spring 2015. The project idea was to find out if FMS movement pattern test could be a useful tool for coaches to use to locate limitations in player's movement, and what can the coaches do when the problem is located. Ice Hockey players are tested in different ways since they are 10-12-year-old, and a lot of different test results are available. Ice hockey injuries is also widely researched subject. Still there is no simple guide to identify bad mobility in a player's movement and instructions to how to fix the problem.

I have found myself to have relatively good movement abilities, but I have noticed that quite many of the hockey players I have coached and played with have a lot of limitations in their movement. Especially groin problems have been common in the teams I have been in.
Being involved in Ice Hockey over twenty years have given me a quite good view of ice hockey players dysfunctions.

First step was to find information about FMS and if it is already in use in ice hockey. Second step was to find out information about ice hockey injuries, movement test results among ice hockey players and possible connections between movement problems and injuries. Third step was to FMS guide for coaches to locate and then create a guide to fix the problems their players have in lower extremity movements. Out of these three steps the second one demanded most work due to the vast nature of the topic.

Functional Movement Screen was chosen for this project because it is not widely used in Finland. It is simple and reliable (Cook et al. 2010, 73.; Onate et al. 2012) test product to find imbalances in one's body. Similar type of testing has been previously used, so there was also quite matching test results available.

During the project I noticed that FMS has been taken into program in approximately 18 National Hockey League teams, and in NHL Combine program. NHL player's test result were not available, which would have given valuable information about professional player's mobility and movement. Some NHL combine test results were available and I compared those results to Parenteau's study's results to get larger group of players. Comparing FMS results to Pohjola-camp deep squat results gave a quite good view about young ice hockey players movement abilities.

Next step was to analyse ice hockey injury researches. The subject is well researched, but the results of the study depends on the players and the level of the game. The results varied a lot in different studies. Skating is the most important skill in Ice Hockey, and lower body injuries are either in majority or includes half of the injuries in most of the researches the lower body injuries were taken subject of the guide. By the results found from injury studies the lower extremity injuries, especially hip/groin injuries, was found to be a probable area to be injured. Also, the previously done movement tests for ice hockey players (Rowan et al. 2015; Parenteau et al. 2013; Laaksonen 2016b) show that lower extremity movements are area that needs improvement.

After finding that lower extremity mobility needs improvement among ice hockey players a guide for developing movement in lower extremities was made. The guide needed to be simple and useful for ice hockey coaches so they can easily locate the problems their players have, so the things that coaches need was considered while building the guide. Coaches need a tool to:

1. Locate the problem their players have

2. Have a tool how to fix the problem

The guide has three tests how to locate problems in lower extremity mobility and instructions how the test should be performed and screened. When the problem is located the guide has 13 mobility movements and 9 muscle stability movements that might help to fix the problem, depending on the problem.

The Deep squat test, inline lunge test and active straight leg raise test was chosen for the test movement to the guide. These tests are easy to execute and doesn't require any special equipment's. These movements are also described in three different terms of: good, mediocre and bad. The meaning of this is to give the coach a tool to recognize the movement of the player performing the movement. After recognizing what type of movement the player has, the guide gives possibilities what the problem might be and movements how to fix the problem.

The project lasted totally 12 months. Idea for the project came in spring 2015, and the next summer was spent for gathering information about FMS, Ice Hockey injuries and functional training in sports. In autumn 2015 I started to put pieces together from the material I had gathered, and I also started to write this thesis. In January 2016 I started to search the proper movements for the guide based on the results of this thesis, and in March and April 2016 the photos for the guide was taken and the guide was created. When I started this project the idea was to be ready in December 2015, but changes in my personal life postponed the project.

7.2 Project outcome

The project outcome is a 29-page guide with instructions to lower body mobility movement that can help prevent injuries and improve athlete's performance. The guide has 13 lower body mobility movement and 9 lower body muscle stability movements, combined 21-movements and instructions how to perform the movement.

