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## Does the FIFA 11+ prevention programme improve sprint time in adolescent elite male football players?

A randomized controlled trial

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# **ABSTRACT**

## **Introduction**

Sprinting is an important element of football and its importance to the sport is increasing. The total sprinting distance performed by any player during a football match average to 385+/-223 metres. Analysis of sprinting distances and duration from two UEFA Europa League seasons show that 90 percent of sprints were shorter than 5 seconds, whereas 10 percent were longer than 5 seconds. With the increasing demands to sprinting ability in football the susceptibility to injury also rise. Muscle injuries are the most common injury to the lower extremity in professional football.

The purpose of this study was to further investigate the results from the FIFA 11+ study “Including the Copenhagen Adduction Exercise in the FIFA 11+ Provides Missing Eccentric Hip Adduction Strength Effect in Male Soccer Players (Haroy et al., 2017)” in regards to sprint times. Through a randomised controlled trial these results are used to see if the FIFA 11+ can improve sprint performance in young elite football players. The correlation between sprint times and hamstring strength will also be explored in this master thesis. The theory behind the modern game of football and sprinting in football is a basis for this thesis, along with the principles of sprinting in the FIFA 11+ warm-up program, importance of hamstring strength in sprinting, how to improve sprinting in football and sprint related injuries.

## **Objective**

The overall aim of this project is to examine whether the FIFA 11+ with the Nordic Hamstring or Copenhagen Adduction exercise affects the sprint times in elite youth football players.

## **Methods**

This master thesis will look into the results of the changes in sprint time after an 8-week intervention program utilizing the FIFA 11+ warm-up program, a randomized controlled trial.

## **Main outcome**

Within- and between-group differences in sprint time (s) from baseline to post-test.

## **Results**

Between-group and within-group analyses showed no significant difference in sprint times at any sprint interval.

## **Conclusions**

The results from the present study could not produce any effect from the FIFA 11+ warm-up program on sprint times.

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## Clarification of concepts and definitions

11+	FIFA 11+, a preventative warm-up program developed by C-MARC and FIFA
CA	Copenhagen adduction, an adduction exercise developed by Serner et al. (2014)
NH	Nordic Hamstring, a hamstring exercise developed by Mjolsnes, Arnason, Osthagen, Raastad, and Bahr (2004)
Sprint speed	sprint velocity, running at a rapid tempo
Walking	speeds of 0 to 7.1 km per hour ( $\text{km}\cdot\text{h}^{-1}$ )
Jogging	speeds from 7.2 to 14.3 $\text{km}\cdot\text{h}^{-1}$
Running	speeds from 14.4 to 19.7 $\text{km}\cdot\text{h}^{-1}$
High intensity runs	high-speed running from 19.8 to 25.2 $\text{km}\cdot\text{h}^{-1}$
Explosive sprint	sprinting $\geq 25.2 \text{ km}\cdot\text{h}^{-1}$
Resisted sprint training	sprint training exerted against external loads
Free sprint training	sprint training without the use of external equipment
Weight training	strength training with weights
Reactive power	the power output to make a forceful movement on reaction

Time-to-stabilization	a dynamic to a static condition as a measure of dynamic stability involving both sensory and mechanical systems ensuring correct posture and body control (including leg alignment, knee-over-toe position and soft landing)
Neuromuscular-control	a complex interacting systems integrating different aspects of muscle actions (static and dynamic, concentric and eccentric), muscle activations, coordination, stabilisation, body posture and balance
Balance	an even distribution of weight enabling someone or something to remain upright and steady
Agility	the ability to think and understand quickly with the power of moving quickly and easily
Power	force-speed relationship

## 1. Introduction

The ability to sprint is an important quality for football players, and sprinting is an increasingly important element in the sport football. The total sprinting distance performed by any player during a football match average to  $385 \pm 223$  metres (Mallo, Mena, Nevado, & Paredes, 2015). Analysis of sprinting distances and duration recorded during the 2008-09 and 2010-11 UEFA Europa League seasons show that 90 percent of sprints were shorter than 5 seconds, whereas 10 percent were longer than 5 seconds (Andrzejewski, Chmura, Pluta, Strzelczyk, & Kasprzak, 2013). Forwards covered the longest sprint distances ( $345 \pm 129$  m), which was 9 percent longer than midfielders ( $313 \pm 119$  m) and 2 times longer than central midfielders ( $167 \pm 87$  m) (Andrzejewski et al., 2013). The average number of sprints found in research performed by Di Salvo et al. (2010) is somewhere between  $17,3 \pm 8,7$  for central defenders and  $35,8 \pm 13,4$  for wide midfielder. These data show that sprint activity per player per game can vary greatly depending on their position on the field. The number of explosive sprints was expectedly lower for all positions (Di Salvo et al., 2010).

With increasing demands of players' abilities to sprint in football the susceptibility to injury also rise. Muscle injuries are the most common injury to the lower extremity in professional football, representing 31 percent of all injuries between 2001- 2009 (Ekstrand, Hagglund, & Walden, 2011a, 2011b). Injury to the hamstring muscle group is the most common injury subgroup, representing 12-17 percent of all injuries and 37 percent of the muscle injuries in the same period (Ekstrand et al., 2011a, 2011b). Another muscle group that is often affected by muscle strain in football is the adductor group. This muscle group represented 23 percent of the muscle injuries found by Ekstrand et al. (2011a). The adductor group also represent 9 percent of all injuries and 21 percent of muscle strain injuries (Ekstrand et al., 2011b; Hallén & Ekstrand, 2014). In elite football 12-16 percent of all injuries are hamstring strains (Arnason, Gudmundsson, Dahl, & Johannsson, 1996; Ekstrand et al., 2011a). Through the last 13 years the occurrence of hamstring injury has increased by 4 percent annually (Ekstrand, Walden, & Hagglund, 2016)

Consequently, injury prevention programs are increasingly necessary in an effort to reduce the occurrence of sports related injuries. Since 2009 the Fédération International de Football Association have promoted the FIFA 11+ injury prevention programme worldwide in an attempt to reduce injuries in football (Bizzini & Dvorak, 2015; FIFA, 2007).

## 1.1 The FIFA 11+ prevention programme

The FIFA 11+ (11+) is an injury prevention warm-up program consisting of three parts. It involves a total of 15 exercises, which should be performed in a specified sequence at the start of each training session (Soligard et al., 2008). In short, the three parts are as follows:

**Part 1**, consists of running exercises at slow speed combined with active stretching and controlled partner contact.

**Part 2**, consists of six exercises focusing on core and leg strength, balance, plyometric and agility, each with three levels of increasing difficulty.

**Part 3**, consists of running exercises at moderate to high speed combined with planting and cutting movements.

A complete description of the 11+ is shown in Appendix A.

The 11+ has been confirmed by large randomised controlled trials (RCT) to significantly reduce injury susceptibility in young female football players, male Nigerian football players, American male football players and female and male amateur football players (Bizzini & Dvorak, 2015; Owoeye, Akinbo, Tella, & Olawale, 2014; Silvers-Granelli et al., 2015; Soligard et al., 2008; Steffen, Emery, et al., 2013). The Nordic hamstring (NH) exercise is implemented in this program to address the recurring problem of muscle injuries to hamstring muscle groups. However, the prevention program does not include any exercises specifically directed towards injuries to the adductor muscle group. The RCT for this thesis was therefore designed to address that matter.

Based on literature of sprinting this thesis will consider how football players can improve their sprinting abilities, and reflect on whether football players can learn from sprinters.

The purpose of this master thesis is to further investigate the results from the FIFA 11+ study “Including the Copenhagen Adduction Exercise in the FIFA 11+ Provides Missing Eccentric Hip Adduction Strength Effect in Male Soccer Players” (Haroy et al., 2017) in regards to sprint times. Through a RCT these results are used to investigate whether the 11+ can improve sprint performance in young elite football players. The correlation between the sprint times and hamstring strength will also be explored in this thesis. This master thesis was part of a larger RCT where the overall aim was to examine the hip adductor strength effect of the CA exercise. To our knowledge this is the first study to assess the CA in the 11+ setting.

## **1.2 Primary objective**

The overall aim of this RCT was to examine the sprint time after 8 weeks of intervention, with the use of the 11+ warm-up program with the Nordic Hamstrings (NH) or Copenhagen adduction (CA) exercise, by measuring time (s) at the time intervals of 0-5 m, 0-10 m, 0-15 m, and 0-20 m, in adolescent elite male football players.

## **1.3 Hypothesis**

H<sub>1</sub> - There will be a change in sprint time at follow up for adolescent elite male football players from the baseline testing.

H<sub>0</sub> - There will be no change in sprint time at follow up for adolescent elite male football players from the baseline testing.

## **1.4 Secondary objective**

The secondary objective in this project was to look into the correlation between the differences from the pre-test to the post-test in hamstring strength (N) and sprint times (s).

## **1.5 Thesis structure**

The introduction defines the thesis question as well as outlines the subject and clarification of concepts. There will be some background theory on the modern game of football, sprinting in football, a look into the theory behind sprinting in 11+, importance of hamstring strength and sprinting, how to improve sprint time in football and sprint related injuries in football in chapter 2.

Chapter 3 defines the method of this thesis with its inclusion and exclusion criterion, the statistical considerations and the ethical aspects, followed by Chapter 4, which describes the results of the 11+ RCT.

Chapter 5 will discuss the scientific findings and theory. The thesis rounds off with a conclusion on the study results.



## **2. Theory**

Sprinting is an increasingly important ability in modern football, and sprint time is therefore an essential measure for evaluating a football player's ability to sprint. This chapter includes the theory of modern football and development of sprint demands. How to improve sprinting ability in football is used as a basis for this thesis. The 11+ and sprinting in the 11+, hamstring strength in sprinting, theory of how sprinters train, and sprint related injuries are the main areas to be explored in this master project. In this section of the thesis, the development of football in regards to sprint demands will be considered with the aim to increase our knowledge of the above mentioned factors, to develop a greater understanding as to why the results of the 11+ study turned out the way it did.

### **2.1 The modern game of football**

In the past few decades there has been an increasing interest in match analysis in football. International match analysis provides important information on physical, tactical and physiological demands in this constantly evolving sport. According to a study by Bradley et al. (2009) there is a much higher running intensity and longer distance covered in the modern elite-standard English Football League than 30 years ago. These results are similar to what has been recorded in the Italian Serie A and the Spanish Primera Division (Di Salvo et al., 2007; Mohr, Krstrup, & Bangsbo, 2003). Between the 2007-2008 and the 2012-2013 seasons of the English Premier league the number of high intensity runs ( $19.8$  to  $25.2$   $\text{km}\cdot\text{h}^{-1}$ ) and explosive sprints ( $\geq 25.2$   $\text{km}\cdot\text{h}^{-1}$ ) in matches increased by 24-35 percent for all positions (Bush, Barnes, Archer, Hogg, & Bradley, 2015). This is in accordance with previous findings by Bradley et al. (2009), showing that physical requirements of the modern elite English League has evolved in regards to high-intensity running.

The increasing intensity in today's modern game of football can be explained by the tactical and physical evolvement (Bradley et al., 2009). In the 1997-1998 season of the English League, matches included more dribbling, passing, running with possession of the ball and crosses (Williams, Lee, & Reilly, 1999). Today, the English players are required to maintain a high level of activity to create space and receive passes or in high-pressure defence to regain possession of the ball even when not directly involved in the play (Bradley et al., 2009).

According to Dallal, Wong, Moalla, and Chamari (2010) elite players of the French First



League had individual ball possession per match ranging from 44.6-74.3 seconds and an average of 2 ball touches per individual possession. This shows that elite-level players are capable to perform repeated high-intensity actions, while having little ball possession. The players must be able to quickly realize tactical actions during a match (Dallal et al., 2010).

## **2.2 Sprinting in football**

A prerequisite for success in today's game of football is the ability to perform high-speed running actions. How professional football players have become faster indicates the importance of sprinting skills in modern football (Buchheit et al., 2014). According to Di Salvo et al. (2007) elite players of the Spanish Primera Division spent 3.9-6.1 percent of the match in high speed running and 2.1-3.7 percent in sprinting, although only 1.2-2.4 percent of the match was spent with possession of the ball. Interestingly enough, it seems that one of the world's best teams performed fewer sprints and covered shorter distances at high speed running and sprints than their opponents in the Spanish La Liga in the 2002-03 and 2006-07 seasons (Minano-Espin, Casais, Lago-Penas, & Gomez-Ruano, 2017). The average number of sprints performed in a match in the Spanish Primera Division was found to be  $17.3 \pm 7.7$ , while Andrzejewski et al. (2013) found the average number of sprints in the UEFA Europa League to be only  $11.2 \pm 5.3$ . Interestingly enough this could indicate higher sprinting actions in the Spanish La Liga than in the UEFA Europa league. According to Andrzejewski et al. (2013) the attackers performed most sprints during a match with an average of  $7.8 \pm 2.9$  sprints between 10.1-20.0 metres and  $7.4 \pm 3.7$  sprints  $>20.1$  metres. Independent of playing position  $48 \pm 16$  percent of the sprints performed in a match was from 10.1 to 20.0 metres.

Sprints are common in many match winning actions, such as winning possession of the ball, passing a defending player, or gaining position to score a goal, which shows how important high-speed running actions are in a match (Faude, Koch, & Meyer, 2012). In a study on the physical demands in the French First League, Dallal et al. (2010) found that attackers spent 2.7 percent of the match in sprinting, 2.7 percent in high intensity runs, and with a total sprint distance of  $208,5 \pm 63.8$  m per game.

Football in the English Premier League is played at a very fast pace, and players with high speed can cause the opponents a great deal of problems with or without the ball. Any team with a high pace attacking strategy will always have an advantage, as shown by the pace of

play by the top teams (Husbands, 2013). There would be great benefits from sprint training in football with the evolvement of today's game. To be able to initiate the acceleration movement from a stationary position, or a moving start, which requires a considerable force generation capacity (R. G. Lockie, Murphy, Schultz, Knight, & Janse de Jonge, 2012), would be beneficial considering that 3 out of 4 sprint actions are leading sprints (Di Salvo et al., 2010).

Quicker players will always have an advantage in a team sport, as their ability to reposition more quickly than their opponents will be crucial during match situations. This is why sprint ability has become an important factor in defining successful performances (Rumpf, Lockie, Cronin, & Jalilvand, 2016).

### **2.3 How to improve sprinting ability**

The biomechanics of sprinting at high speed involves maximizing ground reaction force (GRF), stride length and stride frequency, while minimizing ground contact time (Handsfield et al., 2016). It is important to understand the biomechanical function of the lower limb muscles in different running speeds to be able to influence them through training. There is a considerable difference between the muscles working concentrically to generate energy or eccentrically to absorb energy (Schache et al., 2011). Through a three-dimensional approach, Schache et al. (2011) found that the biomechanical load for the hip extensor and knee flexor muscles is substantially increased in the terminal swing phase with faster running.

There are three external forces acting on the body that determine the acceleration of the player's centre of mass during sprinting: GRF, gravitational forces, and air/wind resistance (Hunter, Marshall, & McNair, 2005). Out of these the only modifiable factor which can potentially impact sprint acceleration performance is the GRF (Bangsbo, Mohr, & Krustup, 2006). The hamstring muscle group, which is a bi-articulate muscle group in the posterior thigh, acts mainly as hip extensors during the stance phase. This gives the hamstring muscle group two actions, a) to push the ground backwards and by this neutralize the knee torque caused by the GRF, and b) to produce a force directed backwards and horizontally to control the direction of external forces that will cause the body to drive forwards (Belli, Kyrolainen, & Komi, 2002).

