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Primary Prevention of Hamstring Injury - Quick Guide

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The aim of this thesis was to search for evidence-based literature regarding hamstring injury prevention. The literature was used to create and produce an educational quick guide on primary prevention of hamstring injury for the Finnish rugby community as the objective was to improve understanding and prevention of hamstring injuries amongst players and coaching staff alike.

Literature was sourced predominantly from within the last 10years except for text that was still applicable but over 10 years old. A generic search of hamstring injury produced concept and strategies across different hamstring prevention types; Primary, Secondary and Tertiary. The literature that was most applicable for this thesis was within the primary prevention category. Given the amateur status of Finnish rugby currently, primary prevention was the logical step or choice for the creation of such an educational guide.

Comprehensive literature from various clinical experts and researchers specifically in the field of hamstring injury prevention and rehabilitation was recently published (2020) from which the backbone of this thesis was based. In addition, this latest evidence-based literature formed the basis of the quick guide in primary prevention of hamstring injury.

Current literature also gave clarity to the plethora of well researched interventions, its shortfalls, and limitations as well as the reinforcement of effective approaches and considerations in creating and implementing primary prevention programmes. It was clear that eccentric based exercises such as the Nordic Hamstring Exercise, as much as it has now been studied and proven, still demanded strict adherence from staff and players alike to ensure its effectiveness.

The aim and objective of this thesis was achieved, resulting in a booklet style educational guide ready for distribution to the wider Finnish rugby community, its coaches, and players.

Key words Hamstrings, Primary prevention, Hamstring Injury, Nordic Hamstring Exercise

CONTENTS

FOREWORD

‘An ounce of prevention is worth a pound of cure’.

Benjamin Franklin (1706–1790)

Glossary of terms

BF	Biceps Femoris
BFlh	Biceps Femoris long head
BFsh	Biceps Femoris short head
ECC	Eccentric Strength Capacity
HSI	Hamstring Strain Injury
MD	Match Day
MTJ	Myotendinous Junction
MTU	Muscle Tendon Unit
NHE	Nordic Hamstring Exercise
RCT	Randomised Control Trial
ROM	Range of Motion
SM	Semimembranosus
ST	Semitendinosus

1 INTRODUCTION

Rugby is a sport which is played worldwide, across all continents. It is a very physical team sport and is considered full contact. Rugby is physically demanding and requires players to have some level of conditioning if they are to participate. Movements are explosive and requires not only changes in direction and high-speed running, but the ability to accelerate and decelerate within seconds. It is not surprising then that the probability for injury is relatively high. This thesis will focus on an exercise-based approach to minimize hamstring injury amongst rugby players in Finland. A literature search based on the most recent scientific evidence on the primary prevention of hamstring injury will provide the basis for such an approach. An educational quick guide will be created for coaching staff and players to help raise awareness and the importance of preventative exercise training for hamstring injury. This thesis is done in collaboration with the Finland Rugby Association (Suomen Rugbyliitto, SRL)

2 AIM AND OBJECTIVES

The aim of this thesis is to search for evidence-based literature regarding hamstring injury prevention. This literature will be used to create and produce an educational quick guide (electronic format) on primary prevention of hamstring injury for the Finnish rugby community as the objective is to improve understanding and prevention of hamstring injuries amongst players and coaching staff alike.

3 HAMSTRING ANATOMY AND PHYSIOLOGY

The hamstring muscle group consists of four muscles divided into two groups: (1) semitendinosus (ST) and semimembranosus (SM) form the medial group, (2) biceps femoris long head (BFlh) and biceps femoris short head (BFsh) form the lateral group. (Vermeulen 2019, 34).

As illustrated in Figure 1 the posterior muscles of the thigh, semimembranosus (SM), semitendinosus (ST), biceps femoris (BF) long head (BFlh) and short head (BFsh) are referred to as the "hamstrings". The long hamstring muscle group (SM, ST, BFlh) crosses both the hip and knee joints, therefore having a role in hip extension, knee flexion and internal (SM and ST) or external knee rotation (BF), during concentric contraction. (Thorborg, Opar & Shield 2020, 1.) As the anatomy the hamstrings are unique, it is suggested to be one of the reasons for the high incidence of injuries in this muscle group. The biarticular nature of the long hamstrings (Thelen et al. 2005, 108–14), the dual innervation of BF (Woods et al. 2004, 36–41) and the shortness of its fascicles (bundles of fibres) (Timmins et al. 2016, 1524–35) are some factors which have been proposed as reasons why hamstring anatomy influences injury risk. (Thorborg, Opar & Shield 2020, 1.)

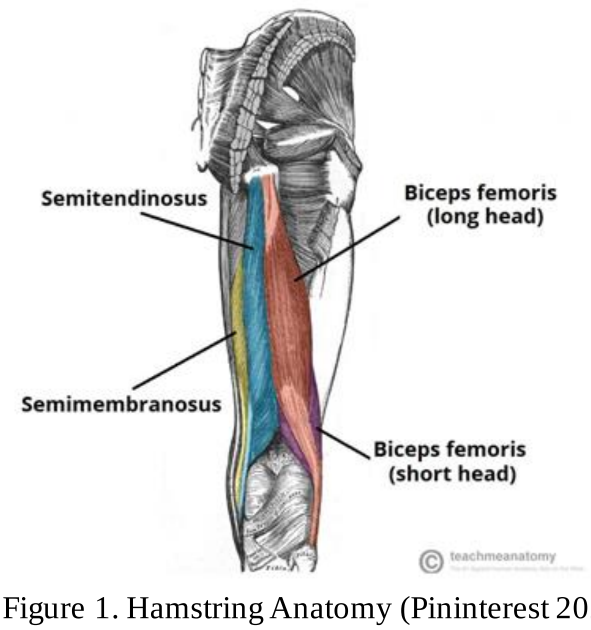

Figure 1. Hamstring Anatomy (Pininterest 2021)

Hamstrings are so named because their tendons are long and stringlike in the popliteal area. Because the hamstrings span two joints (hip and knee), they are both extensors of the thigh and flexors of the leg. (Totora & Derrickson 2009, 399.)

Muscle architecture consists of a range of characteristics that influence function. These characteristics affect a muscle’s maximal force output, shortening velocity (Lieber & Friden 2000, 1647–66) and its susceptibility to injury (Timmins et al. 2016, 1524–35). The architectural characteristics of muscle consist of two main categories: (a) muscle size and (b) fascicles orientation and length. The structure of each of the hamstrings determines its function. A point in case would be the biomechanical demand in a running movement where the hamstrings are exposed to forceful, repetitive lengthening actions. (Chumanov et al 2011, 525-532.)

Architectural characteristics namely the Biceps Femoris long head fascicle length, has been identified as a variable that can modulate the risk of future hamstring injury, and that the ability to cause adaptation to this structural characteristic may assist to guide preventative efforts. (Timmins et al, 2016, 1524-35).

3.1 Semitendinosus

Semitendinosus is one of the four muscles that make up the hamstrings muscle group. It is located at the medial and posterior aspect of the thigh and its name is derived from having a long tendon of insertion. (Physiopedia 2021c.)

The muscle structure is fusiform and tapers below the middle of the thigh in a long round tendon which is situated on the medial side of the popliteal fossa. It curves around the medial condyle of the tibia, over the medial collateral ligament of the knee-joint, from which it is separated by a bursa. It´s insertion point is the upper part of the medial surface of the body of the tibia and is nearly as far forward as its anterior crest. (Physiopedia 2021c.)

The semitendinosus is superficial compared to the semimembranosus and shares close origin and insertion points. As the semimembranosus is wider and flatter than the semitendinosus, it is possible to palpate the semimembranosus directly.