The guide is written in English so it is more usable than Finnish written guide. The main goal was to find the movements and muscle groups that are used in ice hockey (especially in skating), find moves how to test the movement and find possible limitation and corrections to those limitations. The guide was planned to be easy to read with pictures to help the coaches to recognize bad movements. The guide should be useful for coaches to prevent injuries and also help their player's to become better athletes. Having good movement abilities have effect to on-ice performance, for example skating (Laaksonen 2011a).

Original idea was also to create video-guide of the movements, but due to the timetable only paper version with pictures was made. For further studies among FMS I suggest building an online-page with video-guide-material about tests and corrective movements, since seeing the movements in action makes the basic principles more understandable. This demands, however, knowledge about the FMS´s copyrights.

7.3 The implementation of the project

The development has been long and slowly advancing project. The guide has not been taken into use by any coach yet and the usefulness haven't been tested, but in my own coaching career I have used similar movements to develop player's mobility and movement abilities and I found the movements very useful. General movement improved and via this skating improved. According to study results improving mobility could have injury preventing effect, and I would like to continue this project with test group.

Similar type of guides has been made before. Quite many of the guides concentrate on stretching or different routines. The movements in this guide concentrate on developing mobility and stability in lower extremities, that would hopefully prevent some injuries, and also develop player's sports-specific skills and overall athleticism.

8 Discussion

It is very probable to get injured in Ice Hockey. The injuries can be seen as ''part of the game'' due to the nature of the sport. The previously made studies about injuries in ice hockey shows that injuries in lower extremities and especially in hip and groin area are common. Previously done movement testing for ice hockey players indicate that problems in hip, knee and ankle mobility and stability are common in ice hockey. Therefore, it is valid to say that ice hockey players should develop their lower extremity mobility and stability to decrease the injury risk.

Like noticed before, injuries in hockey can be divided to two categories, traumatic and overuse injuries. Injuries in ice hockey is often studied subject, but due to the unpredictable nature of traumatic injuries these kind of injuries are difficult to study, except from the ''what has happened'' point of view. Overuse injuries can be studied and the risk of injury might be recognizable before the actual injury happening. Listola (2013) collected in his study non-contact injuries (Table 1.) in a table. These studies show that non-contact injuries are not majority in injuries.

Most of the injuries seem to occur in contacts (body, surface, stick, puck). Minority of the injuries occur non-contact, being overuse injuries or overstress injuries. Connection between player's movement abilities and injuries has been studied, and the test result show that having good movement abilities can have a reducing effect to injuries. Still, author of this report couldn't find any studies or research about connections between movement abilities and contact-related injuries.

According to different studies (Listola 2013; Tegner & Lorentzon 1991; Tuominen et al. 2014), there is a difference whether upper extremity injuries or lower extremity injuries are in majority. Depending on the study and the study group, from 10% to 40% of the injuries are overuse or non-contact injuries. Therefore, creating a precise sport-specific sport injury analysis is difficult and more emphasis is needed to injury studies.

Functional Movement Screen test have showed in studies to be reliable pattern of tests to predict the possibility of injury. The interrater reliability of the composite score for the FMS is reported to have an ICC value of 0.98 (Onate et al. 2012). FMS is already in use in National Hockey League, and it probably will spread to other leagues and organizations. Using FMS in Ice Hockey, and having a long-term surveillance about the results and injuries of the players, could give valuable information about how to reduce the injuries. Therefore, FMS can be considered as a useful tool for ice hockey coaches to test their player for injury prevention and sport-specific performance improvement.

Even though FMS movement tests are simple, the testing procedure needs to be professional and done correctly to receive reliable results. Therefore, the movement tests in the guide based on this thesis are only directive, they are not meant to be scored. The full FMS tests should not be done before proper education to the subject. Still, Functional Movement Screen test have showed in studies to be reliable pattern of tests to predict the possibility of injury, and it would be a useful to keep the player's in the roster rather than in the infirmary.

While analysing previously collected FMS test results performed by ice hockey players and analysing Pohjola-Camp results the limitations in squat movement can be seen. Limitations in squat movement refers for example problems in ankle dorsiflexion, hip flexion/extension, thoracic extension and/or glute activation. Limitations in these movement have also affect in player's on-ice skating performance (Laaksonen 2011a) The results are not totally comparable because of a little bit different posture and scoring system, but it gives a direction where to concentrate.