### 2.3.1 Training methods to improve sprinting ability

Different training modalities such as plyometric, agility and free and/or resisted sprinting have been reported to improve sprinting performance in football players and other team sport athletes (Chaouachi et al., 2014; Harrison & Bourke, 2009; Robert G. Lockie, Schultz, Jeffriess, & Callaghan, 2012; Markovic & Mikulic, 2010; Rumpf et al., 2016; Spinks, Murphy, Spinks, & Lockie, 2007). When applied in isolation, all of these training methods have been reported to improve performance, but football players usually perform these methods simultaneously in training and matches (Mendiguchia et al., 2015).

A combination of good elastic features of the muscles, a high rate of relaxation and the ability to rapidly produce force is required in sprinting (Bračić, 2011). Buchheit et al. (2014) found that sprint speed could be considered a neuromuscular quality. Individual differences can be explained by the differences in technical ability in use of force and stride mechanics, and the focus on developing maximal horizontal force (Buchheit et al., 2014).

Studies show that sprint performance over 10 metres can be improved by the use of free sprint training, resisted sprint training, weight training and plyometric training (R. G. Lockie et al., 2012). These approaches are especially effective for influencing the quickness over the first steps of acceleration. However, in the transition from acceleration to maximum speed, the only two approaches that significantly increased the speed were weight training and plyometric training (R. G. Lockie et al., 2012).

After the use of free and/or resisted sprint training, it seems that improvements related to acceleration is primarily related to an increase in horizontal and reactive power outputs (R. G. Lockie et al., 2012). This allows the athlete to apply strength through ground contact more effectively (R. G. Lockie et al., 2012). Explosive speed training can improve both explosive sprinting speed and acceleration, although for short distances sprint performance improving horizontal force production seems to be the most effective (Buchheit et al., 2014).

According to Rumpf et al. (2016) specific sprint training (free and resisted sprinting) increase performance at 0-10 metres and 10-20 metres sprint distances. Free sprint training can positively influence technical adaptations like step length and reduced contact time during acceleration. Resisted sprint training involves the use of additional resistance to overload the player, and it is used to improve the acceleration phase. It is considered to be the most

proficient training for improving speed over distances up to 20 metres (Rumpf et al., 2016). Resisted sprint training can also have a positive influence on sprint kinematics by increasing step length and reducing contact time (Rumpf et al., 2016).

Non-specific training, like strength, power (force-speed relationship) and plyometric training, gives less effect on sprinting ability than specific training. However, it is important to recognize that these methods still could influence sprint acceleration (Rumpf et al., 2016). In acceleration force production is important, generating the necessary power for sprinting. Strength and power training can also have positive influences on muscle architecture, movement speed, intramuscular coordination, and sprint technique, and there seems to be a strong relationship between maximum strength and sprint acceleration performance (Rumpf et al., 2016).

In both the acceleration phase and the explosive speed phase, development of maximum dynamic strength is important (Alcaraz, Romero-Arenas, Vila, & Ferragut, 2011). A determining factor for sprinting is the power. The way to proficiently develop power in sprint performance is through training methods like plyometric training, resisted sprint training and strength training with external loads of one repetition maximum (1RM) (Alcaraz et al., 2011).

High levels of strength training and power are related to improving sprinting ability (Otero-Esquina, de Hoyo Lora, Gonzalo-Skok, Dominguez-Cobo, & Sanchez, 2017; Sander, Keiner, Wirth, & Schmidtbleicher, 2013; Styles, Matthews, & Comfort, 2016). For the purpose of improving sprinting ability in football players through strength training it seems to be important to increase maximum strength and power (Otero-Esquina et al., 2017; Sander et al., 2013; Styles et al., 2016; Wong, Chaouachi, Chamari, Dellal, & Wisloff, 2010). Muscular strength training for the purpose to increase maximum strength should consist of 4 sets of 6 RM, which means 85-90 percent of 1RM (Wong et al., 2010). Exposure frequency to strength training of 2 sessions a week has a significant impact on improving sprint performance at 10, 20, and 30 metres (Otero-Esquina et al., 2017; Sander et al., 2013; Styles et al., 2016; Wong et al., 2010), and the combination of strength training and sprint training seem to be a good combination for the purpose of improving sprinting ability in football players (Wong et al., 2010). To implement strength training during the competition season seems to increase both maximal strength and short sprint improvements contrary to what some believe (Styles et al., 2016). It seems that small-sided games (SSG), like 4 vs 4 and 8vs 8, which are often used in

football can improve power actions and sprinting ability (Chaouachi et al., 2014; Rebelo, Silva, Rago, Barreira, & Krustup, 2016). The demands of the 4 vs 4 games develop more power actions and fatigue through its continuous acceleration and deceleration actions, while the high speed running demands were greater in the 8 vs 8 games which improves sprints performance (Rebelo et al., 2016).

Traditional sprint training increases step length and improves horizontal power, but to increase step frequency in football there is a need for another training stimulus (R. G. Lockie et al., 2012). Free sprint training increase horizontal and reactive power, plyometric and resisted sprint training develop reactive power, while weight training increase lower limb strength and thereby improve short sprint performance (R. G. Lockie et al., 2012). In football top speed is achieved more often due to the fact that players initiate sprint while already moving (Little & Williams, 2005). High explosive running speed is an important quality, as many sprints are initiated by a moving start and high explosive speed can then be achieved (Rumpf et al., 2016).

Acceleration, explosive speed and agility are qualities that are unrelated and need different training approaches, although there has been found significant correlation between performance in the 40-meter sprint time and an agility T-test (Little & Williams, 2005). Tonnessen, Shalfawi, Haugen, and Enoksen (2011) found marked improvements in 40 metres sprinting, countermovement jumps (CMJ) and beep test parameters for young well-trained elite male football players after a 10-weeks 40 metres repeated sprint training program without strength training focus.

During a football game 90 percent of sprints were shorter than 5 seconds, whereas 10 percent were longer than 5 seconds (Andrzejewski et al., 2013), and the mean duration of sprints are between 2 and 4 seconds, which is equivalent to 10-30 metres, and most are shorter than 20 metres, which are very short sprints (Rumpf et al., 2016). According to Young, James, and Montgomery (2002) there is a moderate and significant relationship between change of direction performance and leg reactive strength, because of the similar push-off mechanism as in plyometric training it can positively influence sprinting. By improving the dynamic actions through its emphasis on developing the stretch-shortening capacities plyometric training can contribute to increase explosive sprinting speeds (Rumpf et al., 2016).

### **2.3.2 Strength requirements (most important muscle groups) in sprint**

For a sprinter there are three important joints of concern, the hips, knees and ankles. When all these joints are aligned the body can make best use of the generated forces between the body and the ground (Husbands, 2013). Some of the most important muscles during sprinting are m. gluteus maximus, m. rectus femoris, hamstring muscle group, iliopsoas muscle group and m. tibialis anterior (Handsfield et al., 2016). The gluteus muscles and the lower core instigate hip flexion and extension. The hip flexors (mm. iliopsoas) are considered the connection between the hips and core to the leg muscles. The gluteus muscles around the hips are important extensor muscles across the hips and generate a great amount of force. The hips are where the upper body and the lower body meet, which means that they link the core to the lower extremities.

The knees help to stabilize and generate force through flexion and extension of the quadriceps (m. rectus femoris) and hamstrings muscles. The pennate fibers of the hamstrings and gastrocnemius muscles have two important actions to consider, they can use stored elastic energy, as well as redirect considerable energy, when the knee is driven into extension by the gluteus muscles. Together with the GRF this is a great way to take advantage of the power generated in the muscles around the hip joint (Husbands, 2013). Weakness of the gluteus muscles can cause mechanic challenges in generating enough force to accelerate and maintain speed, cause imbalance and tightness in the muscles of the lower extremities, cause instability over the knee and ankle joints, and cause pain in the lower back (Husbands, 2013).

The ankles are surrounded by the least amount of muscles, but have an array of nerves and tendons, which help produce the right responsive balance (proprioception). The gastrocnemius muscles of the legs are important in storing elastic energy and foot speed, together with the tibialis anterior muscle (Husbands, 2013).

Large forces generated in the lower limb muscles is the reason sprinters achieve much higher gait velocities and accelerations than average humans (Handsfield et al., 2016). In a study by Handsfield et al. (2016) they find that muscle hypertrophy, of large hip and knee flexors and extensors in particular, are advantageous for fast sprinting. There was a significant mean difference of 30 percent larger hip- and knee-crossing muscles in sprinters compared to non-sprinters in that study.

There are indications that the hamstring is essential in the initial contact phase for producing hip extension and knee flexion power as lower sprinting speed performance has been recorded (Mendiguchia et al., 2014). Increasing running speed also showed a more forward-directed force in football players returning to sport after a hamstring injury (Mendiguchia et al., 2014).

### **2.3.3 Hamstring strength and sprinting**

The hamstring muscle is believed to be important for sprinting performance in football (Askling, Karlsson, & Thorstensson, 2003). The hamstring group acts eccentrically both during the late swing and terminal stance phases of the running cycle (Schache et al., 2011; Thelen et al., 2005; Yu et al., 2008). This indicates that the hamstring muscle action of knee flexion and hip extension play a very important role in sprinting (Sun et al., 2015).

Large passive loads at both the hip and knee joints during the initial stance and late swing phase act to lengthen the hamstring muscles, where the active muscle torque generated function to counteract this effect (Sun et al., 2015). Kinetic and electromyogram (EMG) studies reveal that the hamstrings are most active and develop the greatest torques at the hip and knee during late swing through to the mid-stance phase of running (Schache et al., 2011; Thelen et al., 2005). The timing of the hamstring contractions, by producing torque quickly, is very important for sprint performance, which seems to have most effect in the acceleration phase (Bračić, 2011).

It has been found that the hamstring muscle-tendon lengthens between 45-90 percent during the sprinting gait cycle. During sprinting the peak hamstring muscle length occurs during late swing phase, this is when the hip is greatly flexed and the knee is slightly flexed. Its peak length continues to occur in the flight phase before foot contact. In the gait cycle of maximal sprint speeds it occurs significantly later than at submaximal speeds. What is important to keep in mind is that sprinting requires a greater stretch of the biceps femoris than of the semitendinosus and semimembranosus. In fast sprinting speeds the hip flexion increases the hamstring muscle-tendon length, but at the same time knee flexion compensates this action and decreases its length. This might suggest that hamstring flexibility may be a limiting factor, which influences postures during the late swing phase (Thelen et al., 2005). The development of posterior thigh strength is believed to be important in order to improve sprint performance (Askling et al., 2003; Bračić, 2011; Robert G. Lockie et al., 2012).

It is also believed that the hamstring muscles can be underdeveloped compared to the quadriceps muscles through football training. According to Mendiguchia et al. (2015) football training alone induced small changes in the hamstring muscles. Also, it induced small, negative changes in sprint performance compared to the experimental group who performed neuromuscular training, comprised of eccentric hamstring training, plyometric and free/resisted sprint training. Takata et al. (2016) concluded that glucose uptake related to muscle activity in the hamstrings and hallux muscles increased by routinely performing part 2 of the 11+ for 4 weeks.

The majority of hamstring injuries in football occur while players are running or sprinting (Woods et al., 2004). It still remains controversial whether the injury occurs during late swing phase or stance phase of the sprint, where the posterior thigh muscles generate tension while lengthening (eccentric contraction) to decelerate knee extension (Schache et al., 2011; Thelen et al., 2005; Yu et al., 2008). A method proposed to prevent hamstring injuries involves increasing the eccentric strength of the hamstring muscles (Arnason, Andersen, Holme, Engebretsen, & Bahr, 2008; Askling et al., 2003; Petersen, Thorborg, Nielsen, Budtz-Jorgensen, & Holmich, 2011). However, this should be done while lengthening the hamstring muscle complex in a loaded and contracted state (Arnason et al., 2008; Askling et al., 2003; Petersen et al., 2011).

#### **2.4 How do sprinters train?**

According to Husbands (2013) there are five important elements the body needs to succeed in sports and sprinting. These are strength, flexibility, endurance, speed and skill. To become a better sprinter you need upper and lower body strength, unilateral strength and core strength (Husband, 2013). Weight training for various types of strength like explosive, dynamic, static, elastic and endurance is therefore important to promote better sprint performance (Husband, 2013). Flexibility is necessary for proper execution of techniques and to prevent injuries by avoiding the body to take shortcuts and compensatory movements (Husband, 2013). Also, endurance is vital for the ability to perform multiple repetitions at the right speed and distance which is essential for sprint performance (Husband, 2013). Speed is of course needed in performance, but it is just as important in coordination and reaction. Enhancing the speed of your reactions can be done through training with the right focus and frequency. To



improve your reaction through the neuromuscular system and central nervous system can only be done through repetitive training (Husbands, 2013). Skills are elements such as balance, agility, coordination and timing, which are all very important to master if you want to become a good sprinter. To learn how to adapt to new skills and execute these skills in the best way is important (Husbands, 2013). The ability to manipulate and control the body while running is also essential (Husbands, 2013). Once these skills are mastered, they will assist in implementing the correct execution of the necessary drills that will improve sprint performance (Husbands, 2013).

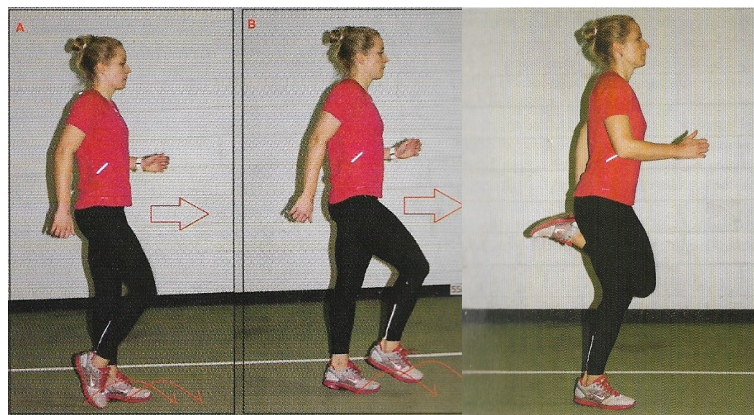
Training drills are important to improve performance and they are supposed to be repetitive. They should be included in the warm-up to correct techniques and tweak performance by stimulating the relevant neuromuscular pathways into readiness. The drills will be vital for getting the body prepared for performance and they promote skill enhancements, speed and movement mechanics, strength and power (Husbands, 2013).

#### **2.4.1 Sprint techniques**

To become a fast sprinter there are a few mechanics that are important in the execution of the sprint. Primarily, it is important to focus eyes ahead towards the end and keep head high and balance in line of the spine. The chin should be down while the shoulders are relaxed. Keep the back straight and the core muscles switched on to avoid torso rotation. The arms need to be in a forward and backwards movement with the elbows at 90 degrees. It is also important to keep the hips stable during the sprint action, and remember to breathe throughout the performance (Husbands, 2013). The greatest difference between elite sprinters and non-elite sprinters are their abilities to have short ground contact time, smaller touchdown distances, higher angular velocities of the stance-leg hip joint, a greater step frequency and greater extension of the hip, knee and ankle joints of the stance leg at take-off, which will contribute to a higher maximum sprinting speed (Rumpf et al., 2016).