(Physiopedia 2021c.) At its insertion it gives off from its lower border a prolongation to the deep fascia of the leg and lies behind the tendon of the sartorius, and below that of the gracilis, to which it is united. These three tendons form the Pes Anserinus, named so due to its resemblance of a webbed “goose’s foot”. (Physiopedia 2021c.)

The semitendinosus arises by a common tendon origin with the long head of the biceps femoris, on the lower medial facet, lateral section of the ischial tuberosity. The semitendinosus muscle partly originates from the medial surface of the tendon of the long head of the biceps femoris, and also originates from the ischial tuberosity with a thin tendon and a muscular part. (Physiopedia 2021c.)

The semitendinosus tendon inserts at the upper part of the medial surface of the tibia, behind the attachment of sartorius and infero-anterior to the attachment of gracilis. It is innervated by the tibial portion of the sciatic nerve. (Physiopedia 2021c.) The function of the semitendinosus is (1) Extend the thigh at the hip, (2) Flex the leg at the knee, and (3) Internally rotate the leg when the knee is in a flexed position. (Physiopedia 2021c.)

3.2 Semimembranosus

Semimembranosus is part of a group of muscles that make up the Hamstrings. Deep to the Semitendinosus it is located on the posteromedial side of the thigh. Its originates from the ischial tuberosity on the inferior part of the pelvis and the insertion is the medial tibial condyle. It's primary action is to flex the knee, extend the hip, and internally rotate the knee. In the lower part of the thigh, semitendinosus and semimembranosus together form the upper medial boundary of the popliteal fossa. (Physiopedia 2021b.)

A strong membranous tendon attaches to the upper lateral facet of the ischial tuberosity. An aponeurotic tendon arises at the distal end of the semimembranosus where it tapers and attaches to a horizontal groove on the posteromedial surface of the medial tibial condyle. The tendon then passes upwards and laterally to form the oblique popliteal ligament. (Physiopedia 2021b.)

A bursae separates the muscle from the medial head of the Gastrocnemius and medial head of the tibia. It innervated by the tibial division of the sciatic nerve. (Physiopedia 2021b.) Its function is to (1) Extend the hip, (2) Flex the knee, and (3) Internally rotate the knee when the knee is flexed. (Physiopedia 2021b.)

3.3 Biceps Femoris

Biceps femoris is a muscle of the posterior compartment of the thigh, in the posterolateral aspect. It originates proximally by two heads, the 'long head' (superficial) and the 'short head' (deep). Its origins are (1) Long head stems from the ischial tuberosity, (2) Short head stems from the linea aspera and lateral supracondylar line of the femur. (Physiopedia 2021a.)

The muscles are innervated by (1) Tibial division of the sciatic nerve for the long head, and (2) Common peroneal division of the sciatic nerve for the short head. (Physiopedia 2021a.) The main functions are (1) The long head flexes the knee, extends the hip, laterally rotates the lower leg when the knee is slightly flexed, assists in lateral rotation of the thigh when the hip is extended, (2) The short head flexes the knee, laterally rotates the lower leg when the knee slightly flexed. (Physiopedia 2021a.)

4 HAMSTRING INJURY

Human skeletal muscle can be injured by direct laceration, strain, or contusion. The majority of sports-related skeletal muscle injuries are caused either by strain or contusion. (Ekstrand 2011, 533–8.) Lacerations are rare or almost nonexistent in sports. Hamstring strain injuries (HSIs) are a result of excessive intrinsic tensile forces and inflict substantial damage across myofibres, the myofibres' basement membrane, as well as mysial sheaths and the connected tendon/aponeurosis. (Thorborg, Opar &

Shield 2020, 31.) In addition, strain injuries cause blood vessels in the endo or perimysium to rupture during the trauma. (Garrett, Nikolaou, Ribbeck, Glisson & Seaber 1988, 7–12; Järvinen, Järvinen , Kääriäinen, Kalimo & Järvinen 2005, 745–766).

Hamstring injuries are common muscular injuries in athletics and in team sports such as football, rugby, and Australian football- sports that all involve high-speed running, sudden acceleration, and deceleration. These types of activities increase the eccentric forces within the hamstring muscles, which in turn increases the likelihood for injury. (Nirmala 2016) Hamstring injury can be classified as part of musculoskeletal injuries which include fractures and joint dislocations, an injury that has a high incidence rate, persistent symptoms and is slow to heal. (Heiderscheit, Sherry, Silder, Chumanov & Thelen 2010.)

4.1 Injury Mechanism

There are two different types of acute hamstring strains which have been described with different mechanisms of injury. Type I acute hamstring strains usually occur during high-speed running. The injury to the hamstring muscle has been shown to occur during the terminal swing phase of running, typically when the hamstring muscles eccentrically contract to prepare for foot strike and to decelerate the swinging limb and. The biceps femoris long head is commonly involved in type I hamstring strain injury, typically at the proximal part of the muscle-tendon junction. (Chu, Rho 2017.) Type II hamstring strains usually occur during excessive lengthening of the hamstrings. These types of hamstring strain injuries are common in activities such as slide tackling, high kicking, and dancing that combine hip flexion with knee extension. Type II hamstring strains commonly involve the proximal free tendon of the semimembranosus, close to the ischial tuberosity. Compared to type I hamstring strain, recovery from type II hamstring strains has been shown to be prolonged. (Chu, Rho 2017.)

A partial tear or strain of the hamstring muscles is referred to as pulled hamstrings or hamstring strains. Liked pulled groins, they are common sports injuries in individuals who run very hard and/or who are required to perform quick starts and stops. Sometimes the violent muscular exertion required to perform a feat tears away part of the tendinous origins of the hamstring, especially the biceps femoris, from the ischial tuberosity. (Tortora & Derrickson 2009, 399.) This is usually accompanied by a contusion, tearing some of the muscle fibers, and rupture blood vessels, producing a hematoma and sharp pain. Adequate training with good balance between the quadriceps femoris and hamstrings and stretching exercises before running or competing are important in preventing this injury. (Tortora & Derrickson 2009, 399.)

The injury is commonly located or adjacent to the myotendinous junction (MTJ). As illustrated in Figure 2, both the proximal and the distal MTJs of the hamstring muscle group cover an extensive part of the muscles rather than a limited area at either end of the hamstring muscles. (Thorborg, Opar & Shield 2020, 31.) As an example, the proximal MTJ of the biceps femoris long head (BFlh) spans approximately a third of the total muscle length, whereby the myofibres attach to the aponeurosis to transmit force from the BFlh muscle to the tendon. The proximal and distal aponeurosis is often called the "intramuscular tendon" or "central tendon," and it is worth noting that the most severe hamstring muscle injuries involve the central intramuscular tendon, further emphasizing the role of the connective tissue in relation to HSIs. (Thorborg, Opar & Shield 2020, 31-32.)

The tendons of the hamstring muscles can be considered as two distinct components:
(1) the "free" tendon which is devoid of any inserting muscle fascicles and
(2) the musculotendinous junction (MTJ), which is the portion of the tendon into which muscle fascicles insert. (Thorborg, Opar & Shield 2020, 7.)

Hamstring strains are caused by a rapid extensive contraction or a violent stretch of the hamstring muscle group which causes high mechanical stress. This results in varying degrees of rupture within the fibres of the musculotendinous unit. (Sutton 1984, 184-95). The greatest musculo-tendon stretch is incurred by the biceps femoris, which may contribute to its tendency to be more often injured than the other 2 hamstring muscles (semimembranosus and semitendinosus) during high-speed running. (Heiderscheit, Sherry, Silder, Chumanov & Thelen DG. 2010, 67-81.)