Sport-specific injury analysis could be in wider use in ice hockey. By creating an injury analysis and using it at the coaching material and coaching education the knowledge about injuries could increase and in a long term it could prevent some injuries. Injury analysis is not in use in any coaching material or coaching program of the Finnish Ice Hockey Association (FIHA 2016; IIHCE 2016). Using a sport-specific warm-up routines and movements could help prevent injuries. Studies have shown that warm-up can help reducing injuries, and more emphasis should be channelled there (Woods et al 2007).

The guide made by the results of this thesis is a one tool for that. The guide could give some new ideas and movements to improve skating and prevent skating based injuries. The original idea was also to make a video-guide from the movements, but due to a scheduling reasons the product was only done as a paper version. The videos of the movements would be easier to explain and understand then written word and picture.

Also, some compromises with the guide needed to be done. The whole FMS pattern tests could not be taken to the guide due to a copyright reasons, and also because I wanted to keep the guide easy to use. Therefore, there is no scoring of the movements, only the ability to perform the movement is measured. The lower body mobility and muscle stability movement are only introduced in the guide, there is no sets and repetition amounts because those need to be planned individually.

While ice hockey injuries are widely researched, more research about the reasons of injuries are needed to help preventing injuries. Especially connections between contact based injuries and player's mobility abilities would give valuable information when planning actions to prevent injuries. Improved knowledge of the mechanism of ice hockey injuries are also needed to develop better equipment and training programs.

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Appendices:

Guide for lower body mobility and stability movements to help prevent lower extremity injuries

Joni Leander, Haaga-Helia University of Applied Sciences

Degree in Sports and Leisure Management

TABLE OF CONTENTS

1. Introduction

This guide is based on HAAGA-HELIA Degree Programme in Sports and Leisure Management thesis, which studied connections between ice hockey player's movement and injuries. Studies show that lower extremity injuries are common in Ice Hockey, approximately 50% of the injuries occur in lower extremities.

This guide is created to help prevent lower extremity injuries. Dynamic lower body mobility movements and muscle stability movements presented in this guide are suitable and recommend to be performed before and after ice practice. Developing mobility and muscle stability can have effect on sport-specific performance and injury prevention.

The three test movements: Active straight leg raise, inline lunge and deep squat movement was selected for this guide to be a screening movement. These movements are part of Functional Movement Screen test movements, and the movements are easy to perform and doesn't require any special equipment. Differing from the FMS movement test, in this guide the movement tests are only directive, they are not meant to be scored. If your player feels pain performing the test movements, test should be stopped and the reason to pain should be examined by a doctor or physician.

Skating is a demanding movement for hip, knee and ankle. The lower body mobility and muscle stability movements presented in this guide were chosen to develop muscles and joints that work on skating. This guide consists pictures of the movement and instructions for the movement to help performing the movement right. There are no sets and repetition amounts for the movement, those need to be considered individually.

2. Common lower extremity injuries in ice hockey

- Low-back injuries
- Lumbar paraspinal muscle strain
- Groin strain
- Hip flexor strain
- Hip pointer
- Medial collateral ligament sprain
- Anterior cruciate ligament disruption
- Meniscus tears
- Ankle sprains

3. How to recognize possible risk factors

Instructions to testing movement abilities

- Test order: Active straight leg raise -> Inline lunge -> Deep squat test.
- As soon as you find problem in movement or asymmetries, don't test more.
- If there is pain in any of these movements, contact to doctor or physician

Active straight leg raise test

1. Good

2. Mediocre

3. Bad

Common leg raise problems

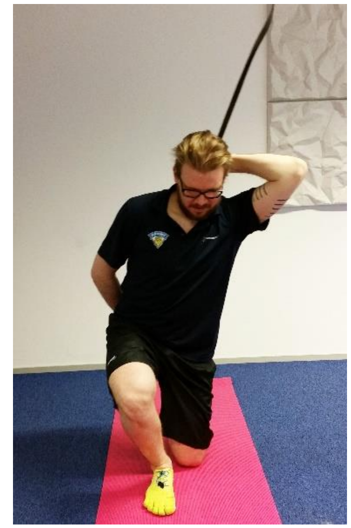
- Pelvis control problems
- Limited hip extension
- Poor functional hamstring flexibility
- When the pattern is correct, the non-moving limb demonstrates stability, an automatic task, while the moving limb demonstrates mobility, a conscious task.