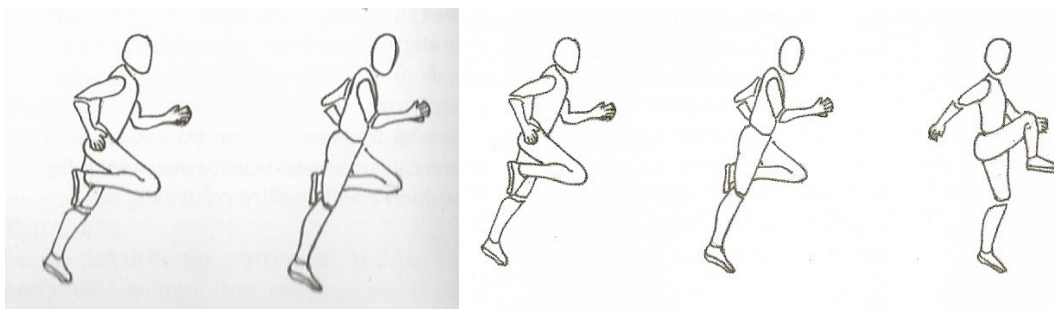
When training to become a better sprinter, there are a few running drills that are important to focus on. Some of these are simple drills, while others are complex specific drills and action specific drills.

Simple drills mimic part of a complex movement or a running action but are only a segment, or a part of the complete movement. Some simple drills are walking on heels, walking on toes, sprint arms, ankling and butt kicks. The benefits of walking on heels and walking on toes are the development of balance and strength in the lower leg muscles. The benefit of sprint arms is that it develops power and endurance in the shoulder muscles. Ankling benefits sprinting by increasing elastic strength of the ankle and increases foot speed, while butt kicks only increase foot speed (Husbands, 2013).



**Figure 1** Simple drills (Husbands, 2013). Reproduced with permission from *Sprinting: training, techniques and improving performance* (2013) page 119-120 (see appendix E).

Complex and specific drills are techniques that require concentration and practice as they build neuromuscular pathways and patterns within the central nervous system (CNS). This means to incorporate the mechanics of a sequence of action that recreates the full running sequence part for part. Examples are running balance, march/walk, skips and march/skip. The running balance enhances proprioception and increases muscle stiffness in the ankle area, while the march/walk increases foot speed. The skips also increase ankle stiffness, and increases hip extension and flexion strength. The march/skips activates hamstrings and benefits hip extension (Husbands, 2013).



**Figure 2** Complex and specific drills (Husbands, 2013). Reproduced with permission from *Sprinting: training, techniques and improving performance* (2013) page 120-121 (see appendix E).

Action specific drills can be divided into wall drills, resisted acceleration drills and agility drills. The wall drills works specifically to able an efficient foot placement to improve the foot plant action in the start and drive phase of the run (Husbands, 2013).

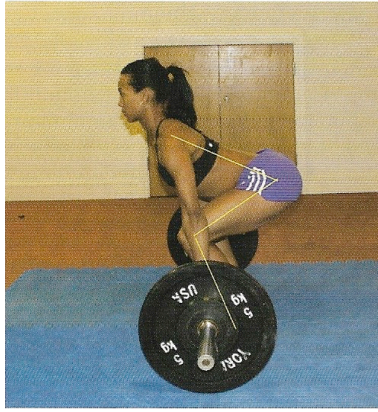
The resisted acceleration drills tries to mimic the action of starting by creating high muscle activation. It is used to work on mechanics required in the first few steps with resistance, which allows for adjustments to the technical performance. Agility and hurdle drills are important for its multi-directional components. These elements involve more than front and backside mechanics and include muscles controlling medial and external rotation of the legs, which are important factors in muscle and joint stability (Husbands, 2013).



*Figure 3 Action specific drills (Husbands, 2013). Reproduced with permission from Sprinting: training, techniques and improving performance (2013) page 121 (see appendix E).*

#### **2.4.2 Strength training**

Sprinting requires integrated muscular coordination in addition to specific strength and power in the relevant muscles. Based on this the Olympic-style lifts, bench press, squats, deadlifts, power-cleans and clean-and-jerk are essential to provide the required strength (Husbands, 2013). These lifts have a very high rate of force production and power output, and involve a transfer of explosive movement and speed, which is needed in a total body discipline. Core stability and neuromuscular coordination is promoted through these lifts, which transfers onto the sprinters' actions in their environment. The focus of these exercises is strength with the aim at explosive dynamic movements under full control with 4-6 repetitions and correct technique (Husbands, 2013).



**Figure 4** Correct technique in squats (Husbands, 2013). Reproduced with permission from *Sprinting: training, techniques and improving performance* (2013) page 158 (see appendix E).

### *The Bench press*

The sprint benefits of this exercise is the strength and stability in the upper body to hold the starting position with strong shoulders and arms and support the upper body in the pushing off (Husbands, 2013).

### *Squats*

The sprint benefit of this exercise is the strength from the starting blocks and in the acceleration and drive phase. The strength benefits are developing the muscles of the quadriceps, gluteus and hamstrings of the lower body (Husbands, 2013).

### *The Deadlift*

The sprint benefit of this exercise is the strength for extending out of the starting blocks and in the acceleration and drive phase. Additionally, it benefits the stride-and-lift phase of the sprint in the backside mechanics by developing the hamstrings along with gluteus, calf and lumbar spine muscles (Husbands, 2013).

### *The Power Clean*

The sprint benefits of this exercise are the strength and stability from start to maximum speed, the power in exploding from blocks, the power to accelerate, the strength in the drive phase to upright run position and synchronization of strength, power, balance and coordination, through strength in a vertical upright position and strength in horizontal/linear movements (Husbands, 2013).

### *The clean and jerk*

The sprint benefits of this exercise include all the benefits of the previous three exercises put into one full routine. It contributes to achieving an explosive start and requires full-body engagement as in the drive phase, when the legs and arms will be pumping together in equal and opposite force. It also develops upper body core strength and control. To achieve maximum speed and the strength to maintain it, upper body core strength and control is needed. The triple extension mechanism is enhanced focusing on the muscles around the hips, knees and ankles (Husbands, 2013).

### *Core strength*

The strength and stability of the core is vital in every movement in the body, and a weak core will be unable to maintain control of the upper body. This comes to show when the athlete starts to tire from activity. To be able to balance extension, flexion and lateral flexion around the spine is vital in maintaining the ability to run fast (Husbands, 2013).

### *Plyometric*

The underlying mechanism of plyometric is the “stretch shortening cycle” which happens when the muscles lengthen and shorten in eccentric and concentric contractions happening in actions immediately after each other. Power is the combination of strength and speed, and plyometric training can help enhance athletic performances by building explosive power into actions and reactions such as jumping and bounding (Husbands, 2013). Plyometric training is an effective training method for improving sprint performances (de Villarreal, Requena, & Cronin, 2012).

## **2.5 The FIFA 11+ warm-up programme**

The systematic review and meta-analysis by Thorborg et al. (2017) shows that there is a substantial injury-prevention effect from the 11+, reducing as much as 39 percent of football injuries in recreational/sub elite football. In total 32-60 percent of football injuries were reduced, even though less than 15 percent of the teams investigated performed the recommended intervention dose, of two sessions a week during the season (Thorborg et al., 2017). This is in accordance with the systematic reviews by Gomes Neto et al. (2017) and Barengo et al. (2014), which showed a significant reduction in the number of injuries (30-70 percent) among the teams that implement the program. Players with high compliance have an

estimated risk reduction of 35 percent and significant improvements in components of neuromuscular and motor performance when participating in more than 1,5 warm-up sessions per week (Soligard et al., 2010; Steffen, Meeuwisse, et al., 2013).

Whittaker and Emery (2015) identified structural adaptations of the abdominal wall for all players who performed greater than 15 11+ exercises per week for 16 weeks. According to the authors these findings suggest that the 11+ somehow alters the way the abdominal muscles are being used, or loaded. As the authors explain it, “The morphological adaptations may be related to alterations in neuromuscular control of the trunk” (Whittaker & Emery, 2015, p. 232). The exposure to 11+ in this study was greater than in previous studies that reported injury reduction (Soligard et al., 2008; Soligard et al., 2010; Steffen, Emery, et al., 2013).

Daneshjoo, Mokhtar, Rahnama, and Yusof (2012b) tested the effect of the 11+ on conventional strength ratio (CSR), dynamic control ratio (DCR) and fast/slow speed ratio (FSR) in young male professional football players. They found that the 11+ improved all parameters, although only significant differences in CSR and DCR for the non-dominant leg between groups, and non-significant for FSR. However, for proprioception, static and dynamic balance the authors found significant improvements in the 11+ group compared to the control group (Daneshjoo, Mokhtar, Rahnama, & Yusof, 2012a). The same group of authors also looked at the effect on knee strength in young male soccer players. They found significant differences between the 11+ group and the control group, indicating that the 11+ has an effect on performance parameters such as hamstring strength, quadriceps-hamstring ratio, proprioception, and balance (Daneshjoo, Mokhtar, Rahnama, & Yusof, 2013; Daneshjoo, Rahnama, Mokhtar, & Yusof, 2013).

In comparison, Hammes et al. (2015) failed to verify any effect of the 11+ in veteran football players. However, in that study the total exposure of 11+ was lower than the recommended 1,5 sessions a week, which may be a contributing factor to the lacking effects.

### **2.5.1 Sprinting in the FIFA 11+ prevention programme**

Significant improvements after implementing the 11+ have been reported with regards to thigh muscle strength, jump height, sprint speed and a number of measures of balance and proprioception in amateur footballers (Bizzini et al., 2013; Brito et al., 2010; Daneshjoo et al.,

2012a; Impellizzeri et al., 2013; Nakase et al., 2013; Steffen, Emery, et al., 2013). All of these measures are relevant and important for performance in the game of football. According to Barengo et al. (2014), there is evidence to suggest that the improvements in measures of proprioception or dynamic balance, core-stability, concentric and eccentric hamstring strength and hamstrings-quadriceps muscle balance are adaptations, which is associated with lower risk for injuries like anterior cruciate ligament rupture and hamstring strains (Arnason et al., 2008; Askling et al., 2003; Petersen et al., 2011). Other studies also support this association (Bizzini et al., 2013; Brito et al., 2010; Daneshjoo et al., 2012a; Nakase et al., 2013).

The study by Bizzini et al. (2013) is one of few studies that have investigated the acute effect (immediate effect of the intervention) of the 11+. The aim of the study was to investigate whether the 11+ is an appropriate warm-up when testing for performance variables. In the results there were reported statistically significant improvements from pre to post warm-up in a number of the performance variables, such as sprint speed, agility, jump performance and balance. The exercises included in 11+ are adequate to induce positive acute physiological responses that can enhance the following performance (Bizzini et al., 2013).

Impellizzeri et al. (2013) showed improved neuromuscular control and time-to-stabilization after 9 weeks of 3 sessions with 11+, which supports previous findings that the 11+ program has an injury prevention effect. According to the authors no meaningful effects on the other performance measures were found, although a non-significant 2,8 percent improvement in sprint performance and some flexor strength differences in favour of the intervention group were found. The authors concluded that “the FIFA11+ cannot be proposed as a training strategy for improving muscle power performance” (Impellizzeri et al., 2013, p. 1501).

### **2.5.2 Injury prevention vs performance enhancing**

The injury preventative effect of the 11+ is supported by several studies (Grooms, Palmer, Onate, Myer, & Grindstaff, 2013; Owoeye et al., 2014; Silvers-Granelli et al., 2015; Soligard et al., 2008; Steffen, Emery, et al., 2013), while some have disputed the performance enhancing effects to be present (Impellizzeri et al., 2013). However, Reis, Rebelo, Krustup, and Brito (2013) found improvements in all performance variables tested in their 12-week two sessions a week intervention in youth futsal players. Their conclusion suggests that the 11+ can be used as an effective conditioning method for improving physical fitness and

technical performance in this group.

Brito et al. (2010) indicate through their study an improvement in isokinetic hamstring strength from the 11+ in sub-elite football players. The study showed improvement in most isokinetic parameters tested, and the most relevant finding was improved functional dynamic control ratio in the non-dominant extremity due to the increased eccentric strength in the hamstrings. Pre intervention there were found significant bilateral differences in the absolute eccentric hamstring peak torque, which after the intervention period were normalized, indicating that the proposed exercises improved functional balance in weaker muscle groups (Brito et al., 2010). According to the study by Nakase et al. (2013) an accumulation of F-fluorodeoxyglucose was found in the rectus abdominus, gluteus medius and minimus after performing the 11+, which indicates activation of the respective muscles during the warm-up program.

It is close to impossible to determine which exercises are the most important in terms of risk reduction since the 11+ usually is implemented as a complete intervention (Barengo et al., 2014). The same would seem to apply for sprint enhancing elements.

The importance of the various components of the 11+ is likely to be dependent on the player's neuromuscular and biomechanical profile, and characteristics like gender, age and previous injury (Barengo et al., 2014). However, the 11+ seem to be useful and effective in overall injury risk reduction at the amateur level. But to prevent injuries at a higher level, where players have a greater baseline neuromuscular performance, the program may require additional loading progressions, such as volume and intensity, or a greater emphasis on exercises that address specific risk factors to produce a significant reduction in injury frequency (Barengo et al., 2014). It would be logic to assume the same for performance enhancing effects, but there are very few studies that have looked into improvements of performance variables in the 11+, so more research on this subject is needed.

### **2.5.3 What exercises in 11+ can improve sprint**

There are some strength elements included in the 11+ that focus on core stability, eccentric hamstrings muscle strength, strength in the gluteus muscles, quadriceps muscles and gastrocnemius muscles, stability over the knee and ankle joints. The 11+ protocol is based on



strength exercises with bodyweight, which will not give an increase in maximal strength, as the load is too low (Raastad, Paulsen, Refsnes, Rønnestad, & Wisnes, 2010). To be able to improve maximal strength the training load needs to exceed ones own bodyweight. Also the number of repetitions and sets does not correspond with strength training principles to increase maximal strength (Raastad et al., 2010). An increase in sprinting ability is dependent on systematic strength training to increase maximal strength (Otero-Esquina et al., 2017; Sander et al., 2013).

The 11+ also include three running drills with focus on bouncing, cutting and increasing runs across the pitch. However, the intensity of the running exercises are too low, and for the purpose of improving sprinting ability the need for more powerful actions and explosive sprints has to be involved (Young et al., 2002). Running actions with change of direction should also be emphasised more for the purpose of improving sprint time (Otero-Esquina et al., 2017).

## **2.6 Sprint related injuries in football**

The most common injury category in professional football is muscle injuries (Ekstrand et al., 2011a, 2011b). Of all injuries 12-17 percent are to the hamstring muscle group and 9 percent are groin injuries (Ekstrand et al., 2011a, 2011b). Of all injuries muscle injuries represent 31 percent, and 37 percent of these are hamstring injuries and 21 percent are muscle strain to the adductor group (Ekstrand et al., 2011b; Hallén & Ekstrand, 2014). The incidence rate of hamstring muscle injuries is 2.74 and groin injury 1.66 (Silvers-Granelli et al., 2015).

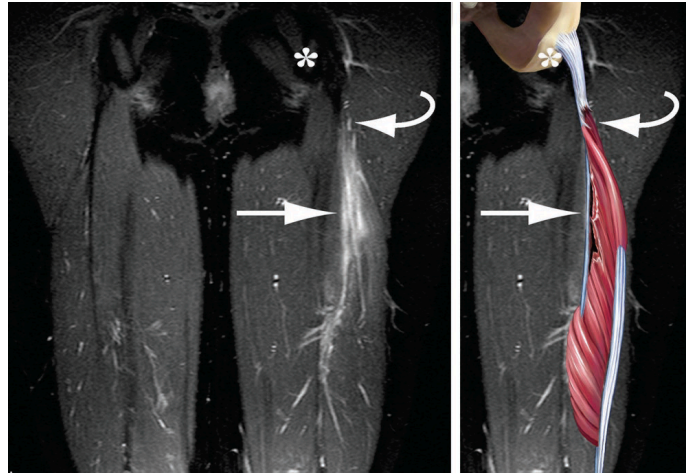
The majority of hamstrings injuries occur during high speed running or sprints (Arnason et al., 1996; Woods et al., 2004). Woods et al. (2004) found that as much as 57 percent of the hamstring strains were sustained during running actions, and two-thirds of the hamstring strains are sustained during match play. The strain injuries are most likely to occur in the late part of the swing phase in preparation for the foot strike as the eccentric contraction of the hamstring muscle occur to decelerate knee extension (Stanton & Purdham, 1989). It is thought to be the tension developed in the muscle through eccentric force while lengthening that causes injuries to the muscle (Kujala, Orava, & Jarvinen, 1997). The hamstring muscle actions to counteract the effect of large passive loads of muscle lengthening at both the hip and knee joints during the initial stance and late swing phase can make the hamstring muscles

more susceptible to strain injury (Sun et al., 2015).