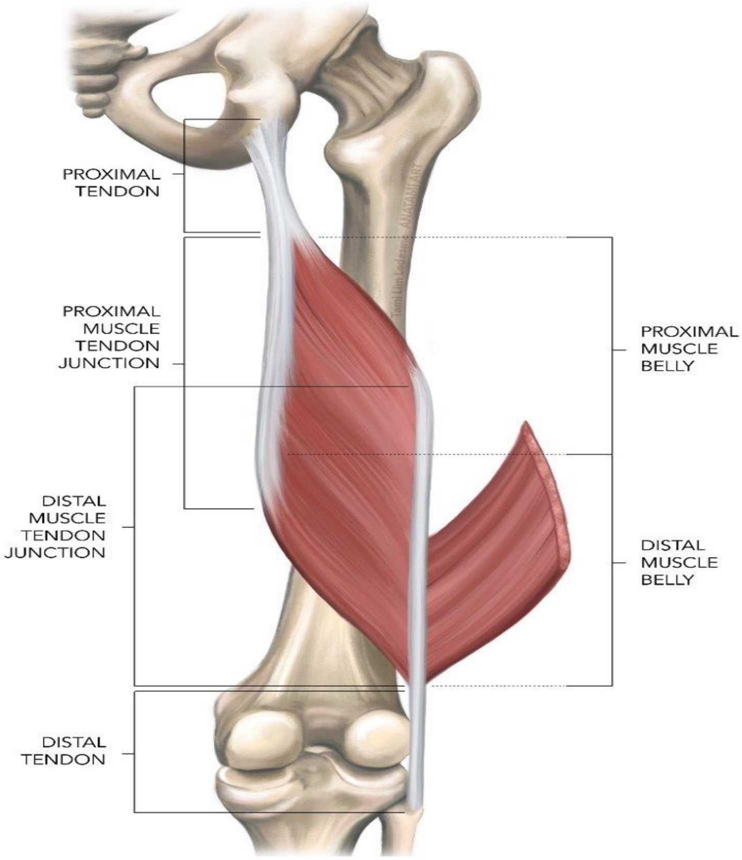

Figure 2. Hamstring tendon anatomy (Sports Injury Bulletin 2021)

As illustrated in Figure 3, muscle overload is the main cause of hamstring muscle strain. This happens when the muscle is challenged with a sudden load or stretched beyond its capacity. Hamstring muscle strains often occur when the muscle lengthens as it contracts or shortens. Although it may sound contradictory, this happens when you extend a muscle while it is loaded or weighted, which is described as an "eccentric contraction." During sprinting, the hamstring muscles contract eccentrically as the back leg is straightened and the toes are used to push off and move forward. The hamstring muscles are not only lengthened at this point in the stride, but they are also loaded with body weight as well as the force required for forward motion. (American Academy of Orthopedic Surgeons 2021.)

Figure 3. Muscle overload (American Academy of Orthopedic Surgeons 2021)

4.2 Injury Grade Classification

There is no standardized classification system for the severity of muscle strain injuries; however, different classification systems share a common categorization. Combining anatomical diagnosis, ultrasound, physical examination, and imaging, the severity of muscle strain injuries is generally categorized into 3 grades as seen in Figure 4. Grade I is a mild strain injury with minimum tear of the musculotendinous unit and minor loss of strength, Grade II is a moderate strain injury with a partial tear of the musculotendinous unit and a significant loss of strength which results in significant functional limitations, and Grade III is a severe strain injury with a complete rupture of the musculotendinous unit. (Liu, Garrett, Moorman & Yu 2012, 92-101.)

Figure 4. Hamstring Injury Grades (PhysioPrescription 2021)

5 SPORT OF RUGBY

Rugby is a fast-paced and popular contact sport where teams try to get the ball into the opponent's goal area. The ball is carried with both hands and is only allowed to be passed backwards to a supporting player. The ball can also be moved forward on the field by kicking it. The sport involves physical contact, such as stopping the player carrying the ball by tackling them, scrummaging, and in ruck situations. The size of the rugby field is very close to the size of a football field. (Suomen Rugbyliitto, 2021.)

Rugby is also often compared to gridiron, but the sports are, after all, very different from each other. American football is based on the alternating performance of various trained game patterns, while rugby is based on playing a ball that is in a continuous play using a guiding game strategy. This makes rugby much faster, a faster sport with significantly fewer game breaks. (Suomen Rugbyliitto, 2021.)

Rugby is also special with its many different positions and their very different roles during the game. The playing position is largely determined by the player's own physique - a large and strong player is usually the plays in the ´forwards´, who is responsible for various scenarios requiring contact, while the smaller player finds his role in the ´backs´, whose main responsibility is to transport the ball with speed and passing play. Because of this dichotomy, rugby is suitable for players of all sizes and fitness levels. (Suomen Rugbyliitto, 2021.)

Rugby is a football game played with an oval ball by two teams of 15 players (rugby union) or with 13 players (rugby league). Rugby union and rugby league have their origins in the style of football played at Rugby School in England. In 1823 William Webb Ellis, a pupil at Rugby School, defied the conventions of the day (that the ball may only be kicked forward) to pick up the ball and run with it in a game, thus creating the distinct handling game of rugby football. (Britannica 2021.)

As seen in Figure 5, Rugby is a full contact sport as it requires physical contact between players. It is played at a fast pace and often involves multidirectional dynamic movement. In some countries for example, the USA, rugby is described as a ´collision sport; in collision sports athletes hit or collide with each other or with inanimate objects (including the ground) with great force.´ (Rice 2008).

Figure 5. Rugby Tackle (Warwick-Smith 2021)

In terms of rugby and its relationship to hamstring injury, the long head of biceps femoris is particularly vulnerable to hamstring injury/strain, accounting for 80% of the injuries. (Ekstrand et al. 2016). In sports such as rugby and football, up to 80% of injuries to the biceps femoris long head resulted from high-speed running. Another likely contributing factor is the greater length changes in the biceps femoris long head muscle-tendon unit. (MTU) (Nirmala 2016.) In a rugby game which involves a lot of running and kicking, the hamstring will lengthen with concurrent hip flexion/knee extension, this lengthening may reach the mechanical limits of the muscle which can lead to the accumulation of microscopic muscle damage. (Brockett et al. 2004,379-87).

6 RISK FACTORS

A trade-off exits between risk and reward across all sports, the risk of injury versus the reward of performance. There has been considerable research and multiple risk factors proposed for hamstring injury. Risk factors for injury can be classified as extrinsic or intrinsic. Extrinsic factors are external to the individual and can include variables such as the type of sport, exposure to the sport, training, and playing environment. (Van Mechelen et al 1992, 82-99.)

Intrinsic factors are internal personal factors that can be further dichotomized into modifiable and non-modifiable risk factors. Non-modifiable risk factors cannot be changed or altered, such as age, gender, previous injury, and ethnicity. Modifiable intrinsic risk factors are those factors that can be influenced, for example, strength, physical fitness, and flexibility. (Thorborg, Opar & Shield 2020, 83.) Several reviews have combined and synthesized the literature on hamstring injury risk factors with the most comprehensive meta-analysis identifying age, previous history, and greater quadriceps strength as potential risk factors for hamstring injury (Freckleton & Pizzari 2013, 351-8).

6.1 Interpreting Risk Factors

Effective identification of modifiable, intrinsic risk factors is a vital component of injury prevention. (Van Mechelen et al. 1992, 82-99; Finch C 2006, 3-9). The injury aetiology model proposed by van Mechelen in 1992 identified principles for understanding injury risk which included three steps: (1) to identify the magnitude of the problem (incidence and/or severity); (2) to ascertain the aetiology, risk factors, or injury mechanisms responsible; and based on these findings, (3) to introduce a preventative measure to address the injury occurrence. (Thorborg, Opar & Shield 2020, 84.)