Inline Lunge test

1. Good

2. Mediocre

3. Bad



Common lunge problems

- Ankle, knee or hip mobility problems
- Dynamic stability of the core muscles
- Limited mobility in the upper torso (for example lower back)

Squat Test

1. Good

2. Mediocre

3. Bad

Common Squat problems

- Limited mobility in the upper torso (back)
- Limited mobility in ankle, knee or hip (for example poor flexion of hips or knees
- Weakness and poor stabilization or control of the core muscles (for example knees turn inside - picture 3
- Tight hamstrings, hip adductors or hip abductors

4. What to consider when planning off-ice warm-up

Warming up can improve performance and reduce injury!!

The warm-up produces an elevation of body temperature that produces:

- Better oxygen delivery to muscle tissues
- Better chemical reactions that improve energy production and reduce fatigue
- Muscle blood flow and relaxation improves
- Nerve receptors sensitivity increases
- Ability of muscles and ligaments to absorb forces enhances
- Psychological preparation for the practice

- Always start warming up your muscles with activities like jogging, stationary bike, different games (football, handball, basketball…) etc.
- Dynamic vs. static movements
- Structure of the warm-up
- Specify the warm-up to be similar to the activity after warm, for example skating oriented ice practice -> plan the warm-up for legs and core

MOBILITY BEFORE STABILITY!

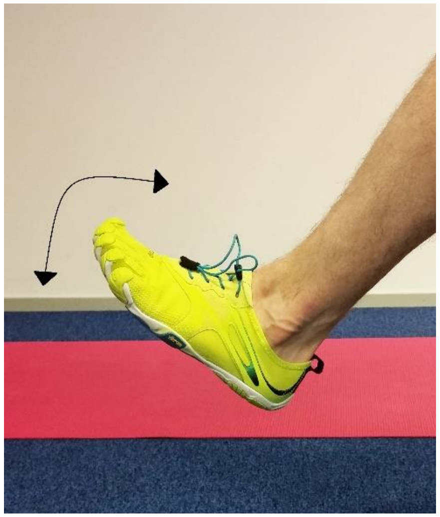
- **Mobility exercise** – focus on joint range of motion, tissue length and muscle flexibility – Targets basic freedom of movement
- **Stability exercise** – focus on basic sequencing of movement – targets basic motor control

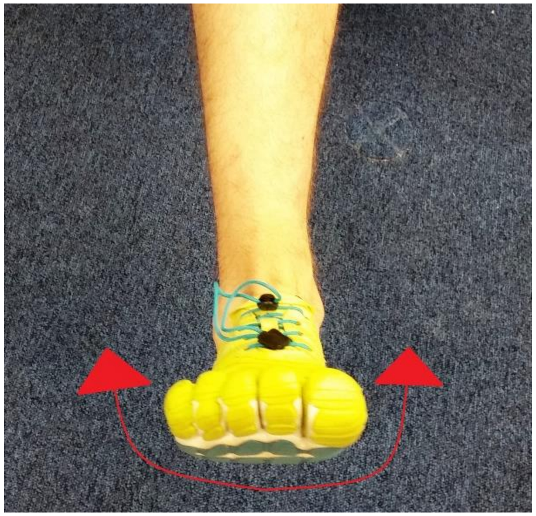
5. Warm-up and off-ice practice movements to develop lower body movement

1. Dynamic lower body mobility movements

Ankle

1. Ankle mobility exercise





Instructions:

1. Move your foot up and down.
2. Move your toes and foot sideways
3. Rotate your ankle (combination of the movements)

Effect: Ankle dorsiflexion, ankle plantarflexion, ankle inversion, ankle eversion

Variations: Perform in movement, combine stretching by using your hand to stretch the ankle, combine to other movements.