Hamstring strains, primarily involving the biceps femoris, account for 12 percent of the total amount of injuries (Woods et al., 2004). According to Ekstrand, Lee, and Healy (2016) 84 percent of the hamstring injuries reported were located in the biceps femoris muscle. The majority of grade 1 and 2 hamstring injuries affect the intramuscular myotendinous junction. There are less frequent injuries affecting the myofascial tissue without affecting the tendon, and pure fascial or muscle injuries are rare. This is in accordance with what Woods et al. (2004) found, although according to their records only 53 percent of the hamstring strains were located in the biceps femoris muscle.

Dolman, Verrall, and Reid (2014) demonstrated that the biceps femoris muscle is required to exert a greater force in the lengthening contraction compared to the semimembranosus and semitendinosus, as it has to lengthen a greater distance in the same amount of time. This may be a contributing factor to the susceptibility of the biceps femoris to injury, as repetitive forces are required during repeated sprints. A forward trunk leaning action during stance phase increase elongation loads on the biceps femoris long head and semimembranosus muscles when sprinting, which increase the potential for hamstring muscle strain injuries (Higashihara, Nagano, Takahashi, & Fukubayashi, 2015)

Adductor muscle related injuries are the most common injury in the groin area (Holmich, Thorborg, Dehlendorff, Krogsgaard, & Gluud, 2014; Werner, Hagglund, Walden, & Ekstrand, 2009), and account for 69% of all groin injuries (Serner et al., 2014). It seems like weakness in the adductor muscles is a contributing factor in sustaining a muscle strain injury (Engebretsen, Myklebust, Holme, Engebretsen, & Bahr, 2010). Adductor muscle injuries are most common in high speed movements where the groin related muscles are involved, such as kicking, sprinting or sudden changes of direction which generates great stress upon the adductors (Holmich et al., 2014). 66 percent of groin injuries involve the adductor muscles, and the muscle, which is mainly involved is the adductor longus (Serner et al., 2015)



**Figure 5** Type I hamstring injury shown on MRI. Reproduced with permission from Brukner et al. (2016) page 688 (see Appendix E).

### *Definition of muscle injury*

For the purpose of this master thesis the definition by Ekstrand et al. (2011a) of a muscle injury will be used, and is stated as “a traumatic distraction or overuse injury to the muscle leading to a player being unable to fully participate in training or match play”. Most muscle strain injuries occur at the muscle-tendon junction where the muscle fibrils intersect with the tendon and are structurally vulnerable to strain (Arnason et al., 1996; Higashihara, Nagano, Ono, & Fukubayashi, 2016).

### *Classification of muscle injuries*

There are four grades of muscle strain injuries, and in this thesis the definition used by Hallén and Ekstrand (2014) will be used. This grading definition is based on magnetic resonance imaging (MRI) examinations from 386 radiological examinations on European professional football players between 2001-2013.

Grade 0, also referred to as structural muscle disorders, is when there is pain without muscle fibre damage, or very little muscle fibre damage, after an acute onset indirect muscle disorder (Hallén & Ekstrand, 2014).

Grade 1, also referred to as minor/partial muscle injury, is where there is intra-fascicle structural muscle damage with no hematoma but pain on stretching and palpation (Hallén & Ekstrand, 2014).

Grade 2, also referred to as moderate/partial muscle injury, is where there is inter-fascicle or muscle bundle structural muscle injury with visible hematoma, palpable defect in muscle tissue, pain on touch and gentle stretch (Hallén & Ekstrand, 2014).

Grade 3, also referred to as subtotal/complete muscle injury/tendinous avulsion, is where there is a subtotal, complete muscle or tendinous injury with extensive hematoma, obvious defect in muscle tissue or tendon, severe pain with passive motion and large palpable defect in muscle-tendon junction (Hallén & Ekstrand, 2014).

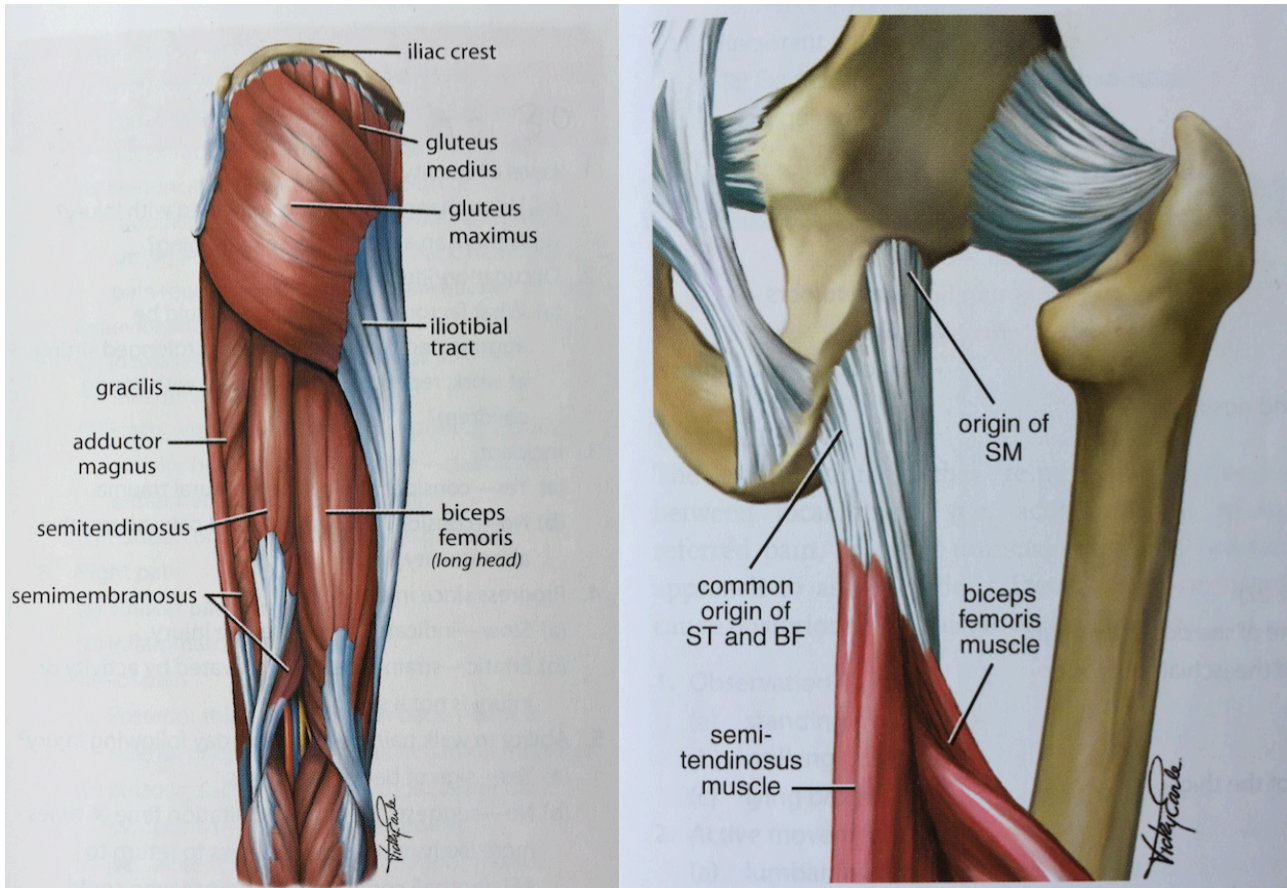
**Table 1** Definition of muscle injuries by Hallén and Ekstrand (2014) with permission from author (Appendix E)

<b>Structural muscle disorders</b>	Painful muscle disorder without evidence of muscle fibre damage. Any acute indirect muscle disorder with macroscopic evidence of muscle fibre damage.
<b>Partial muscle injury – minor</b>	Structural muscle injury involving only Intra-Fascicle Tear. Acute, sharp pain often at muscle-tendon junction. Focal pain on palpation without palpable defect. No visible hematoma. Aggravation of pain by stretching and palpation. Intra-fascicle hematoma and focal muscle defect on imaging with intact surrounding fascia.
<b>Partial muscle injury – moderate</b>	Structural muscle injury involving Inter-Fascicle or Muscle Bundle Tear. Acute severe, stabbing pain often at muscle-tendon junction often associated with fall from reflectory unloading. Palpable, defined defect in affected muscle, painful to touch and gentle stretch. Quickly developing, visible hematoma. Defect of muscle, fascia, and hematoma visible on imaging.
<b>Subtotal/complete muscle injury/tendinous avulsion</b>	Structural muscle injury involving the subtotal (>90%) or complete muscle diameter or complete tendinous avulsion. Acute severe pain (“someone kicked/hit me”) and reflectory unloading. Severe pain with passive motion and palpation. Immediate functional deficit with development of extensive hematoma. Large palpable defect often at the muscle-tendon junction or retraction of avulsed muscle. Obvious muscle defect or tendinous avulsion and with hematoma formation is observed on imaging.

### 2.6.1 Anatomy of the hamstring muscles

The hamstring muscle group is located on the dorsal side of the thigh, consisting of three muscles, m. biceps femoris, m. semimembranosus, and m. semitendinosus (Brukner et al., 2016; Dahl & Rinvik, 2010). The biceps femoris muscle is located laterally and is divided into two heads - a short head and a long head. The long head (caput longum) originates from the ischial tuberosity, while the short head (caput breve) originates from the lateral aspect of linea aspera (Dahl & Rinvik, 2010). The short head is not considered part of the hamstrings muscle group as it only articulates across the knee joint. The two heads conjoin into a distal tendon that has multiple insertions, including the lateral aspect of the femoral epicondyle, the head of fibula and m. popliteus. The semimembranosus muscle, which is located medially, originates from the lateral facet of the ischial tuberosity and splits into three attachments, the posterior part attaches into the kneecapsule in a lateral direction, the intermediate part

continues down into the fascia and attaches to m. popliteus, and the anterior part continues anteriorly underneath the medial collateral ligament and attaches to the medial tibial condyle. The semitendinosus muscle, which is located medially together with m. semimembranosus, originates together with the biceps femoris muscle long head from the medial aspect of the conjoint tendon from the ischial tuberosity and inserts onto the proximal aspect of tibia as part of the pes anserine (Brukner et al., 2016).



**Figure 6** The anatomy of the posterior thigh; muscles and proximal origin. Reproduced with permission from Brukner et al. (2016) page 680 (see Appendix E).

### 2.6.2 Anatomy of the adductor muscles

The adductor muscle group is located proximally on the thigh, and medial to the hip joint. It consists of five main muscles, m. adductor longus, m. adductor brevis, m. adductor magnus, m. pectineus and m. gracillis (Dahl & Rinvik, 2010). Considering that adductor muscle strain injuries in football mainly affect the m. adductor longus, this thesis will describe this muscle only in detail (Serner et al., 2015). The adductor muscle group originates from the pubic bone or the ischial bone and insert on the medial aspect of linea aspera (Dahl & Rinvik, 2010). The

adductors fill the triangular space between the femur and pelvic girdle and adduct the lower leg (Dahl & Rinvik, 2010).

The adductor longus muscle is the most ventrally located muscle in the adductor group (Dahl & Rinvik, 2010). It originates from the anterior aspect of the pubic tuberosity by a short, strong tendon, and spread out in a fan shape and insert with a flat tendon to the middle third of the medial aspect of the linea aspera between the insertions of m. vastus medialis and m. adductor magnus (Dahl & Rinvik, 2010).

### **2.6.3 Preventing sprint related injuries**

The 11+ has been confirmed by large, randomised controlled trials (RCT) to significantly reduce injury susceptibility in young female football players, male Nigerian football players, American male football players, female and male amateur football players (Bizzini & Dvorak, 2015; Owoeye et al., 2014; Silvers-Granelli et al., 2015; Soligard et al., 2008; Steffen, Emery, et al., 2013), which include the NH exercise, a component primarily targeting the hamstring muscles. However the prevention program does not include any exercises directed mainly towards addressing the injuries to the adductor muscle group.

Prevention of hamstring muscle injuries is possible through utilisation of the NH exercise (Arnason et al., 2008; Petersen et al., 2011; van der Horst, Smits, Petersen, Goedhart, & Backx, 2015). The incidence of hamstring muscle strain injuries can be reduced by up to 70 percent through the NH exercise protocol (Arnason et al., 2008; Petersen et al., 2011). The NH exercise improves the eccentric muscle strength, optimizes speed of movement and neuromuscular adaptation in the hamstring muscles (Delahunt, McGroarty, De Vito, & Ditroilo, 2016) as well as withstand forceful stretching which reduces the risk of injury (Iga, Fruer, Deighan, Croix, & James, 2012).

The prevention of adductor muscle injuries seems to have an association with muscle strength in the adductor muscles, and especially the m. adductor longus (Serner et al., 2015). The CA exercise, together with a hip adductor exercise with elastic band, has displayed increase in muscle strength for the m. adductor longus (Serner et al., 2014). These exercises are dynamic high-intensity, which are easy to perform on the football field as well as in any training facility (Serner et al., 2014). The purpose of the current RCT was to implement the CA

exercise into the 11+ to see its strength effects. Results of the study will be published separately (Haroy et al., 2017).

### **3. Methods**

This master thesis is part of a larger RCT, which was completed in the preseason of the Norwegian regional elite U19 league (January – March 2016). The complete results of this RCT has been published elsewhere (Haroy et al., 2017) This master thesis used sprint data collected in this RCT to investigate whether the 11+ programme with either the NH or CA exercise affects the sprint times in elite youth football players.

#### **3.1 Method of FIFA 11+ study**

Two U19 football teams (n=45 players) in the Oslo region were invited to take part in an 8-week randomized controlled trial to examine the hip adductor strength effect of the 11+ adding the CA exercise. The players were randomized into different groups, the 11+ and the 11+ with CA (11+CA). The players in the 11+ group were asked to carry out the exercises as described in previous studies (Soligard et al., 2008), while the players in the 11+CA group were asked to carry out the 11+ replacing the NH exercise with CA exercise. A sports physiotherapist ensured that the players were given adequate instruction on how to perform the exercises and supervised each training session during the project.

##### **3.1.1 Inclusion- and exclusion criterion**

Players who could not complete testing due to injury or illness, who did not follow the intervention procedures or participated in excessive hamstring and/or adductor training, were excluded from the analysis to reduce the contamination.

##### **3.1.2 Randomization and blinding**

The players were randomized individually into the different training groups stratified according to which team they belonged to. A statistician not involved in the study used SPSS (IBM SPSS Statistics for Windows, v. 22.0, IBM Corp., Armonk, New York, USA) to generate random numbers, stratified by team. An independent third person allocated group assignment in sealed envelopes. Each player received a sealed envelope from the principal investigator with his group assignment after pre-testing.