An athlete's risk of injury fluctuates over time as individual intrinsic and extrinsic risk factors change. An example, exposure to load or sport varies and intrinsic features such as power and strength can vary across a season and can even change from one day to the next. Subsequently traditional systems of screening the risk profile of athletes at a single time point, usually in preseason, may fail to identify important risk factors for hamstring injury. (Thorborg, Opar & Shield 2020, 84.) When considering athletes in different sports, it is possible that risk factors are not the same due to differences in the demands of competition (i.e., running demands during match play), training history (i.e., exposure to high-intensity sprinting), or overall management practices (i.e., eccentric strengthening) (Meeuwisse et al. 2007, 215-9; Bahr et al 2003, 384-92; Shadle et al. 2017, 573-7; Varley et al. 2014, 1858-66). The presence or absence of a risk factor in an individual athlete does not predict with any certainty that the athlete will sustain an injury. (Bahr R 2016,776-80).

6.2 Intrinsic Non-Modifiable Risk Factors

Clinical implications on non-modifiable intrinsic risk factors can be stated that previous injury is a strong risk factor for subsequent hamstring injury and the potential for persistent muscle deficits should be addressed to minimise risk of occurrence, that age holds inherent risk of injury but may be mitigated by strength and inducing morphological changes. Ethnicity has limited evidence and could be a surrogate measure of differences in muscle morphology, playing position, body size, and running demands. (Thorborg, Opar & Shield 2020, 90.)

6.2.1 Age

Advancing age has been implicated as a risk factor for hamstring strain in many studies. (Freckleton & Pizzari, 2013, 351–8). Additionally, older athletes have generally been participating in sport for a longer period, resulting in a greater likelihood of a previous hamstring injury as a consequence of greater exposure. Arnason et al (2004, 5-16) identified age as an independent risk factor for hamstring injury, not mediated by previous history of injury.

Athletic qualities evidently decline with ageing, including metrics of strength, power (Faulkner, Davis, Mendias & Brooks. 2008, 501–7), and running (Korhonen, Mero & Suominen 2003,1419–28). Changes in the structural characteristics of the ageing muscle-tendon unit (MTU) are possibly the basis for declining function, such as muscle mass (Faulkner, Davis, Mendias & Brooks 2008, 501–7; Kostka 2005, 140–5), stiffness (Narici, Maffulli & Maganaris 2008, 1548–54.), fibre population (Faulkner, Larkin, Claflin & Brooks 2007, 1091–6), and tissue quality (Doherty, Vandervoort & Brown 1993,331–5843), but these changes typically occur to a greater extent after a professional career has ended.

Altered training in older athletes is a frequently employed strategy to minimize injury risk. (Rogalski, Dawson, Heasman & Gabbett 2013, 499–503). It might also be implicated in loss of muscle strength (Freckleton, Cook & Pizzari 2014, 713–7) as athletes may train less, at a reduced intensity, or with a greater focus on sports specific training in place of strength training. The training history and habits of individual athletes may therefore moderate injury risk with ageing. (Rogalski, Dawson, Heasman & Gabbett 2013, 499–503).

6.2.2 Previous Hamstring Injury

Once an index injury has occurred, the athlete is at an increased risk of a subsequent injury (Freckleton & Pizzari, 2013, 351–8), particularly in the first 4 weeks following return to sport. (Wangensteen et al, 2016, 2112-21). Following index injury, there is evidence of ongoing deficits in the hamstring muscle. (Fyfe, Opar, Williams & Shield 2013, 523–30). These could be associated with inadequate rehabilitation and a failure to address the potential persistent muscle changes, which is one explanation for previous injury being a risk for re-injury. Sustaining an index injury may also indicate the presence of other individual factors that place the athlete at greatest risk for injury. (Hamilton, Meeuwisse, Emery, Steele & Shrier 2011,941–8.) Contextual factors such as behaviour, genetics, biomechanics, activity exposure, and psychology may elevate an individuals' re-injury risk. (Thorborg, Opar & Shield 2020, 89).

6.2.3 Ethnicity

The role of ethnicity in hamstring injury is not clear and unfortunately there are limited studies evaluating this variable. Indigenous Australian (Verrall, Barnes, Fon & Spriggins 2001, 435–40) and Black African or Caribbean (Brooks, Fuller, Kemp & Reddin 2006, 1297–306; Woods et al. 2004, 36–41) athletes are purported to be at greater risk of hamstring injury, with muscle fibre type and excessive anterior pelvic tilt suggested as contributing factors in these populations. (Verrall, Barnes, Fon & Spriggins 2001, 435–40; Woods et al 2004, 36–41.)

6.3 Intrinsic Modifiable Risk Factors

Strength is associated with increased risk of hamstring injury subsequently clinicians should focus on eccentric strengthening as both primary and secondary prevention. Clinical implications on intrinsic modifiable risk factors also highlight that the need for flexibility of the hamstring muscle as a whole is not supported, however the length of individual muscle fascicles of the hamstring may be critical. (Thorborg, Opar & Shield 2020, 109.)

6.3.1 Strength

Poor muscle strength is considered a risk factor for muscle injury. (Burkett 1970, 39–42). If an activity requires loading beyond the capacity of the MTU, it could result in structural damage. (Thorborg, Opar & Shield 2020, 90). Research investigating strength as a risk factor for hamstring injury is extensive and includes the evaluation of multiple lower limb muscles, using multiple methods and contraction modes, at variable speeds, in varying athlete populations, and in varying positions. (Freckleton & Pizzari, 2013, 351–8; Green, Bourne & Pizzari 2017, 29–36.)

As seen in Figure 6b the potential for improvements in strength, in particular eccentric hamstring strength, to ameliorate the risk represented by the presence of non-modifiable factors is vital information for the athlete, coach, and clinician. (Opar et al 2015, 857–65). The interaction between the intrinsic non-modifiable risk factors of age, past history of hamstring injury and strength is highlighted in Figure 6a.

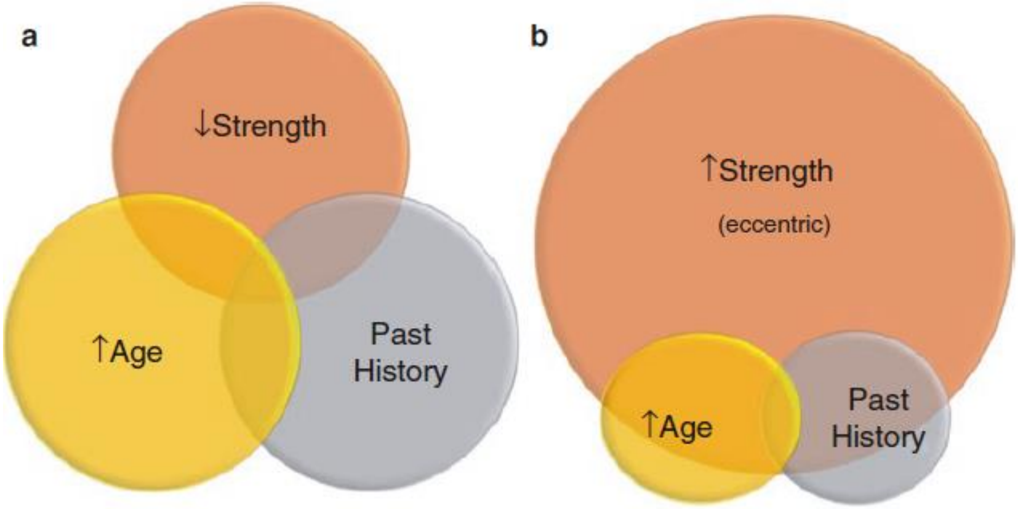

Figure 6a and 6b. Interaction between intrinsic risk factors, namely strength, age, and past history (6a). Potential moderation of increasing strength on non-modifiable intrinsic risk factors (6b). The size of the circle represents the significance of the risk factor. (Thorborg, Opar & Shield 2020, 91)

6.3.2 Eccentric Hamstring Strength

In recent times there has been a focus on reduced eccentric hamstring strength and injury risk, which is logical given the known persistent deficits in eccentric strength post-injury (Maniar, Shield, Williams, Timmins & Opar 2016, 909–20) and the common mechanism of injury in the terminal swing phase during high-speed running. (Chumanov, Schache, Heiderscheit & Thelen 2012, 90). There is also evidence that hamstring injuries can be reduced in cohorts of athletes undertaking adequately intense eccentric strengthening. (van Dyk, Behan & Whitley 2019, 1362–70).