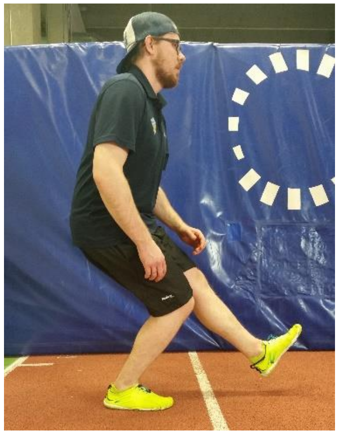
2. Ankle mobility exercise

Instructions:

1. Take inline lunge position, front leg toes forward
2. Put your hockey stick in front of your toes and knee
3. Start leaning forward, knee going over the stick inside your leg, heel staying on the ground, hold for 3-5 seconds
4. Use your core muscles to hold the posture
5. Lean back to start position

Effect: Ankle dorsiflexion, Ankle supination, hip extension, core stability

3. Clock Drill



Instructions:

1. Stand on one leg, other being off the ground
2. Keep your back straight, eyes looking forward
3. Hands on the side controlling balance
4. With free leg, reach first to 12' and 6', repeat 3 times
5. Reach to 3' and 9', repeat 3 times
6. Reach to 11' and 5' (standing on left leg) or 1' and 7' (standing on right leg), repeat 3 times
7. Every time reach as far as possible, bend you knee, knee and ankle stays on the same line

Effect: Ankle dorsiflexion, ankle inversion, ankle eversion, hip extension, hip adduction, hip abduction, core stability, balance

Variations: Combine this movement or parts of this movement to other movements

4. Ankle movement exercise with thigh stretching

Instructions:

1. Sit on the floor, legs together and straight, back straight, hands above you head
2. Take your toes forward as far as you can (ankle plantarflexion), then take your toes as close your body as you can (ankle dorsiflexion)
3. Take your toes forward as far as you can, then lean forward and take your hands as close your toes as you can, hold for 3-5 seconds

Effect: Ankle plantarflexion, ankle dorsiflexion, hamstrings, back mobility

Hips

5. Hip movement exercise with thigh stretching

Instructions:

1. Start from squat position, palms on the ground, heels up, standing on your toes
2. Start pushing yourself up, try to keep your head close to your knees
3. Keep your leg close together, put you heels on the ground and keep your palms on the ground
4. Push yourself up as far as you can, chest as close to your legs as you can, hold for 3-5 seconds and return to starting position

Effect: Hip flexion, ankle dorsiflexion, hamstrings, back mobility

6. Lunge with arm swing

Instructions:

1. Take a long step forward and bend down
    - Keep your foot, knee and hip on the same line
2. While going down swing your hands above your head
3. Return to starting position

Effect: Hip Flexion, hip extension, knee flexion, ankle dorsiflexion, balance

Variations: Backward lunge, perform in movement

7. Hip flexion on one foot

Instructions:

1. Stand on two legs, back straight, eyes looking forward
2. Lift your hands above your head
3. Lift your knee as close to your chest as you can, hold for 3-5 seconds
4. Return to starting position

Effect: Hip flexion, core stability, balance

Variations: Performing exercise in movement, combinations to other movement (for example lunge),

8. Leg Swings





Instructions:

- Stand on two legs, back straight, eyes looking forward
    1. Swing your opposite leg and opposite hand to forward and backward
    2. Swing your opposite leg and opposite hand sideways
    3. Hip rotation: Bring your knee up front -> turn your knee to side -> bring your leg back to ground
    4. Hip rotation: Perform step three backwards.

Effect: Hip flexion, hip extension, hip adduction, hip abduction, hip external rotation, hip internal rotation

Variations: Combinations of movements, performing in movement.