All the testers were blinded to group allocation during pre- and post-testing. During the



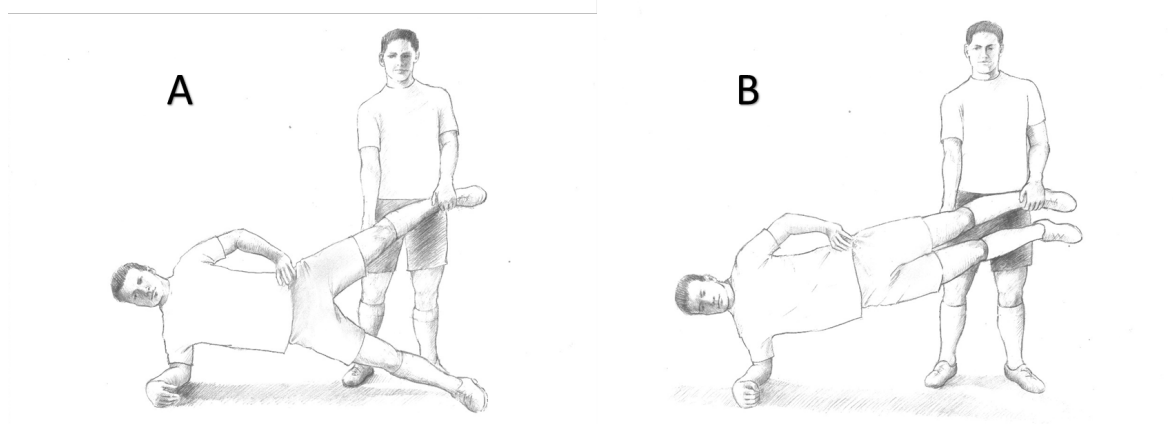
intervention the two sports physiotherapists instructing the team warm-up sessions were not blinded to group assignment. The project leader was blinded from all data collection and management throughout the project.

### 3.2 Intervention procedures

The players in both groups conducted 11+ as regular warm-up for three training sessions each week. Players in the 11+ CA group were asked to carry out the 11+, but replacing NH with CA. In other words individually they performed either the NH or CA exercise depending on which group they belonged to.

#### 3.2.1 The Copenhagen adduction exercise

The CA exercise (Serner et al., 2014), as shown in fig. 1, is a partner exercise where the player is lying on the side with one forearm as support on the floor and the other arm placed along the body. The upper leg is held in approximately the height of the hip of the partner, who holds the leg with one arm supporting the ankle and the other supporting the knee. The player then raises the body from the floor and the lower leg is adducted so that the feet touch each other and the body is in a straight line. The body is then lowered halfway to the ground while the foot of the lower leg is lowered so that it just touches the floor without using it for support.



*Figure 7 shows start (A) and end (B) position of the CA exercise (Serner et al., 2014).*

### 3.2.2 Training protocol

Both groups follow the same protocol, as shown in table 1.

Level	Frequency (training sessions per week)	Number of sets for each leg	Number of repetitions for each leg
Beginner			3-5
Intermediate	3	1	7-10
Advanced			12-15

**Table 2** Shows protocol for NH exercise (and CA exercise).

### 3.3 Strength and performance testing

Players performed testing prior to intervention and directly after ended intervention. All tests were performed at The Norwegian Olympic Centre in January and March 2016. The players met in groups of five and started a warm-up protocol including 15-minutes light running on a treadmill. All tests were performed in the same order, starting with eccentric hip adduction strength test, continuing with sprint tests and finishing with hamstring strength test. For each test, all test procedures were standardized. The players were not allowed to play matches the last two days prior to testing, and all players were weighed before start of testing.

This master thesis will focus on the data recorded from the sprint test and the hamstring strength test. The data from the eccentric hip adduction test will not be clarified and therefore not be described in any more detail.

#### 3.3.1 20 meter sprint test

The 20 meter (20 m) sprint tests was performed on an 8-mm Mondotrack FTS surface (Mondo, Conshohocken, PA, USA) using a Newtest Powertimer portable system (Oy, Finland) infrared photocells (Model 300s), which was mounted on the sprint running track and connected via cables to a computer that measured time to the nearest 0.001 seconds. The players performed three sub-maximal 20m sprints before testing. The maximum running speed was tested by sprinting 3 x 20 m with 4-6 minutes recovery between trials. Recording time was started when the player broke the photocell line 60 cm before the starting line. The time was measured for every five meters and the best result (0-5 m, 0-10 m, 0-15 m and 0-20 m) was retained for analysis.

### **3.3.2 Eccentric hamstring strength test**

For the eccentric hamstring strength test the set-up included a NordBoard (VALD Performance Brisbane, Australia). Legs were tested bilateral for all players. The players were placed kneeling on a padded board, with the ankles secured immediately superior to the lateral malleolus by individual ankle braces (Opar, Piatkowski, Williams, & Shield, 2013). The players were told to gradually lean forward at the slowest possible speed while maximally resisting the movement with both legs while keeping the trunk and hips held in a neutral position and the hands held along the sides throughout the movement. When the players had been instructed in the procedure, they were asked to perform one practice trial before performing one set of three maximal repetitions. Force values were reported as absolute hamstring strength in Newton (N) and relative hamstring strength in Newton per kg body weight (N/kg). The maximum and mean values of the three maximal trials were recorded.

The standardized command by the examiner was "go ahead-hold-hold-hold ". A trial was deemed acceptable when the force output reached a distinctive peak (indicative of maximal eccentric strength), followed by a rapid decline in force, which occurred when the athlete no longer was able to resist the effects of gravity on the segment above the knee joint. The investigator was monitoring the performances of all the repetitions visually, and a repetition was rejected if the participant displayed excessive hip movement, arm movement or did not control the descent from the beginning of the movement.

## **3.4 Outcome measures**

The primary outcome was sprint time quantified as seconds (s). The secondary analysis was the correlation between difference in hamstring strength (N) and difference in sprint time (s).

### **3.4.1 Sample size calculations**

The sample size for the 11+ study was a result of calculation based on a previous study examining strength effect on CA (Serner et al., 2014). The calculation showed that 20 players were needed in each group with a power of 80% and a 10% increase in eccentric hip adduction strength in the 11+ CA group, and no strength increase in the 11+ group. The data

is collected in association with the previously mentioned study and the sample size calculation was therefore not based on sprint effects.

### **3.4.2 Statistical analyses**

All data analyses were performed using SPSS. A per protocol analysis was conducted where a  $\alpha$  level of 0.05 was considered significant, and a compliance limit set at 16 training sessions (67%). A per protocol analysis was preferred in these analyses as the specific effects of the intervention on sprint performance was the primary focus to be investigated. An intention-to-treat analysis was not performed. As the potential efficacy of the exercise was of interest only participants who complied with the specific intervention as planned were of interest (Laake, Benestad, & Olsen, 2007). Between-groups differences in sprint times were assessed using a repeated measures analysis of covariance (ANCOVA). The within-group difference from baseline to post-test was calculated using a paired t-test. Data are presented as mean values with their standard deviation (SD), unless otherwise stated. For the secondary outcome measures a linear regression was used to assess the correlation between difference in hamstring strength and difference in sprint time. Between-groups differences of hamstring strength were assessed using an independent sample t-test with equal variances not assumed.

### **3.5 Ethical aspects**

In accordance with The Declaration of Helsinki and approved by the Regional Committees for Medical Research Ethics (2015/1921/REK) South East and the Norwegian Social Science and Data Service (45393/3/LT/LR), all participants received written and oral information about the purposes and procedures of the project before providing their written consent to participate in the study. The trial was registered in the International Standard Randomized Controlled Trial Number registry (ISRCTN13731446).



## 4. Results

The flow of participants throughout the study is shown in figure 2. Out of the 45 players invited and tested at baseline, 30 were included in the per-protocol analysis. A total of 15 players were therefore excluded from the per-protocol analyses for different reasons. Two of these players attended training with the club's senior squad for several weeks, two goalkeepers had individual warm-up and four players had long periods with illness. Also, during the intervention period one player in the 11+ CA group suffered a knee injury and one player in the 11+ group suffered a groin injury and they were therefore unable to complete post-testing. Another two players, one in each group, were excluded from the analyses due to intensive hip adductor rehabilitation during the study, and another three did not complete post-testing of unknown causes.

### 4.1 Participants

There was an average compliance of  $21.5 \pm 1.9$  sessions (90%) in the CA group. While, in the NH group the compliance was  $21.0 \pm 1.5$  sessions (88%). In total there were 24 training sessions planned in this project.

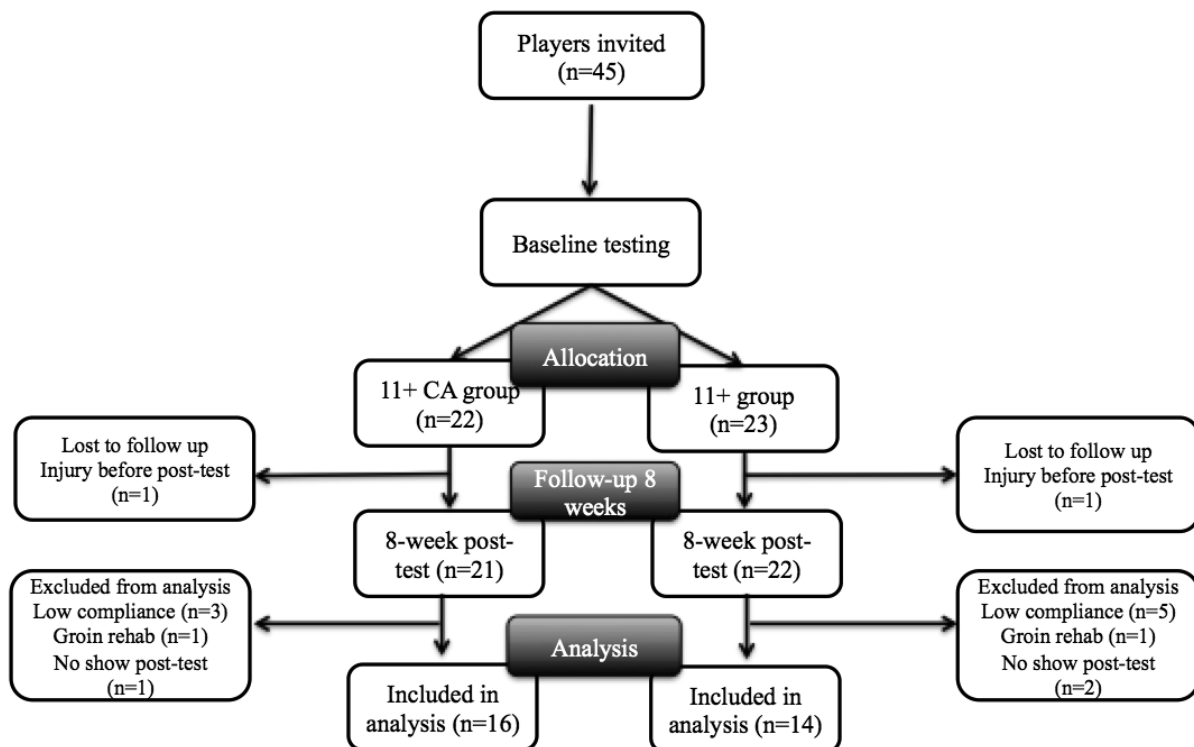


Figure 8 Flow of participants throughout the intervention period.

At baseline there was no significant difference between the two groups in player characteristics, as shown in table 2.

**Table 3** Baseline characteristics of the 30 players included in the per-protocol analyses.

	NH group (n=14)	CA group (n=16)
<b>Age (years)</b>	16.9 (0.9)	16.7 (0.9)
<b>Height (cm)</b>	177.8 (6.0)	179.3 (6.6)
<b>Weight (kg)</b>	68.2 (9.9)	67.8 (8.2)
<b>Weekly football training (h)</b>	7.3 (1.8)	7.9 (2.2)
<b>Weekly individual training (h)</b>	2.3 (1.7)	1.5 (1.2)
<b>Weekly match exposure (min)</b>	39 (15)	44 (18)
<b>Player position (%)</b>		
- Defender	4 (28.6)*	8 (50.0)*
- Midfielder	7 (50)*	6 (37.5)*
- Attacker	3 (21,4)*	2 (12.5)*
<b>Leg dominance (%)</b>		
- Left side	2 (14.3)*	2 (12.5)*
- Right side	12 (85.7)*	14 (87.5)*

*Data are shown as group means and SD. \*reported in percentages*

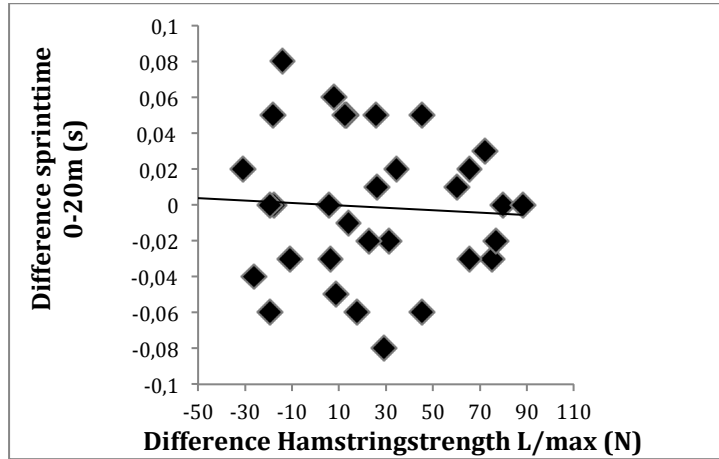
#### 4.2 Primary outcome: Sprint times

We did not find any overall within-group or between-group differences in running speed at any of the time intervals (table 4).

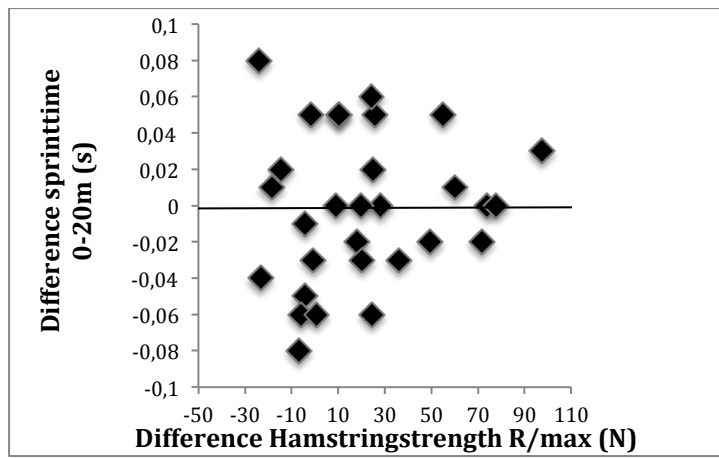
#### 4.3 Secondary outcome: Correlation between hamstrings strength and sprint time

We did not observe any correlation between the difference in hamstring strength (post-test – pre-test) and sprint times (post-test – pre-test). However, we found a small, but not significant, tendency that sprint times decrease with increased left-sided hamstring strength (see figure 9). Which show that with increasing hamstrings strength the sprint time decrease according to  $\beta = -6.74 \cdot 10^{-5}$  through the coefficient of a linear regression. However an increase by 100 N will not give a significant decrease in sprint time ( $\Delta 100 = -0,0067s$ ). There seems to be no such tendency between increase in right-sided hamstring strength (see figure 10) and decrease in sprint times ( $\beta = 3.79 \cdot 10^{-6}$ ). The left-sided mean total hamstring strength

difference was 15,1 N (SD 69,4), (min. -342,3 N – max. 88,1 N), and the right-sided mean total hamstring strength difference was 13,0 N (SD 77,7), (min. -381,1 N – max. 123,9 N).