Measuring eccentric hamstring strength using the Nordic hamstring exercise (NHE) as a test has gained recent attention following two studies showing football and Australian football players with lower levels of eccentric strength in the preseason to be at a greater risk of sustaining a hamstring injury in the season that followed. (Timmins et al. 2016, 1524–35). The NHE activates the hamstrings at high levels of muscle activity and at angles similar to the joint angles at which peak hamstring activation occurs during sprinting. (van den Tillaar, Solheim & Bencke 2017, 718–27).

6.3.3 Flexibility, Mobility, and Range of Motion

Reduced range of motion (ROM), mobility or flexibility has been considered to put athletes at greater risk of hamstring injury. Movements such as sprinting and kicking involve large stresses (Askling, Tengvar, Saartok & Thorstensson 2007,197–206; Heiderscheit, Sherry, Silder, Chumanov & Thelen 2010, 67–81) at reasonably long MTU lengths (Heiderscheit, Sherry, Silder, Chumanov & Thelen 2010,67–81). Although it is apparent that most athletes do not require exorbitant tissue lengths or ROM, it is generally accepted that there may be a minimum requirement to function effectively in sport. (Thorborg, Opar & Shield 2020, 95).

The majority of tests related to ROM, flexibility, and mobility, do not show a relationship with increased risk of future hamstring injury. (Thorborg, Opar & Shield 2020, 95). Deficits in ROM are apparent after a hamstring injury has occurred, and this could be one reason tests of this kind have been traditionally considered to be related to injury risk. (Mendiguchia et al 2017, 1482–92; Whiteley, van Dyk, Wangensteen & Hansen 2018, 303–10; Thorborg, Opar & Shield 2020, 95).

6.4 Extrinsic risk factors

The physical demands of elite athletes are high, and in team sports such as rugby, football, and Australian football, all have large running demands, and these demands rise with the playing standard. (Varley, Gabbett &, Aughey 2014, 1858–66.) The risk and rate of hamstring injury can therefore be greater with a higher level of competition. (Woods et al 2004, 36–41). Between sports there are however large differences in running and playing requirements, which may influence the patterns of injury and risk profiles seen. (Varley, Gabbett &, Aughey 2014, 1858–66).

In a study on incidence of hamstring injury in rugby, the incidence of hamstring muscle injuries was 0.27 per 1000 player training hours and 5.6 per 1000 player match hours.

Injuries, on average, resulted in 17 days of lost time, with recurrent injuries (23%) significantly more severe (25 days lost) than new injuries (14 days lost). Running activities accounted for 68% of hamstring muscle injuries, but injuries resulting from kicking were the most severe (36 days lost). (Brooks, Fuller, Kemp, Reddin. 2006, 1297-306.)

Injury risk management should be a shared decision-making process. In team sports the role of other members of the multidisciplinary team, including the coach, is vital in protecting the athlete from unnecessary risk. (Thorborg, Opar & Shield 2020, 100.) In the high-performance environment, it is essential for coaching staff to be informed regarding the results of certain risk factor findings as it pertains to the athlete and, when applicable, the team. (Thorborg, Opar & Shield 2020, 101). There is some preliminary evidence that the leadership style and communication quality of the head coach may be associated with the overall injury rates and player availability of their teams. (Ekstrand, Lundqvist, Davison, D'Hooghe & Pensgaard 2019,304–8).

7 INJURY PREVENTION AND IMPLEMENTATION

The most effective approach in preventing hamstring injuries relating to high-speed running is to improve muscle capacity. This can be achieved by increasing eccentric strength and tolerance of high running load to high running loads. The most potent mechanism of eccentric strength capacity (ECC) training for injury prevention is that the exercises increase strength; tissue capacity and the length of the BFlh fascicle. (Nirmala 2016.)

Injury prevention can be divided into primary, secondary, and tertiary approaches. (Petersen, Thorborg, Nielsen, Budtz-Jørgensen & Hölmich 2011, 2296–303). Primary prevention relates to the prevention of the initial event. This is done by preventing exposures to hazards that cause injury, altering unhealthy behaviour and increasing resistance to injury when exposure occurs. Secondary prevention aims to reduce the impact of the injury that has already occurred. Tertiary prevention aims to soften the impact of an (ongoing) injury that has lasting effects. (Thorborg, Opar & Shield 2020, 146.)

Insufficient warmup strategies could increase the risk of hamstring injury, so a proper warmup is essential for general injury prevention. (Junge et al 2011, 57–63). Warm-up regimes can be applied in different formats, from running drills to targeted exercises, with or without additional weight and equipment. Ultimately, the aim of a good warm-up is to be prepared physically and mentally for an upcoming bout of activity. (Thorborg, Opar & Shield 2020, 147.)

7.1 Nordic Hamstring Exercise

The Nordic hamstring strengthening exercise may reduce the incidence and severity of hamstring muscle injuries sustained during training and competition. (Brooks, Fuller, Kemp, Reddin. 2006, 1297-306). As seen in Figure 7, there is level 1a evidence showing that eccentric hamstring strength training delivered via the NHE is an effective measure for hamstring injury prevention (Al Attar, Soomro, Sinclair, Pappas & Sanders 2017, 907–16), so long as the exercise is implemented gradually, with appropriate volumes, and compliance is high. (Goode et al 2015, 349–56).

Figure 7. The Nordic hamstring exercise (Warwick-Smith 2021)

The NHE is typically performed in pairs as a body weight exercise. (Petersen, Thorborg, Nielsen, Budtz-Jørgensen & Hölmich 2011, 2296–303). The instructions and pictures on how the NHE are performed is illustrated in appendix 1.

Hamstring injury prevention programmes need to be implemented and adhered to by the targeted end users to show effectiveness. (Goode et al 2015, 349–56). Implementation of hamstring injury prevention in a sports environment is often a difficult task, even for athletes at increased risk of hamstring injury. (Engebretsen, Myklebust, Holme, Engebretsen & Bahr 2008, 1052–60). Ultimately, however, the athlete is the end user, and his/her views with regard to the drivers and barriers for adoption of evidence-based hamstring prevention programmes need to be considered. Clearly, there are many reasons to excuse athletes from injury prevention: these include heavy game schedules, competing training priorities, poor staff communication, player and staff motivation and limited knowledge of preventive strategies. (Van der Horst et al 2018; O'Brien 2017, 1507–8.)

7.2 Roles in prevention

Stimulating injury prevention adherence should be a mutual effort from all stakeholders involved. The individual athlete, the coaching staff and the medical team are often responsible for planning of sports-specific technical and medical routines for each training and match activity. (Thorborg, Opar & Shield 2020, 157.)

From a practical perspective for the athlete, it is suggested that the NHE programme should be supervised to improve adherence. (Van der Horst et al 2018; O'Brien 2017, 1507–8). Athletes need to be made aware of, or educated about, the importance of hamstring injury prevention considering the increased risk for hamstring injuries as well as the high recurrence rates after the initial injury. (Steffen et al 2013, 480–7; Twomey, Finch, Roediger & Lloyd 2009, 452–6).