9. Side walking lunge

Instructions:

1. Stand on both legs, back straight, toes forward
2. Take a long step to side, bend yourself towards floor
    - Foot, knee and hip on the same line under the body
3. Hold for 1-3 seconds, return to starting position

Effect: Ankle dorsiflexion, Knee flexion, hip flexion, hip abduction, core stability

Variation: Side lunge with arm swing, Side lunge in movement, side lunge with cross-step

Back

10. Back movement exercise

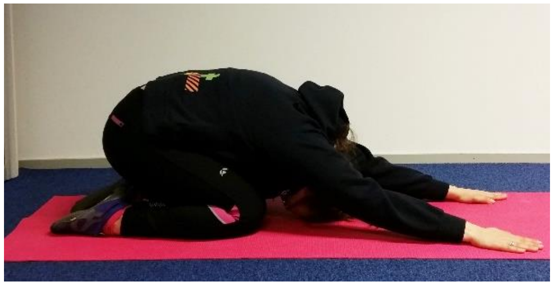
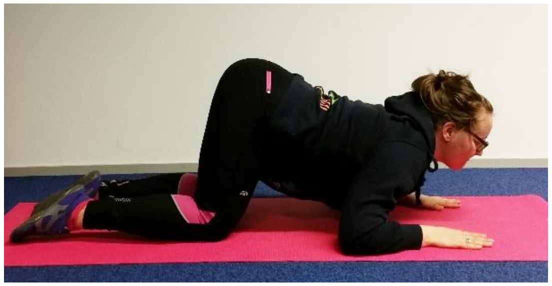
Instructions:

1. Take a crawling position. Ankles, knees and palms on the same line, back straight
2. Start flexing your back, hold for few seconds -> extend your back and hold for few seconds
3. Return to starting position.

Effect: Back flexion, back extension, low-back muscles

Variations: Combinations with other movement (for example ‟Cobra”)

11. Back movement exercise 2 – ‘’Cobra’’

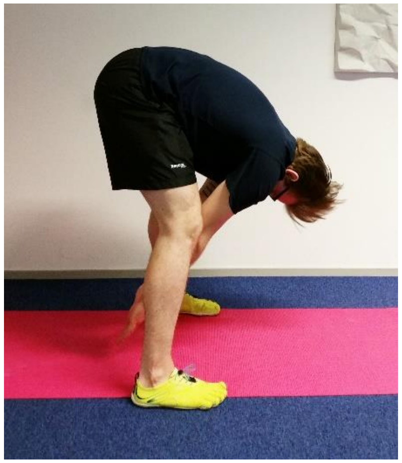
Instructions:

1. Take a praying position.
2. Push yourself up to half-crawling position -> start moving your upper body forward and chest to floor -> move your upper body forward and push your hips to ground.
3. Extend your back, hold for few seconds.
4. Reverse to starting position

Effect: Back flexion, back extension, hip flexion, hip extension

Variations: Combinations with other movement

12. Back movement exercise

Instructions:

1. Take a wide stance, bend your back and place your hands between your legs
2. Swing your hands forward, hold your hip position
3. Flex your back and swing your hand above hip height
4. Hold for 1-3 seconds
5. Return to starting position

Effect: Back extension

Variation: Combinations with other movements

2) Muscle stability movements for lower body

Hips and thigs

1. Side-lying clam exercise

Instructions:

1. Lie on your side hand on your pelvis, bend your knees, back straight and on the same line with heels
2. Start lifting your knee up, rotating your hip, keeping your feet together
3. Hold for 3-5 second and return to starting position.

Effect: Gluteus medius, deep lateral rotators

2. Lateral leg-raise

Instructions:

1. Lay on your side hand on your pelvis, back straight, bend your lower leg, upper leg stays straight, back and heels are on the same line
2. Start lifting your upper leg, keep the leg on the same line with back
3. Hold for 3-5 seconds
4. Return to starting position

Effect: Gluteus medius

3. Medial leg-raise

Instructions:

1. Lay on your side hand on your pelvis, back straight, lower leg extended straight to the side and the upper leg bent at 90 degrees with the foot flat on the ground behind the lower leg.
2. Raise the bottom leg so the bottom foot is 6-8 inches above the ground. Hold for 3-5 seconds
3. Return to the starting position.