**Figure 9** Correlation between difference in left sided hamstring strength (N) and difference in sprint time (s)



**Figure 10** Correlation between difference in right sided hamstring strength (N) and difference in sprint time (s)



**Table 4** Test results sprint. Baseline results and changes from test 1 to test 2 within the NH and CA groups, as well as between-group differences in the change from test 1 to test 2.

	NH group (n=14)				CA group (n=16)				Between group difference		
	Test 1 <sup>b</sup>	Change T2-T1 <sup>b</sup>	%	P	Test 1 <sup>b</sup>	Change T2-T1 <sup>b</sup>	%	P	Difference (CA-NH) <sup>c</sup>	%	P
<b>Sprint 0-5 m (s)</b>	0.82 (0.05)	0.01 (0.04)	1,2%	0.26	0.82 (0.03)	-0.00 (0.03)	0,0%	0.60	-0.02 (-0.03,0.00)	-2.4%	0.06
<b>Sprint 0-10 m (s)</b>	1.56 (0.06)	0.01 (0.04)	0,6%	0.47	1.55 (0.05)	-0.00 (0.03)	0,0%	0.88	-0.01 (-0.03,0.01)	-0.6%	0.34
<b>Sprint 0-15 m (s)</b>	2.21 (0.07)	0.01 (0.04)	0,5%	0.48	2.21 (0.06)	-0.00 (0.04)	0,0%	0.81	-0.01 (-0.04,0.02)	-0.5%	0.43
<b>Sprint 0-20 m (s)</b>	2.83 (0.09)	0.00 (0.04)	0,0%	0.68	2.83 (0.08)	-0.00 (0.05)	0,0%	0.71	-0.01 (-0.04,0.02)	-0,4%	0.58

*Positive values denote decreased performance (slower sprint time) from test 1 to test 2.*

<sup>b</sup>*Values are reported as mean with (standard deviation).*

<sup>c</sup>*Values are reported as mean (95% CI).*

**Table 5** Analyses of hamstring strength (N). Total differences within the NH group and CA group for hamstring strength (N) from baseline to test 2.

	NH	CA	P
<b>Δ Left</b>	14,3 (96,4)	15,9 (29,3)	0.948*
<b>Δ Right</b>	11,5 (107,7)	14,4 (33,4)	0.912*

*Positive values denote increase in hamstring strength (N).*

*Values are reported as mean with (standard deviation).*

*\*Equal variances not assumed. Non-significant p-values for between group differences.*



## 5. Discussion

The purpose of the current study was to examine the effect of the 11+ on sprint time in adolescent elite male football players performing either the CA or NH exercise. The results showed no effect of the intervention on sprint time in neither groups, nor any correlation between sprint time and hamstring strength. Consequently, the hypothesis that there would be a change in sprint time on either group was rejected. The possible reasons for these results and their methodological considerations will be discussed in the following section.

### 5.1 Discussion of results

#### 5.1.1 Primary outcome measures

##### *Sprint time (s)*

The results from the present study show no effect, neither within-group nor between-group differences, on sprint time when using 11+, with or without the CA exercise, as a warm-up program. Another study by Bizzini et al. (2013) showed also no effect on sprint time from the 11+ in amateur male players, which supports these findings. In contrast, the study by Reis et al. (2013) showed a significant improvement in 5 metres and 30 metres sprint (8.9 and 3.3 percent respectively) after a 12-week period using the 11+ among adolescent male futsal players. However, the data reported from the futsal players shows a considerably lower total exposure to training load compared to players in the present project, making comparison challenging. Yet another study, by Impellizzeri et al. (2013), showed an improvement in 20 metres sprint of 2.8 percent after a 9-week intervention period using 11+ in amateur male players. Although non-significant, these results support those found by Reis et al. (2013) that improvements in sprint times can be achieved by the 11+. In the present study, however, we did not expect substantial improvements in sprint measures, since the sprint stimulus from the 11+ did not appear to be enough to induce meaningful effects for these U19 elite-players.

Sprint demands in football are more complex and involve more multi-directional movements than sprinting on a track (Chaouachi et al., 2014). The tests performed in this study were completed on a straight 40 m indoor track with infrared photocells recording in intervals of 5 meters up to 20 metres. Although most sprints in football are less than 20 metres, and most match winning actions are straight sprints (Faude et al., 2012), there is a great difference in

individually running in a quiet enclosed area with training shoes on plastic cover from running on a grass field with opponents either blocking your path or trying to push or pull you off your path. The transferability of the sprint results is therefore questionable.

Another important aspect of sprinting in football is that the player needs to predict the play to calculate where to run in order to optimize its chances of receiving the ball. In this way a player creates space to receive the ball without the need for sprinting. In other words, a player can create chances, receive the ball and score goals without full sprint actions. It is important to consider that 3 out of 4 sprint actions in football are leading sprints (Di Salvo et al., 2010). This indicate that the acceleration from a standing position is less important than the ability to transition from running into high speed runs, with the potential to reach explosive sprint, in a short instance. However, this does not account for the lack of sprint results in the present study, but it should be considered as a factor when improving sprinting ability in football is a primary objective. Training modalities, such as plyometric, agility and free and/or resisted sprinting, have been reported to improve sprinting performance in football players when applied in isolation (Chaouachi et al., 2014; Harrison & Bourke, 2009; Robert G. Lockie et al., 2012; Markovic & Mikulic, 2010; Rumpf et al., 2016; Spinks et al., 2007). However, football players usually perform these methods simultaneously in training and matches (Mendiguchia et al., 2015), which confirm that high explosive running speed is an important quality for sprinting in football.

To implement strength training during the competition season seems to increase both maximal strength and short sprint improvements (Styles et al., 2016), and the combination of strength training and sprint training seem to be good for the purpose of improving sprinting ability in football players (Wong et al., 2010). The demands of SSG, like the 4 vs 4 and 8vs 8 games, develop more power actions and fatigue through its continuous acceleration and deceleration actions, while the high speed running demands improves sprints performance in football (Rebelo et al., 2016).

### **5.1.2 Secondary outcome measure**

In the present study, no significant correlation could be found between the difference in hamstring strength (N) and difference in sprint time (s). An extremely small tendency ( $\beta = -6.74 \cdot 10^{-5}$ ) was seen between left-sided difference in hamstring strength and difference in

sprint time, but the decrease is so small that an increase of 100 units N in left-sided hamstring strength is needed for a decrease in sprint time of -0,0067s. The right-sided hamstring strength difference indicated no such decrease in sprint time ( $\beta=3.79 \cdot 10^{-6}$ ). The numbers are so small ( $\Delta 100 = -0,0067s$ ) that any effects found, need to be interpreted with caution as the results of the correlation can only be considered as coincidental. From the hamstring strength analyses (see table 5) there is great variation in mean minimum (min.) and maximum (max.) values (N), shown by left-sided min. -342,3 and max. 88, and right-sided min. -381,1 and max.123,9. This might indicate that one player has a considerable decrease in muscle strength between test 2 and test 1, which has a great impact on the mean result due to the small sample size. Such a decrease in hamstring strength can only be considered as coincidental, but due to the sample size it can have an impact on the results. There is a need for further studies looking into the correlation between difference in hamstring strength (N) and difference in sprint time (s).

### **5.1.3 Factors possibly influencing the results**

#### *Prevention programme, not performance enhancing*

There is no specific element in the 11+ that focus on improving sprint performance. The 11+, as presented today, is an injury prevention warm-up and not a performance-enhancing program, as it lacks the basic elements of explosive strength, power and sprint training. There are some strength elements included in the 11+, but not with the resistance and emphasis required to elicit improvements in sprint performance. There is probably a need for more explosive strength and power than what is presented in the 11+ today. The 11+ includes three running drills with focus on bouncing, cutting and increasing runs across the pitch, but there are no elements of the sprint specific drills that focus on correct mechanics in sprint performance, neither are the running drills at full speed.

The 11+ includes exercises that are easy to implement on a football pitch without a great deal of equipment, and the strength training benefits suffer because of the need to only use body resistance. The sprint performance could possibly improve slightly through the current running drills. The focus of the current 11+ is, however, not performance enhancing by performing these drills at full sprints, but rather a preparation for further football practice and decreasing injury rate.

To increase sprint performance, the running drills in the 11+ would most likely need to be performed at an explosive speed, some specific drills to improve running mechanics need to be added, and the strength elements included needs to involve more power and explosive elements. Elements of agility and plyometric exercises should also be added, and more focus on change of direction elements could help improve the 11+ into a performance enhancing warm-up programme.

### *Dose-response*

The lack of effect on sprint time can be associated with the dose-response of the strength elements in the 11+. Strength and power training has a positive influences on muscle architecture, movement speed, intramuscular coordination, and sprint technique (Rumpf et al., 2016), which are all important elements of sprinting. There is also a strong relationship between maximum strength and sprint acceleration performance, as many sprints are initiated by a moving start and high explosive speed can then be achieved (Rumpf et al., 2016). In football high levels of strength training and power are related to improving sprinting ability (Otero-Esquina et al., 2017; Sander et al., 2013; Styles et al., 2016). For the purpose of increase maximum strength in football players muscular strength training should consist of 4 sets of 85-90 percent of 1RM and exposure frequency should be 2 sessions per week (Otero-Esquina et al., 2017; Sander et al., 2013; Styles et al., 2016; Wong et al., 2010). The dose-response in the 11+ does have a moderate effect on hamstring and adductor strength (Haroy et al., 2017), however the dose-response was not great enough for developing maximum strength or power (Husbands, 2013; Raastad et al., 2010). The dose-response in the 11+ might be adequate to give an increase in muscle strength sufficient enough to prevent muscle injuries (Haroy et al., 2017), but for the purpose of developing power, and maximum strength the dose-response needs to be increased (Husbands, 2013; Raastad et al., 2010).

### *Compliance*

In the present study, the compliance was considered high in both groups (88 percent NH group, 90 percent CA group). The rates in the present study are high compared to other studies examining the effect of the 11+ (Owoeye et al., 2014; Silvers-Granelli et al., 2015; Soligard et al., 2008; Steffen, Emery, et al., 2013). Of the studies examining the effect of 11+ on sprint time (Bizzini et al., 2013; Impellizzeri et al., 2013; Reis et al., 2013) only Reis et al. (2013) reported on compliance, which was 90 percent in their study.

Compliance is an important element that can affect the study results significantly (Laake et al., 2007). An association between compliance and the injury prevention effects of the 11+ have been indicated by previous studies (Bizzini & Dvorak, 2015; Owoeye et al., 2014; Silvers-Granelli et al., 2015; Soligard et al., 2008; Steffen, Emery, et al., 2013). The probability of attaining a reliable result was increased considering the high compliance rate of the present study. To ensure high quality in performing the exercises and then performance of a satisfactory completion of the 11+, the present study had two physiotherapists present at every training with responsibility for, and controlling, performances.

#### *Intervention period*

The time period in which the intervention took place might have an impact on performance. The study was completed in the preseason, which is the period where most players and teams try to include a lot of resistance training and running. Although an assessment on this issue was identified, and an effort was made to control and register the resistance training done in both team trainings and individually, there still is a chance some players under-reported. In comparison to other studies examining sprint time Reis et al. (2013) and Bizzini et al., (2013) did not report when the intervention period took place, while Impellizzeri et al. (2013) reported their intervention period took place in preseason. Considering the variation in results it does not seem like timing of the intervention period does not make a significant impact.

#### *Playing level*

The study failed to report a sprint effect, there was no significant difference between groups or within groups. This could be association with the level of fitness for these U19 elite players. The 11+ is primarily designed for amateur or recreational football players (FIFA, 2007). As the subjects in this study were adolescent elite football players, it would be a fair assessment that their daily training load might exceed the strength protocol in this intervention. The average training load was 10,3 hours in the NH group and 10,2 hours in the CA group, which included football training, individual training and match play, as is presented in table 2. As these adolescent elite football players have a greater baseline neuromuscular performance, the program may require additional loading progressions to produce a significant increase in performance parameters, for example volume and intensity (Barengo et al., 2014). Given this information it would be a fair assessment that the training load could be considered too low for any significant improvements from the intervention to be made. Other studies that found increased effects from the 11+, observed subjects on either

amateur level (Impellizzeri et al., 2013) or sub-elite football players (Bizzini et al., 2013). Reis et al. (2013), who showed increase in sprint results, did not report at what level their subjects were playing.

### *Age*

The mean age in the study was 16.8 years, which is 0,5 years younger than reported by Reis et al. (2013), and as much as 6 and 7 years younger than the mean age reported by Bizzini et al. (2013) and Impellizzeri et al. (2013). By comparison, Reis et al. (2013) showed an increase in sprint times in their study, however Impellizzeri et al. (2013) did not find any improvements. Considering that physical ability develops considerably in this age period, a comparison to these studies will be more difficult.

## **5.2 Discussion of methodological considerations**

### **5.2.1 Subjects**

It is important to strive for a homogenous subject group to ensure the internal validity of a study (Laake et al., 2007). The two groups in the present study were similar in demographic data and training exposure at baseline. The mean age of the subjects was 16.8 years and is therefore representative for adolescent elite football players, which is considered to be 15-19 years. The similarity in mean age of the subjects between this study and the study by Reis et al. (2013) makes it possible to compare the results on sprint time. In contrary, transferability of the results from Impellizzeri et al. (2013) is not possible due to the opposite reason. As the subjects were male the results are only representative for that gender. Considering the results produced might have been different if the population was sub-elite male or female the results have less of transferability to different populations. The subjects in the present study were playing at elite level which is very different from the level reported in the other studies assessing effects of the 11+ on performance parameters, such as sprint times, which might have given smaller effects and could have affected the results negatively.

The number of subjects involved in a study is significant for the outcome of the study (Laake et al., 2007). A more accurate assumption about the population can be made from the observations with a larger sample size (Laake et al., 2007). The present study included a total of 33 players in the per-protocol analyses, which is similar to two of the other studies examining the sprint effects of the 11+ (Bizzini et al., 2013; Reis et al., 2013), ranging from



20-36 players. However, in the study by Impellizzeri et al. (2013) a total of 80 players were included, which makes the results from their study considered to have a higher validity. The small number of subjects in the present study was a limitation and reduced the validity of the results. To increase the number of participants we would have had to include more football clubs to ensure homogeneity equal to age and equal level.

### **5.2.2 Study design**

The present study was part of a larger RCT examining the effects of an intervention, which is the preferred design (Laake et al., 2007). RCT is the preferred design for preventing systematic bias and avoiding confounding factors to influence the results (Laake et al., 2007). The RCT study design increases the certainty that the effects of the intervention are real, and not due to other confounding factors. The study design is therefore considered a methodological strength.

#### *Randomization and blinding*

Randomization of the subjects ensures a high internal validity of a study when executed right (Laake et al., 2007). In this study the players were individually randomized into one of the two intervention groups and stratified according to teams. Each player received a sealed envelope with his group assignment made from a computerized random number generator, and the study consequently limited the contamination between the two groups. This form of randomization ensures that selection bias is reduced between the groups compared, which allows a true effect of the intervention to be obtained (Laake et al., 2007).

Blinding of the subjects strengthens the validity of a study by ensuring that the registration and interpretation of data is not influenced by subjective assumptions on the effects in favour, or disfavour, of the treatment (Laake et al., 2007). The testers in the present study were blinded to group allocation. In addition, the principal investigator was blinded to all data registration, as all pre and post testing results were registered and handled by the two physiotherapists assigned to the clubs, and then handled by an independent data manager. The players were not blinded to each other's intervention type and could therefore have performed exercises from both groups during training. However, the risk of this type of contamination is reduced to a minimum, considering two physiotherapists supervised every training session weekly and recorded if a player performed any other hamstring or hip adductor strength

exercises during their individual training sessions. As shown in figure 2, the two players that performed extensive hip adductor strength training during the intervention period were not included in the per protocol analyses. Anyhow, it is unlikely that the effects of the intervention in the two groups are influenced by placebo, nor the motivation of the players as they all performed training exercises.