With regard to the coaches, it should be recognised that injuries have a significant influence on team performance. (Hägglund et al 2013, 738–42). For the medical staff, there is an important role to play in facilitating knowledge transfer from evidence-based medicine to end users (e.g., the athlete) and the administrators (e.g., the coaches or other members of team staff) because knowledge of the effectiveness of an intervention plays a major role in hamstring injury prevention adherence for all of these stakeholders. (Thorborg, Opar & Shield 2020, 157).

As shown in Figure 8, level 1 evidence strongly indicates that primary hamstring injury prevention should utilize exercise programmes for hamstring strength with eccentric overload. Ultimately, stimulating adherence to preventive measures is the final step to make evidence-based hamstring injury prevention work in a real-world setting. (Thorborg, Opar & Shield 2020, 160.)

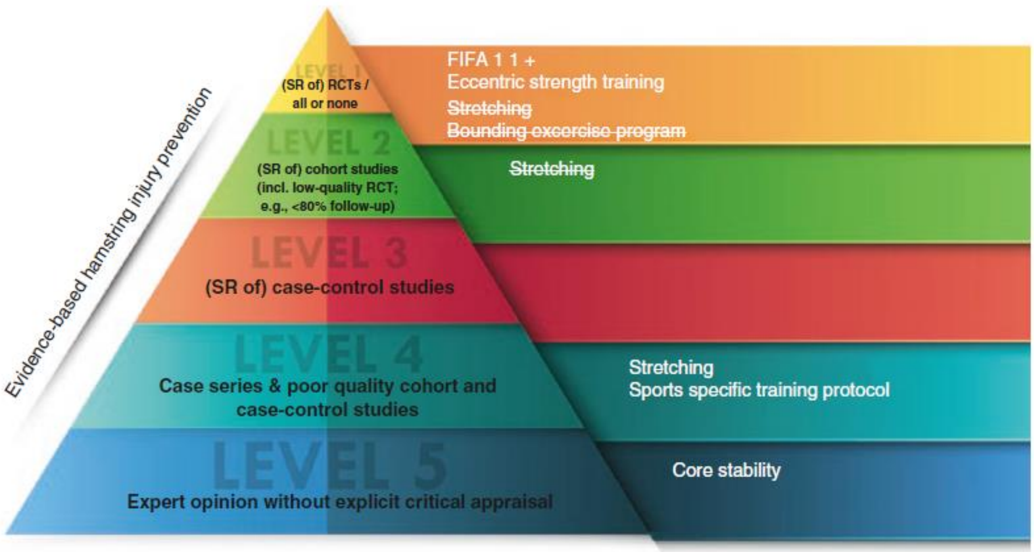

Figure 8. Levels of evidence based on (Howick 2009). Variables with a strike-through the text indicate that this variable has shown no preventative effect (Thorborg, Opar & Shield 2020, 146).

7.3 Injury Prevention Programme Implementation

As conducted in a Randomised Control Trial (RCT) by Petersen et al. (2011) and illustrated in Table 1, Evidence suggests building up a hamstring injury prevention programme during preseason and maintaining it in the in-season. When playing a one match per week schedule, the recommended day to perform the main eccentric exercise session seems likely to be on match day (MD) + 3. (Thorborg, Opar & shield 2020, 160.) Players should, however, be accustomed to the eccentric stimulus by maintaining at least weekly sessions to minimise the damage response prior to the next match. Based on expert opinion, it may also be appropriate to perform low-load/low-volume eccentric exercise on the MD + 1, but again, players must be accustomed to this. (Thorborg, Opar & shield 2020, 160.)

Table 1. Training volumes of NHE protocols derived from prevention RCTs, (Thorborg, Opar & Shield 2020, 150).

Study	Intervention period	Week	Sessions, p/wk	Sets	Reps	Rest period
Gabbe 2006 [19]	12 weeks; 3 sessions in preseason and 2 sessions during first 6 weeks of competition	–	–	12	6	10 s between reps; 2–3 min between sets
Engebretsen 2008 [18]	10 weeks	1	1	2	5	Not reported
		2	2	2	6	Not reported
		3	3	3	6–8	Not reported
		4	3	3	8–10	Not reported
		5–10	3	3	12, 10, 8	Not reported
Petersen et al. 2011 [1]	10 weeks (plus ongoing maintenance throughout the season)	1	1	2	5	Not reported
		2	2	2	6	Not reported
		3	3	3	6–8	Not reported
		4	3	3	8–10	Not reported
		5–10	3	3	12, 10, 8	Not reported
		11+	1	3	12, 10, 8	Not reported
van der Horst 2015 [20]	13 weeks	1	1	2	5	Not reported
		2	2	2	6	Not reported
		3	2	3	6	Not reported
		4	2	3	6, 7, 8	Not reported
		5	2	3	8, 9, 10	Not reported
		6–13	2	3	10, 9,	Not reported

8 DISCUSSION

The idea behind the thesis arose through my connection with Finnish rugby. Being active as both a player and as part of the coaching staff, I felt that I could develop a quick guide designed to educate, reduce the risk, and minimize the severity of hamstring injury. The quick guide on hamstring injury prevention could be beneficial to current staff and players alike.

The initial step was to approach the SRL with the idea of such an educational quick guide to which they accepted and approved. The proposal for the thesis subject was made in autumn 2019.

Hamstring injury prevention and rehabilitation is a widely researched topic and not surprisingly, a lot of literature exists. It was therefore a challenge to source current and applicable scientific data in creating the quick guide. Consideration had to be made for the audience that it was being created for, their existing level of knowledge on the subject, and importantly the professional knowledge of the direct influencers such as the coaching and medical staff.

Rugby in Finland is still amateur at best and therefore lacking consistency in its view or action towards specific preventative exercises, adopting a more generalized ´one size fits all´ approach to primary prevention. All too often coaching and medical staff would source supportive material from unfiltered platforms such as YouTube or Google to supplement their knowledge. In cases where content is informative or educational, the challenge falls to the individual in the proper implementation and execution of such exercises.

The result of this literature search, utilizing current and applicable literature, would be used to create a unique exercise based quick guide designed for the Finnish rugby community. The quick guide would supplement existing knowledge, and to bring about a consistent and proactive approach to preventing hamstring injury particularly through implementation during training sessions as part of warm up or as part of pregame routine. This educational quick guide could then be rolled out for the 2022 Finland domestic rugby season.

The thesis and subsequent quick guide are meant to be simple, easy to follow and supported by current literature (within the last 10 years, exceptions made for data that is still applicable or has not changed). The thesis would highlight the anatomy and physiology of hamstrings, injury severity classification, risk factors and the most important subject of what exercises could be implemented to prevent or minimise injury.

This quick guide can serve as a basis for future development, research, and assessment of the effectiveness of NHE in Finnish rugby players, its adoption of using NHE in rugby training, interviews of players in terms adherence or obstacles faced. Further research could include investigation into hamstring injury rates before and after the quick guide was implemented.

8.1 Anatomy and Physiology

The anatomy and physiology of the hamstrings were presented in a way that was easy to digest and understand in terms of its names, structures and its role or physiology. It would provide a basis for understanding; how they are involved in the injury mechanism and, how they become modifiable variables in injury prevention.

There was a lot of text regarding specific measurements on the muscles point of origins, the nerves that innervate and the points of insertion which I decided not to include. The text included in the thesis however was aimed at providing a general overview of the hamstrings, its point of origin, and its physiology. A color-coded figure of hamstring anatomy, and a clear illustration of (hamstring) tendon anatomy was included to supplement and facilitate learning and understanding.

8.2 Risk Factors

Besides the injury mechanism itself, I believe that understanding risk factors and how to interpret them is a huge step towards (primary) preventative care. Risk factors can help coaching staff and players alike in understanding and importantly, managing themselves in preparing their teams/ themselves physically.