Effect: Hip adductors

4. Straight leg raise flexion

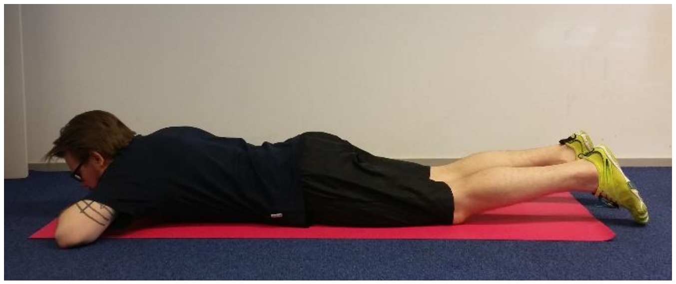
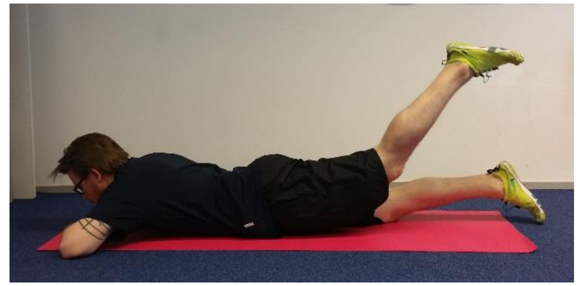
 

Instructions:

1. Lay on your back, spine neutral, legs in front of you, other leg straight on the floor and bend the other to 90-degree angle foot on the floor.
2. Slowly lift the straight leg off the floor.
3. Hold for 3-5 seconds.
4. Return to starting position.

Effect: Iliopsoas

5. Straight leg raise extension

Instructions:

1. Lay on your stomach, pelvis neutral, legs straight behind you.
2. Slowly lift your single leg off the floor.
3. Hold for 3-5 seconds.
4. Return to starting position.

Effect: Gluteus maximus, hamstrings

Back and abdominals

6. Dead bug

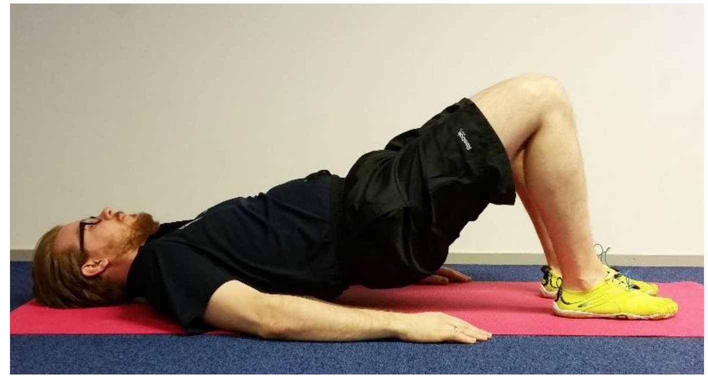


Instructions:

1. Lay on your back, knees bend on 90-degree angle, hands together between your legs, spine neutral.
2. Lift and flex your single leg off the ground.
3. Straighten your leg and bring your hands straight over your head.
4. Hold the position for 5 seconds.
5. Return to starting position.
6. Repeat 3-5 times per leg

Effect: Rectus abdominis, erector spinae

7. Bridge



Instructions:

1. Lay on your back, knees bend on 90-degree angle, spine neutral
2. Contract your abdominal muscles and lift your bottom off the ground approximately 5 cm.
3. Hold for 5-10 seconds
4. Return to starting position.

Effect: Rectus abdominis, erector spinae

8. Partial sit-up

Instructions:

1. Lay on your back, hands on your thigs.
2. Contract your abdominals and start lifting your shoulder and upper back off the ground, hands gliding on your thigs.
3. Lift your back until your hands touch your knees, back and neck stay straight.
4. Hold for 5-10 seconds.
5. Return to starting position.

Effect: Rectus abdominis, erector spinae

9. Plank with leg raise

Instructions:

1. Take a push up position.
2. Contract your abdominals to keep your back straight.
3. Start lifting your single leg, keep your back straight
4. Hold the position for 5-10 seconds
5. Return to starting position

Effect: Rectus abdominis, erector spinae

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