### *Control group*

In the present study, the two groups acted as each other's control group. The lack of a control group that performed a "normal" warm-up is a significant weakness of the present study. The downside to not using a control group is that any results reported would lack a control reference, which makes it difficult to conclude any effects of the improvements found. However, the two groups give a control reference to each other in that the NH group follows the 11+ as described and can be considered a control group for the CA group. To increase the validity of the present study a three-armed RCT could have been used, with the two intervention groups and a control group. This might have given a more true effect of the 11+ and 11+CA, but this would require a greater number of participants to obtain 80 percent power, and the financial cost would be a great deal higher.

### **5.2.3 Statistical analysis**

The preferred statistical analysis used in this thesis was a per protocol analysis, which shows the specific effect of the intervention on sprint performance. There was a predetermined minimum compliance limit set at 16 training sessions (67 percent). The use of a per protocol could be considered a weakness in accordance to Laake et al. (2007) since no intention-to-treat analysis was performed. As dropout would be considered normal in the real world a per-protocol analysis might be considered as not reflecting reality. Although the CONSORT statement (Moher et al., 2012) advocates the use of intention-to-treat analyses for RCT results, the per-protocol analyses have a stronger focus on the potential efficacy of the intervention (Laake et al., 2007). Poor compliance to the intervention tends to weaken the treatment effects when performing intention-to-treat analyses. However, since the potential efficacy of the intervention was of interest only participants who complied with the specific intervention as planned were interesting to our analysis. The per-protocol analysis was therefore considered a strength in the present study, increasing the possibility of achieving a reliable result.

### *Sample size calculation*

A relevant weakness to this statistical analysis is the sample size calculation. The sample size for the 11+ study was based on a previous study examining strength effect on Copenhagen Adduction. When intended for sprint analysis the sample size is considered small and inaccurate. For future research of the effects of improving sprint times, sample size calculation need to be based on previous studies examining the effects of exactly that. Neither Reis et al. (2013) or Bizzini et al. (2013) report their sample size calculation while Impellizzeri et al. (2013) report a calculated sample size of  $n = 42$  needed for detecting a small effect size 0.05 alpha level and target power of 0.80. However, these calculations were not based on finding the effect of sprint time. To be able to find sprint effects from the result found in the present study, the sample size will have to increase, considering the effects seen in the present results are very small ( $\Delta 100 = -0,0067s$ ).

### **5.3 Clinical implications**

The present RCT showed no effect on sprint time. More specific, the results show no improvements in sprinting ability at the time intervals of 0-5, 0-10, 0-15, or 0-20 metres and no correlation between hamstring strength and sprint time between the two groups. These results are equivalent to the majority of the studies found on the performance enhancing effect of the 11+ prevention programme (Bizzini et al., 2013; Impellizzeri et al., 2013; Reis et al., 2013). The 11+ is primarily an injury prevention programme and any increase in performance enhancing ability would be beneficial, but not expected. For the purpose of improving sprinting ability in football, the 11+ would not be the preferred training protocol.

### **5.4 Future research**

The quality of the present study was considered to be level 1, however the effects on sprint time (s) by performing the 11+ warm-up programme could not be confirmed due to the sample size calculations being low. For anyone to conclude with whether the 11+ could improve sprinting ability in football players there is a need for more high-quality RCTs on the performance enhancing effects of the different elements of the 11+. The 11+-prevention programme has shown results in regards to preventing injuries (Bizzini & Dvorak, 2015; Owoeye et al., 2014; Silvers-Granelli et al., 2015; Soligard et al., 2008; Steffen, Emery, et al.,

2013), but more research on the dose-response and intensity of exercises would be beneficial to increase the understanding of importance, so that implementation of the programme in more warm-up routines will increase.

## **6. Conclusions**

The results from the present RCT could not produce any sprint effect from the 11+. There were no overall within-group or between-group differences in running speed at any of the time intervals. With regard to the secondary outcomes there were no correlation between the difference in hamstring strength (post-test – pre-test) and sprint times (post-test – pre-test). There is a need for more high-quality research on the performance enhancing effects of the 11+ in regards to sprinting ability.



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## ACRONYMS

11+	The FIFA 11+ prevention programme
CA	The Copenhagen Adduction exercise
NH	The Nordic Hamstring exercise
FIFA	Fédération Internationale de Football Association
RCT	Randomised Controlled Trial
m.	Muscle
mm.	Muscle group (multiple muscles)
MRI	Magnetic resonance imaging
1RM	1 repetition maximum
CSR	conventional strength ratio
DCR	dynamic control ratio
FSR	fast/slow speed ratio
CMJ	counter-movement jumps
SSG	small-sided games



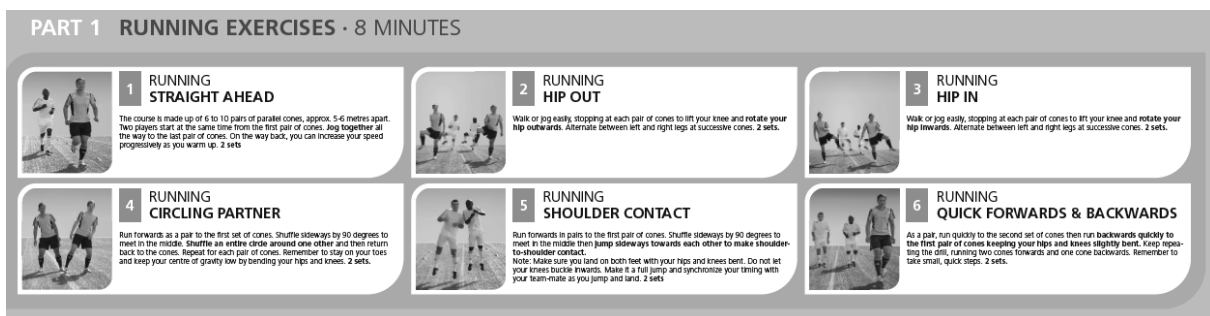


## APPENDIX A. The FIFA 11+ prevention programme

The Fédération Internationale de Football Association (FIFA, 2007), with representatives from the Oslo Sports Trauma Research Center, the Santa Monica Orthopaedic and Sports Medicine Research Foundation, and the FIFA Medical Assessment and Research Centre, convened an expert group to develop the prevention warm-up program, FIFA 11+.

The FIFA 11+ program is a warm-up programme which consists of three parts (picture 1-3) as described below by Soligard et al. (2008). It consists of a total of 15 exercises, which should be performed in a specified sequence at the start of each training session.

The initial part (picture 1) is running exercises at slow speed combined with active stretching and controlled contacts with a partner. The running course includes six to ten pairs of cones (depending on the number of players) about five to six meters apart (length and width).



Picture 1. Running exercises FIFA 11+ (Soligard et al., 2008), illustration FIFA.com.

The second part (picture 2) consists of six different sets of exercises; these include strength, balance, and jumping exercises, each with three levels of increasing difficulty.

**PART 2 STRENGTH · PLYOMETRICS · BALANCE · 10 MINUTES**

LEVEL 1		LEVEL 2		LEVEL 3	
<b>7 THE BENCH STATIC</b> Starting position: Lie on your front, supporting yourself on your forearms and feet. Your elbows should be directly under your shoulders. Exercise: Lift your body up, supported on your forearms, and pull your stomach in, and hold the position for 20-30 sec. Your body should be in a straight line. Try not to sway or arch your back. 3 sets.	<b>7 THE BENCH ALTERNATE LEGS</b> Starting position: Lie on your front, supporting yourself on your forearms and feet. Your elbows should be directly under your shoulders. Exercise: Lift your body up, supported on your forearms, and pull your stomach in. Lift each leg in turn, holding for a count of 2 sec. Continue for 40-60 sec. Your body should be in a straight line. Try not to sway or arch your back. 3 sets.	<b>7 THE BENCH ONE LEG LIFT AND HOLD</b> Starting position: Lie on your front, supporting yourself on your forearms and feet. Your elbows should be directly under your shoulders. Exercise: Lift your body up, supported on your forearms, and pull your stomach in. Lift one leg about 10-15 centimetres off the ground, and hold the position for 20-30 sec. Your body should be straight. Do not let your opposite hip dip down and do not sway on each your lower back. Take a short break, change legs and repeat. 3 sets.			
<b>8 SIDEWAYS BENCH STATIC</b> Starting position: Lie on your side with the knee of your lowermost leg bent to 90 degrees. Support your upper body by resting on your forearm and knee. The elbow of your supporting arm should be directly under your shoulder. Exercise: Lift your uppermost leg and hips until your shoulder, hip and knee are in a straight line. Hold the position for 20-30 sec. Take a short break, change sides and repeat. 3 sets on each side.	<b>8 SIDEWAYS BENCH RAISE &amp; LOWER HIP</b> Starting position: Lie on your side with both legs straight. Lean on your forearm and the side of your foot so that your body is in a straight line from shoulder to foot. The elbow of your supporting arm should be directly beneath your shoulder. Exercise: Lower your hip to the ground and raise it back up again. Repeat for 20-30 sec. Take a short break, change side and repeat. 3 sets on each side.	<b>8 SIDEWAYS BENCH WITH LEG LIFT</b> Starting position: Lie on your side with both legs straight. Lean on your forearm and the side of your foot so that your body is in a straight line from shoulder to foot. The elbow of your supporting arm should be directly beneath your shoulder. Exercise: Lift your uppermost leg up and slowly lower it down again. Repeat for 20-30 sec. Take a short break, change sides and repeat. 3 sets on each side.			
<b>9 HAMSTRINGS BEGINNER</b> Starting position: Kneel on a soft surface. Ask your partner to hold your ankles down firmly. Exercise: Your body should be completely straight from the shoulder to the knee throughout the exercise. Lean forward as far as you can, controlling the movement with your hamstrings and your gluteal muscles. When you can no longer hold the position, gently take your weight on your hands, falling into a push-up position. Complete a minimum of 3-5 repetitions and/or 60 sec. 1 set.	<b>9 HAMSTRINGS INTERMEDIATE</b> Starting position: Kneel on a soft surface. Ask your partner to hold your ankles down firmly. Exercise: Your body should be completely straight from the shoulder to the knee throughout the exercise. Lean forward as far as you can, controlling the movement with your hamstrings and your gluteal muscles. When you can no longer hold the position, gently take your weight on your hands, falling into a push-up position. Complete a minimum of 7-10 repetitions and/or 60 sec. 1 set.	<b>9 HAMSTRINGS ADVANCED</b> Starting position: Kneel on a soft surface. Ask your partner to hold your ankles down firmly. Exercise: Your body should be completely straight from the shoulder to the knee throughout the exercise. Lean forward as far as you can, controlling the movement with your hamstrings and your gluteal muscles. When you can no longer hold the position, gently take your weight on your hands, falling into a push-up position. Complete a minimum of 12-15 repetitions and/or 60 sec. 1 set.			
<b>10 SINGLE-LEG STANCE HOLD THE BALL</b> Starting position: Stand on one leg. Exercise: Balance on one leg whilst holding the ball with both hands. Keep your body weight on the ball or your foot. Remember: try not to let your knees buckle inwards. Hold for 30 sec. Change legs and repeat. The exercise can be made more difficult by passing the ball around your waist and/or under your other knee. 2 sets.	<b>10 SINGLE-LEG STANCE THROWING BALL WITH PARTNER</b> Starting position: Stand 2-3 m apart from your partner, with each of you standing on one leg. Exercise: Keeping your balance, and with your stomach held in, throw the ball to one another. Keep your weight on the ball of your foot. Remember: keep your knee just slightly flexed and try not to let it buckle inwards. Keep going for 30 sec. Change legs and repeat. 2 sets.	<b>10 SINGLE-LEG STANCE TEST YOUR PARTNER</b> Starting position: Stand on one leg opposite your partner and at arm's length apart. Exercise: Whilst you both try to keep your balance, each of you in turn tries to push the other off balance in different directions. Try to keep your weight on the ball of your foot and prevent your knee from buckling inwards. Continue for 30 sec. Change legs. 2 sets.			
<b>11 SQUATS WITH TOE RAISE</b> Starting position: Stand with your feet hip-width apart. Place your hands on your hips if you like. Exercise: Imagine that you are about to sit down on a chair. Perform squats by bending your hips and knees to 90 degrees. Do not let your knees buckle inwards. Descend slowly then straighten up more quickly. When your legs are completely straight, stand up on your toes then slowly lower down again. Repeat the exercise for 30 sec. 2 sets.	<b>11 SQUATS WALKING LUNGES</b> Starting position: Stand with your feet hip-width apart. Place your hands on your hips if you like. Exercise: Lunge forward slowly at an even pace. As you lunge, bend your leading leg until your hip and knee are flexed to 90 degrees. Do not let your knee buckle inwards. Try to keep your upper body and hips steady. Lunge your way across the pitch (approx. 10 times on each leg) and then jog back. 2 sets.	<b>11 SQUATS ONE-LEG SQUATS</b> Starting position: Stand on one leg, loosely holding onto your partner. Exercise: Slowly bend your knee as far as you can manage. Concentrate on preventing the knee from buckling inwards. Bend your knee slowly then straighten it slightly more quickly, keeping your hips and upper body in line. Repeat the exercise 10 times on each leg. 2 sets.			
<b>12 JUMPING VERTICAL JUMPS</b> Starting position: Stand with your feet hip-width apart. Place your hands on your hips if you like. Exercise: Imagine that you are about to sit down on a chair. Bend your legs slowly until your knees are flexed to approx 90 degrees, and hold for 2 sec. Do not let your knees buckle inwards. From the squat position, jump up as high as you can. Land softly on the balls of your feet with your hips and knees slightly bent. Repeat the exercise for 30 sec. 2 sets.	<b>12 JUMPING LATERAL JUMPS</b> Starting position: Stand on one leg with your upper body bent slightly forwards from the waist, with knees and hips slightly bent. Exercise: Jump approx. 1 m sideways from the supporting leg on to the free leg. Land gently on the ball of your foot. Bend your hips and knees slightly as you land and do not let your knee buckle inward. Maintain your balance with each jump. Repeat the exercise for 30 sec. 2 sets.	<b>12 JUMPING BOX JUMPS</b> Starting position: Stand with your feet hip-width apart. Imagine that there is a cross marked on the ground and you are standing in the middle of it. Exercise: Alternate between jumping forwards and backwards, from side to side, and diagonally across the cross. Jump as quickly and explosively as possible. Your knees and hips should be slightly bent. Land softly on the balls of your feet. Do not let your knees buckle inwards. Repeat the exercise for 30 sec. 2 sets.			

Picture 2. Strength exercises FIFA 11+ (Soligard et al., 2008), illustration FIFA.com.

The final part (picture 3) is speed running combined with football specific movements with sudden changes in direction.

**PART 3 RUNNING EXERCISES · 2 MINUTES**

<b>13 RUNNING ACROSS THE PITCH</b> Run across the pitch, from one side to the other, at 75-80% maximum pace. 2 sets.	<b>14 RUNNING BOUNDING</b> Run with high bounding steps with a high knee lift, landing gently on the ball of your foot. Use an exaggerated arm swing for each step (opposite arm and leg). Try not to let your leading leg cross the midline of your body or let your knees buckle inwards. Repeat the exercise until you reach the other side of the pitch, then jog back to recover. 2 sets.	<b>15 RUNNING PLANT &amp; CUT</b> Jog 4-5 steps, then plant on the outside leg and cut to change direction. Accelerate and sprint 5-7 steps at high speed (80-90% maximum pace) before you decelerate and do a new plant & cut. Do not let your knee buckle inwards. Repeat the exercise until you reach the other side, then jog back. 2 sets.
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Picture 3. Running exercises FIFA 11+ (Soligard et al., 2008), illustration FIFA.com.