Again, there was a lot of literature regarding risk factors. It was a challenge to not include all and to be selective (based on personal/subjective rugby experience what to be included in the thesis). Surprisingly in the book published by Kristian Thorborg and colleagues last year (2020) he highlighted that despite the large volume of research undertaken to elucidate these factors, evidence was weak or conflicting for many. This recently published book is arguably the most comprehensive collection of literature on hamstring injury prevention and rehabilitation ever published. In terms of risk factors, I decided to focus on intrinsic factors such as (non-modifiable) age, previous hamstring injury, and (modifiable) eccentric strength. Other considerations briefly included ethnicity/genetics, flexibility/mobility, and range of motion.

Ethnicity/Genetics as a variable has limited research to date, however some studies into indigenous Australians, Black African and Caribbean athletes are purported to be at greater risk due contributing factors such as muscle fibre type and excessive anterior pelvic tilt. In another study in 2018 looking at genetic variants (in soccer players) in hamstring injuries found that genetics appeared to be involved in the etiology of hamstring injuries but were not found to be predictive values on their own (Larruskan 2018).

A notable omission from the thesis was the use of stretching as a factor in reducing the risk of hamstring injury. For most readers not familiar with the subject, stretching would have presented as an important factor in primary prevention. Surprisingly, stretching is not strongly supported by scientific evidence-based literature as was illustrated in Figure 6.

Interestingly, literature highlighted that the presence or absence of a risk factor does not provide with certainty that a player would sustain a hamstring injury. Consideration then had to be made to consider the relationship between the external/extrinsic environment which may have a direct impact on intrinsic factors. To clarify, how the training load and game schedule would contribute or compound the incidence of sustaining a hamstring injury. Risk factors are however important in profiling players who are high risk and subsequently implementing preventative strategies.

It is important to understand that risk factors are not predictive on their own but needs to be considered multifactorial. It is therefore in my opinion and consistent with current literature that if coaches and players can interpret and approach risk factors correctly, they are able to better manage risk, facilitate participation and performance. Furthermore, continuous monitoring of risk factors over time may identify changes and its association with risk of injury.

8.3 Hamstring Injury Prevention and Implementation

There is an established understanding that prior hamstring injury is the strongest predictor of future hamstring injury. As a result, prevention of an initial hamstring injury allows an individual to avoid the potential of the injury-reinjury cycle. This statement could not be further from the truth.

Whilst there are numerous factors that may contribute to a high risk of incurring a hamstring injury, it is equally important to identify those risk factors which can be modified in an effort to avoid that initial injury. Strong (level 1) evidence has shown that the best way of preventing such an injury is by way of improving capacity through eccentric strength and tolerance to high running loads. These can be implemented through selective exercises incorporated to an existing programme where the aim is to increase strength; tissue capacity and fascicle length (for example biceps femoris long head).

As seen in appendix 1, the eccentric loading Nordic hamstring exercise (NHE) along with other exercises by Carl Askling (L Protocol) have shown in studies to be very effective in primary and secondary care of hamstring injuries. It is important to note that most of the studies on NHE and the L Protocol, were performed in semi professional and amateur football environments and so the translation of these findings to the rugby population can be a topic for further research.

I do however want to point out the injury mechanism in rugby is similar to football if not the same. There are indications that the inclusion of eccentric strength training in the injury prevention approach may reduce the risk of hamstring injury is the sport of rugby.

A programme worth highlighting is one that was created by Fédération Internationale de Football Association (FIFA) called FIFA 11+, a warmup programme which has level 1 evidence to support its effectiveness. The inclusion of the NHE exercises into this warmup programme presents a good example of including specific eccentric exercises in reducing the risk of hamstring injury. The creation of a similar programme for amateur or semiprofessional rugby could also be another thesis topic.

A reason I chose to exclude certain interventions like stretching, core stability, plyometric, sports specific training, and running drills is simply that evidence from studies indicate that these interventions either do not seem to be effective, or that current evidence remain too limited too fully understand their effectiveness on hamstring injury prevention.

Whilst rugby in Finland is considered amateur, there is no reason that multiple stakeholders such as the SRL (for rules and legislations), club boards, coaches, medical staff members and players cannot be proactive in their approach to hamstring injury prevention. Coaches and medical staff are often the most important administrators of the prevention programme.

Furthermore, evidence suggests building up a hamstring injury prevention programme during preseason and maintaining it in the in-season. As noted in literature, strong evidence supports the use of exercise programmes for primary hamstring prevention for hamstring strength with a focus on eccentric overload. It is therefore important to plan and gradually or progressively increase eccentric training load for each player. To optimise effectiveness, facilitate performance and stimulate adherence, careful planning is required.

As studies have predominantly been conducted in football, the actual scheduling and implementation in rugby can be a challenge but not impossible. Due to the similarities in injury mechanism, I believe that a similar schedule can be implemented considering the sports specific loads of rugby, which is more intensive physically and just as explosive, for example, Match Day +3/ Saturday +3 (Tuesday). Finnish rugby usually plays the one game per week + 2 training days during a normal season. Eccentric exercise training can then be performed on the Tuesday. Additionally, expert opinion says that it may also be appropriate to perform low load/low volume eccentric exercise on Match Day + 1.

What is important in these scheduling scenarios is that players are accustomed to the eccentric stimulus by maintaining at the very least, weekly sessions to minimise damage response prior to the next match.

Finnish rugby is at an amateur level at present so a priority and recommendation would be to introduce a warmup programme which incorporates eccentric overloading exercises such as the NHE.

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American Academy of Orthopedic Surgeons. 2021. Referred 28.07.2021. https://orthoinfo.aaos.org/en/diseases--conditions/hamstring-muscle-injuries. Figure 3 Muscle Overload

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Warwick-Smith, A.J. 2021. Figure 5, A Rugby Tackle.

Warwick-Smith, A.J. 2021. Figure 7, The Nordic Hamstring Exercise.

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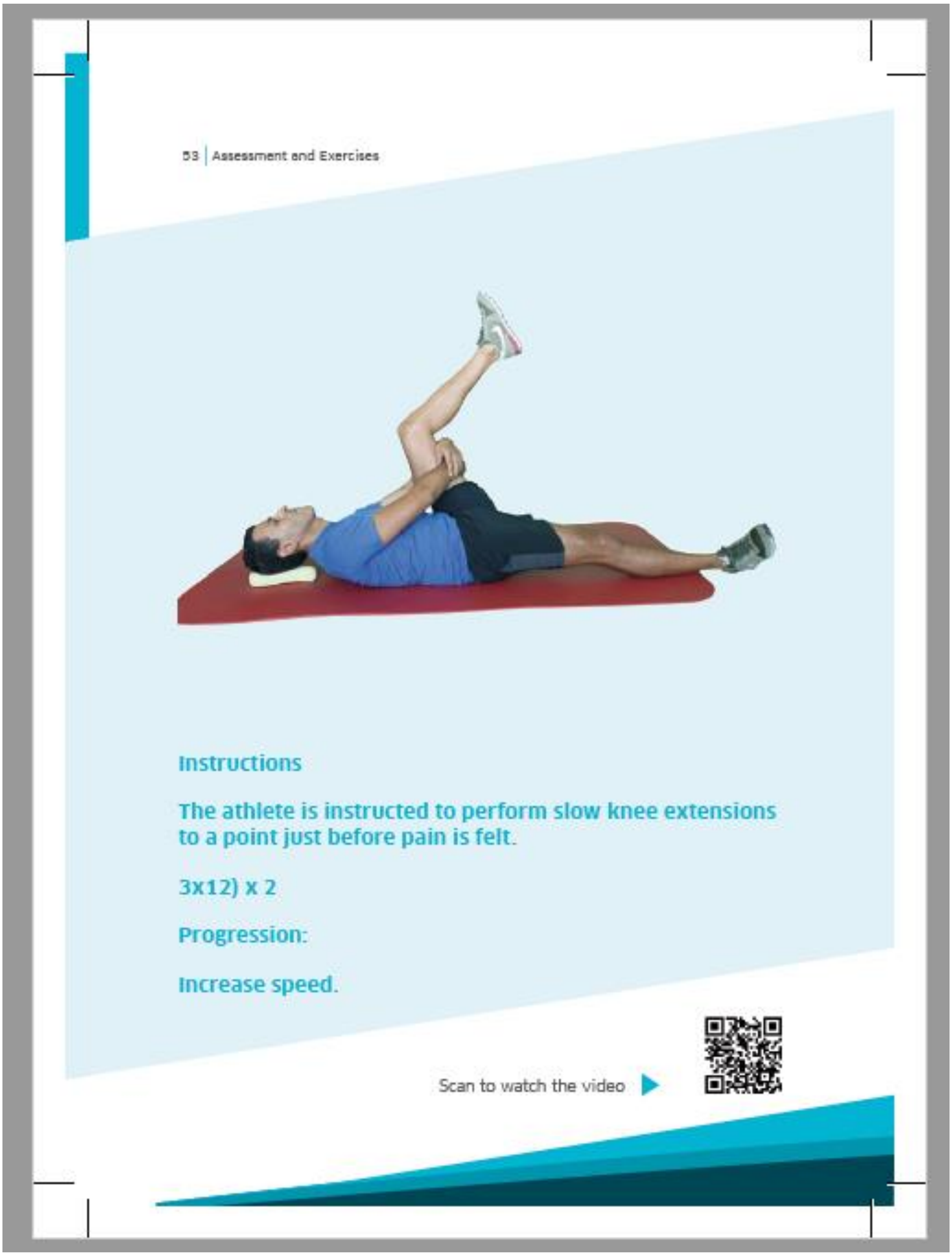
APPENDIX 1