## APPENDIX B. The Nordic Hamstrings exercise

The Nordic Hamstring exercise (Soligard et al., 2008), as shown in fig. 1, is a partner exercise within the FIFA 11+ program, where the subject attempts to resist a forward-falling motion using his or her hamstrings to maximize loading in the eccentric phase. The subject is asked to keep his or her hips fixed in a slightly flexed position throughout the whole range of motion, and to brake the forward fall for as long as possible using his or her hamstrings. The aim is to try to keep tension in the hamstrings even after one has to “let go”, use the arms and hands to buffer the fall, let the chest touch the surface briefly, then immediately get back to the starting position by forcefully pushing-off with the arms and hands to minimize loading in the concentric phase.

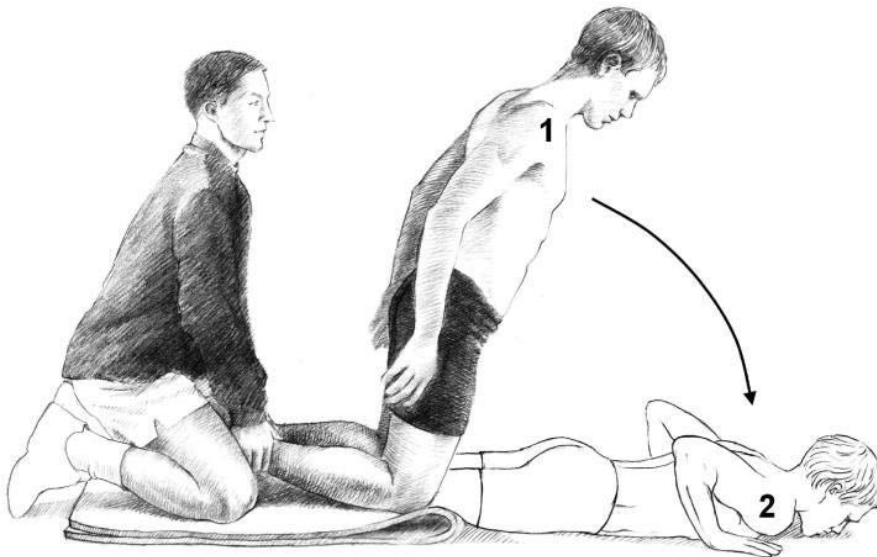


Figure 1 shows start (Todd et al.) and end (2) position of the Nordic hamstring (Arnason et al., 2008).



## APPENDIX C. REK approval



<b>Region:</b> REK sør-øst	<b>Saksbehandler:</b> Jakob Elster	<b>Telefon:</b> 22845530	<b>Vår dato:</b> 19.11.2015	<b>Vår referanse:</b> 2015/1921 REK sør-øst B
			<b>Deres dato:</b> 22.09.2015	<b>Deres referanse:</b>

Vår referanse må oppgis ved alle henvendelser

Joar Harøy  
Norges Idrettshøgskole

### 2015/1921 Bør Copenhagen adduction legges til The 11+

**Forskningsansvarlig:** Norges Idrettshøgskole  
**Prosjektleder:** Joar Harøy

Vi viser til søknad om forhåndsgodkjenning av ovennevnte forskningsprosjekt. Søknaden ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk (REK sør-øst) i møtet 28.10.2015. Vurderingen er gjort med hjemmel i helseforskningsloven (hfl.) § 10, jf. forskningsetikkloven § 4.

#### Prosjektleders prosjektbeskrivelse

*"Dette prosjektet bygger videre på resultatene fra prevalensstudien som vist høy forekomst av lyskeproblemer på flere nivå i norsk fotball. Vi mener at The 11+ mangler øvelser som øker styrken i hofteadduktoren og ønsker derfor å undersøke om 8 uker med The 11+ med copenhagen adduction kan gi en styrkeøkning i hofteadduktorene. Et eventuelt positivt resultat vil brukes til å anbefale at copenhagen adduction bør inn i the 11+. Vi ønsker å gjennomføre en randomisert kontrollert studie med fotballspillere som deltagere der en gruppe gjennomfører The 11+ som normalt tre ganger i uken, mens den andre gruppen gjennomfører The 11+ der vi bytter nordic hamstring med copenhagen adduction. Også denne gruppen gjennomfører tre ganger i uken. I begge gruppene vil en fysioterapeut stå for gjennomføringen av alle treningsøktene. Alle deltagere vil før og etter treningsperioden bli testet i hamstringstyrke (nordboard) og styrke i hofteadduksjon (dynamometer) og 40m sprint."*

#### Komiteens vurdering

Helseforskningsloven gjelder for medisinsk og helsefaglig forskning, det vil si «virksomhet som utføres med vitenskapelig metodikk for å skaffe til veie ny kunnskap om helse og sykdom», jf. helseforskningsloven § 2, jf. § 4. Dette prosjektet skal prøve ut et nytt treningsprogram for unge fotballspillere og måler styrkeeffekt som en følge av dette. Formålet med prosjektet er å redusere omfanget av lyskeskade, og måling av styrke er relevant, da redusert styrke i hofteadduktorer i henhold til søknaden er en risikofaktor for lyskeskader. Siden formålet med prosjektet er å undersøke effekten av at skadereduserende tiltak, anser komiteen at prosjektet omfattes av helseforskningslovens virkeområde.

#### Frivillighet

Deltakere i prosjektet er mannlige fotballspillere som er tilknyttet fotballklubb i junior interkrets (U19) serie. Dette inkluderer deltakere mellom 16 og 18 år. Man skal inkludere 40-50 deltakere.

Deltakerne rekrutteres ved at man inviterer til fotballklubber med 20-25 spillere hver til å delta. Det ser her ut til at man regner med at alle som inviteres til å delta vil takke ja, i og med at man trenger 40-50 deltakere og skal invitere til klubber med til sammen 40-50 deltakere. Når spillerne rekrutteres via fotballklubben, kan

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Gullhaugveien 1-3, 0484 Oslo

Telefon: 22845511  
E-post: post@helseforskning.etikkom.no  
Web: <http://helseforskning.etikkom.no/>

All post og e-post som inngår i saksbehandlingen, bes adressert til REK sør-øst og ikke til enkelte personer

Kindly address all mail and e-mails to the Regional Ethics Committee, REK sør-øst, not to individual staff

det også oppstå et visst press om å delta. Komiteen vil understreke at deltakelse i forskning skal være frivillig, og forutsetter at man bestreber seg på å unngå enhver form for press på fotballspillerne.

Under denne forutsetningen har prosjektet ingen forskningsetiske innvendinger til at prosjektet gjennomføres.

#### *Informasjons- og samtykkeskriv*

Det vedlagte informasjons- og samtykkeskrivet bør revideres på enkelte punkter:

- Det står at studien er «en viktig brikke i arbeidet med å redusere omfanget av skulderproblemer». Dette ser ikke ut til å passe med den aktuelle studien.

- Det står at hvis man trekker sitt samtykke, vil dette ikke få konsekvenser for videre behandling. I og med at det her ikke dreier seg om behandling, bør dette endres.

- Det kreves ikke skriftlig samtykke fra foresatte, i og med at deltakerne er fylt 16 år. Plass for underskrift fra foresatt bør derfor fjernes fra samtykkeskjemaet.

Ut fra dette setter komiteen følgende vilkår for prosjektet:

- Informasjonsskrivet revideres i tråd med komiteens merknader og sendes komiteen til orientering.

#### **Vedtak**

Komiteen godkjenner prosjektet i henhold til helseforskningsloven § 9 og § 33 under forutsetning av at ovennevnte vilkår oppfylles.

I tillegg til ovennevnte vilkår, er godkjenningen gitt under forutsetning av at prosjektet gjennomføres slik det er beskrevet i søknaden.

Tillatelsen gjelder til 01.08.2016. Av dokumentasjonshensyn skal opplysningene likevel bevares inntil 01.08.2021. Opplysningene skal lagres aidentifisert, dvs. atskilt i en nøkkel- og en opplysningsfil. Opplysningene skal deretter slettes eller anonymiseres, senest innen et halvt år fra denne dato.

Forskningsprosjektets data skal oppbevares forsvarlig, se personopplysningsforskriften kapittel 2, og Helsedirektoratets veileder "*Personvern og informasjonssikkerhet i forskningsprosjekter innenfor helse- og omsorgssektoren*"

#### *Sluttmelding og søknad om prosjektendring*

Dersom det skal gjøres endringer i prosjektet i forhold til de opplysninger som er gitt i søknaden, må prosjektleder sende endringsmelding til REK. Prosjektet skal sende sluttmelding på eget skjema, se helseforskningsloven § 12, senest et halvt år etter prosjektslutt.

#### *Klageadgang*

Du kan klage på komiteens vedtak, jf. forvaltningslovens § 28 flg. Klagen sendes til REK sør-øst B. Klagefristen er tre uker fra du mottar dette brevet. Dersom vedtaket opprettholdes av REK sør-øst B, sendes klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag for endelig vurdering.

Komiteens avgjørelse var enstemmig.

Med vennlig hilsen

Grete Dyb  
førsteamanuensis dr. med.  
leder REK sør-øst B

Jakob Elster  
Seniorrådgiver

## APPENDIX D. Consent Form



### FORESPØRSEL OM DELTAKELSE I PROSJEKTET:

#### ***"Bør Copenhagen adduction legges til i 11+? - En randomisert kontrollert studie"***

##### **Bakgrunn for prosjektet**

Lyskeproblemer i fotball har over lang tid vært et aktuelt tema både i media og i forskningssammenheng. I en kartleggingsstudie vi gjennomførte på ulike nivå og begge kjønn i løpet av vårsesongen i 2015 fikk vi bekreftet at lyskeproblemer er et utbredt problem, og at forebyggende tiltak er nødvendig. I løpet av sesongen hadde gjennomsnittlig 30% av spillerne, på alle nivå, symptomer fra lysken. De oppgav at de måtte redusere treningsmengden og opplevde at de ikke presterte optimalt. Formålet med det kommende prosjektet vil være å følge opp disse resultatene og undersøke om oppvarmingsprogrammet "11+" har med øvelser som bidrar til å øke styrken i lyskemuskulaturen. Resultatene fra denne undersøkelsen vil være til stor nytte for norsk fotball, da "11+" benyttes til oppvarming i mange klubber på ulike nivå.

Senter for idrettsskadeforskning er en forskningsgruppe bestående av fysioterapeuter, kirurger og biomekanikere med kunnskap innen idrettsmedisin. Vår hovedmålsetting er å forebygge skader i norsk idrett, med spesiell satsning på håndball, fotball, ski og snowboard. Denne studien er en viktig brikke i arbeidet med å redusere omfanget av lyskeproblemer. Vi ønsker nå å undersøke effekten av et forebyggingsprogram som har til hensikt å redusere utbredelsen av lyskeproblemer i norsk fotball.

##### **Gjennomføring av prosjektet**

Vi ønsker at du som spiller i junior interkrets deltar i denne studien, og deltakelsen er frivillig. I løpet av en trening i sesongoppkjøring til 2016 sesongen vil vi gjennomføre tester for å måle styrken i muskulatur rundt hoftelrådet samt 40m sprinttest. Testing vil ta ca. 1 time og bli gjennomført på samme måte også etter at prosjektet er avsluttet om 8 uker. I tillegg vil laget 3 ganger i uken gjennomføre "11+" som oppvarming før trening.

##### **Hva skjer med informasjonen om deg?**

Vi vil etter den 8 ukers treningsperioden undersøke om det er forskjell i styrke og hurtighet før og etter laget benyttet "11+" til oppvarming. Informasjonen som registreres om deg skal kun brukes slik som beskrevet i hensikten med studien. Alle opplysningene vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende. Dataene vil bli behandlet konfidensielt, kun i forskningsøyemed og vil bli anonymisert ved prosjektets slutt, 01.08.2018. Alle som deltar i gjennomføring av prosjektet og forskere som benytter dataene er underlagt taushetsplikt.

##### **Angrer du?**

Det er frivillig å delta i studien. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke til å delta i studien. Dersom du ønsker å delta, undertegner du samtykkeerklæringen på siste side. Om du nå sier ja til å delta, kan du senere trekke tilbake ditt samtykke uten at det påvirker din øvrige behandling.

##### **Spørsmål?**

Ring gjerne til Joar Harøy, tlf.: 971 95 435 dersom du har spørsmål om prosjektet, eller send e-post til [joar.haroy@nih.no](mailto:joar.haroy@nih.no).

**"Bør Copenhagen adduction legges til i 11+?  
- En randomisert kontrollert studie"**

**SAMTYKKEERKLÆRING**

Jeg har mottatt skriftlig og muntlig informasjon om studien *"Bør Copenhagen adduction legges til i 11+? - En randomisert kontrollert studie"*.  
Jeg er klar over at jeg kan trekke meg på et hvilket som helst tidspunkt.

.....  
Sted

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Dato

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**Emne:** SV: Tillatelse til å bruke tabell i masteroppgave  
**Dato:** 10. oktober 2017 kl. 13.42  
**Til:** Linn Rolstad l\_rolstad@hotmail.com



Hej Linn

Du får gjerne använda tabellen ( med sedvanlig hänvisning förstås).

Lycka till

Hälsningar

Jan Ekstrand

---

UEFA Injury Study Group  
Professor Jan Ekstrand, MD, PhD  
Home address: Hertig Karlsgatan 13B, 582 21 Linköping, Sweden  
Mob: +46 70 515 6393  
Twitter: @JanEkstrand  
Website: [www.footballresearchgroup.eu](http://www.footballresearchgroup.eu)

---

**Från:** Linn Rolstad [mailto:l\_rolstad@hotmail.com]  
**Skickat:** den 10 oktober 2017 13:36  
**Till:** jan.ekstrand@telia.com  
**Ämne:** Tillatelse til å bruke tabell i masteroppgave

Hei Jan,

jeg skriver ferdig min masteroppgave i idrettsfysioterapi ved Norges Idrettshøgskole og ønsker i den forbindelse å bruke deler av en tabell publisert ideres artikkel "Return to play following muscle injuries in professional footballers" Journal of Sports Sciences, 2014. Vol. 32, No. 13, 1229–1236, <http://dx.doi.org/10.1080/02640414.2014.905695>, side 1230 "Table I. Operational definitions.»  
Håper på positiv tilbakemelding.

Med vennlig hilsen  
Linn E. Rolstad-Martinez  
Fysioterapeut/Manuellterapistudent  
Hans og Olaf Fysioterapi  
Mob. 911 70 549



Fra: **Ken Hathaway** kenhathaway@crowood.com   
Emne: Re: Crowood Website Enquiry - permission request  
Dato: 10. oktober 2017 kl. 12.31  
Til: Linn Rolstad l\_rolstad@hotmail.com




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A randomized controlled trial.

It will not be published other than a digital version in the school library, The Norwegian School of Sports Science, Department of Sports Science.

page 119 fig 50

page 120 fig 51 & fig 52

page 121 fig 53, 54 & 55

page 158 fig 81

there are no direct written quotes from the book

Med vennlig hilsen  
Mrs. Linn E. Rolstad-Martinez  
Fysioterapeut/Manuellterapistudent  
Hans og Olaf Fysioterapi  
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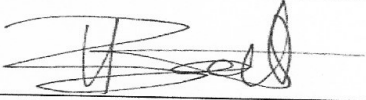
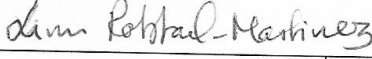
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