THE EXTENDER
(Askling et al)

Starting position

The athlete is lying supine, holding and stabilize the thigh of the injured leg with the hip flexed approximately 90°.

Aspetar Hamstring Protocol


53 | Assessment and Exercises

Instructions

The athlete is instructed to perform slow knee extensions to a point just before pain is felt.

3x12) x 2

Progression:

Increase speed.

Scan to watch the video

Aspetar Hamstring Protocol

THE DIVER

Starting position

The athlete is standing with full weight on his injured leg and the opposite knee slightly flexed backwards.

Aspetar Hamstring Protocol

55 | Assessment and Exercises

Instructions

The athlete is asked to perform the exercise as a simulated dive (hip flexion from an upright trunk position) of the injured, standing leg and simultaneous stretching arms forward and attempting maximal hip extension.

3 X 6

*Good quality, ASIS/pelvis horizontally throughout the whole movement

*Maintain 10-20° knee flexion in the standing leg.

Scan to watch the video

Aspetar Hamstring Protocol

THE GLIDER

Starting position

The exercise is started with the patient positioned with upright trunk, one hand holding on to a support and legs slightly split. All the body weight should be on the heel of the injured leg with approximately 10–20° knee flexion.

Aspetar Hamstring Protocol

Instructions

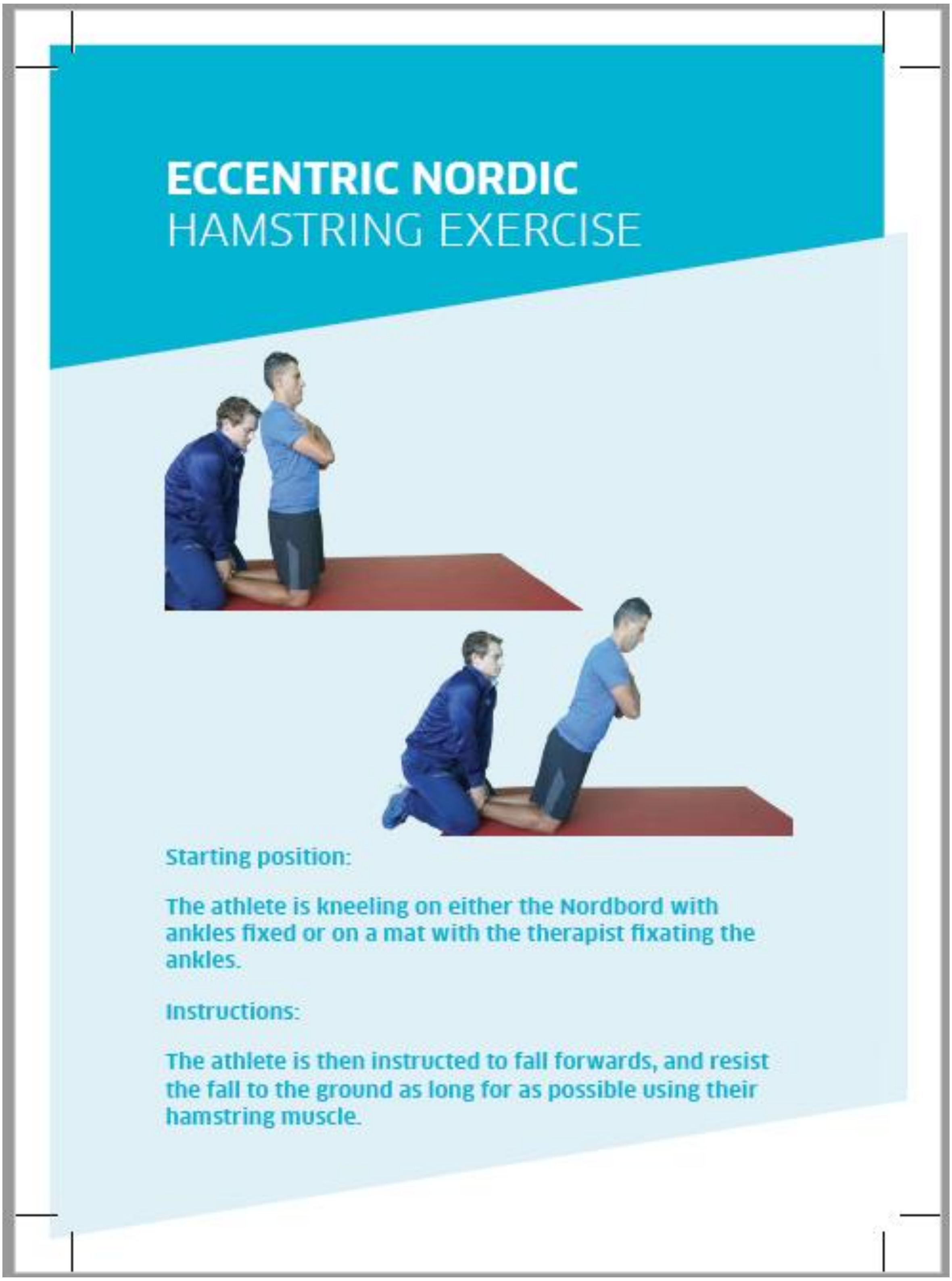
The athlete is instructed to perform a gliding backward movement on the other leg and stop the movement before pain is reached. The movement back to the starting position should be performed by the help of both arms, not using the injured leg.

3 X 6

Progression is achieved by increasing the gliding distance and performing the exercise faster.

Scan to watch the video

Aspetar Hamstring Protocol



Aspetar Hamstring Protocol

Complete 2 painfree sessions before progression to next level

Complete all 3 sessions, drop only, then progress through session again with drop and curl

***That the loading of the injured leg is similar to the uninjured leg (without pain)**

3 times per week

1) 2x 5 reps, drop only

2) 2(3)x 5 – 8, drop only

3) 2(3)x 8 – 12 , d rop only

4) Repeat sessions 1-3 with drop AND curl

Scan to watch the video

Aspetar Hamstring Protocol