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Hamstring injury prevention in male football players during an adoles- cent growth spurt

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<p data-bbox="312 696 424 723">Abstract</p> <p data-bbox="312 768 1441 943">Hamstring injuries are the most common injuries in football, while hamstring muscles are the most affected by adolescent growth spurt. Hamstring injuries have remained as a huge problem in the sport of football as their prevention has been proven to be difficult, despite the vast amount of studies and research done about hamstring injury prevention.</p> <p data-bbox="312 987 1441 1126">The theoretical background of this thesis consists of adolescent growth spurt, how it affects the training and playing of football and also the anatomical structure of the hamstring and information about hamstring injuries and the risk factors and injury prevention methods associated with them.</p> <p data-bbox="312 1171 1441 1346">The methodology of this thesis is practical-based which is supported by an evidence-based theoretical background. The practical implementation section of the thesis was an information package for a local Finnish football club. The objective of the information package was to increase knowledge about playing and training football during an adolescent growth spurt and its' target group was boys aged 13-15 and their parents.</p> <p data-bbox="312 1391 1441 1570">As a result of this thesis the information package was created. It contains 5 pages. The content of the information package is based on the theoretical background of this thesis which means that it contains information about hamstring injuries and the risk factors associated with them, adolescent growth spurt and how it affects playing football, recovery and what kind of exercises should be done for hamstring injury prevention.</p>		
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INTRODUCTION

Football is the most popular hobby among adolescents between the ages of 11-15 in Finland. Football can take between 8-25 hours from their weekly schedule depending on their level of play, without including the time that it takes to travel to the training sessions and back home. (Koskinen, Hynninen & Raimoaho 2018) Injuries can be a negative side effect of playing sports or being physically active and in professional team sports they not only have an effect on the affected individual, but also the performance and wealth of the team. Hamstring injuries have remained as an important medical issue in football since they are the most prevalent injuries sustained in football, despite having a vast amount of research and studies done about them. Most hamstring injuries in football are sustained during sprinting, kicking the ball, when performing sliding tackles or in quick changes of direction. (Bahr, McCrory, Laprade, Meeuwisse & Engebretsen 2012 40-42; Buckthorpe et al. 2019, 449; Lahti 2020.)

Lack of muscle strength and muscle tightness are among the intrinsic risk factors associated with hamstring injuries and they are also among some of the effects an adolescent growth spurt can have on the body. The hamstring muscles can be considered to be the most affected muscles by the adolescent growth spurt (Alvarez-Ponce & Guzmán-Muñoz 2018; Buckthorpe et al, 451. 2019; Midwinter 2017). Adolescent growth spurt usually affects boys more than girls due to boys growing at a faster rate, which can also increase the effects that the growth spurt has on playing sports. (Ashburner 2019; Midwinter 2017).

Multifactorial approach is currently agreed to be most effective way of preventing hamstring injuries among researchers. Exercises that target the hamstrings and especially increase the eccentric strength of the hamstrings have been proven to be effective, but also lumbopelvic stability training and exercises that target other surrounding muscles, while high-speed sprinting has in more recent studies been used and studied as a hamstring injury prevention intervention. (Buckthorpe et al. 2019, 453; Lahti et al. 2020; Schuermans, Danneels, Van Tiggelen, Palmans & Witvrouw 2017.) Proper recovery after sport, for example good nutrition and sufficient amount of sleep, are also ways of preventing hamstring injuries. (Gallucci 2018; Rollo & van Loon 2018)

This thesis was done for a local football team FC Jazz and an information package about hamstring injury prevention adolescent growth spurt was done as the practical implementation. The information package aims to explain the hamstring injuries and what causes them and how adolescent growth spurt affects playing football while also providing information about hamstring injury prevention.

1 AIM AND OBJECTIVES

The aim of this thesis is to provide information about hamstring injury prevention during an adolescent growth spurt and how the growth spurt affects the body as well as hamstring injury risk factors, exercises and other methods used in hamstring injury prevention, by creating an information package. The information package is directed mainly at the players and their parents, but also the coaching staff.

The objective of this thesis is to help the prevention of hamstring injuries of a local football team's boys aged 13-15 during growth spurt.

2 EFFECTS OF AN ADOLESCENT GROWTH SPURT IN THE BODY

2.1 Puberty

Puberty is a period of life during adolescence that is defined by the development of physical growth, maturation of psychosocial skills and sexual characteristics in the adolescents' body. Timing of puberty and its rate of progression are highly individual and vary a lot especially between genders, but the stages of the process and the pubertal changes occur in a predictable step by step manner, which can be seen in Figure 1. (Brown, Patel & Darmawan 2017.) During puberty the adolescent gains full reproductive ability and adult features, which depend on their sex. (Hirsch 2019)

Puberty is started by increased pulses of the gonadotropin hormones and the hypothalamus, which first begin occurring during nights but later happen throughout the day. This developmental change occurs typically six months to a year earlier in females than in males. In males this triggers the increase of size of the testes as they start to produce testosterone under the stimulation of gonadotrophins, which is also characterized as an onset of puberty. The hypothalamus is responsible for secreting the luteinizing hormone, which causes the testes to produce testosterone. The increase in testosterone levels causes the reproductive organs to grow and mature, bones and muscles

to grow, changes in voice and it causes pubic and facial hair to start growing. (Hayward 2003, 22; Hirsch 2019.)

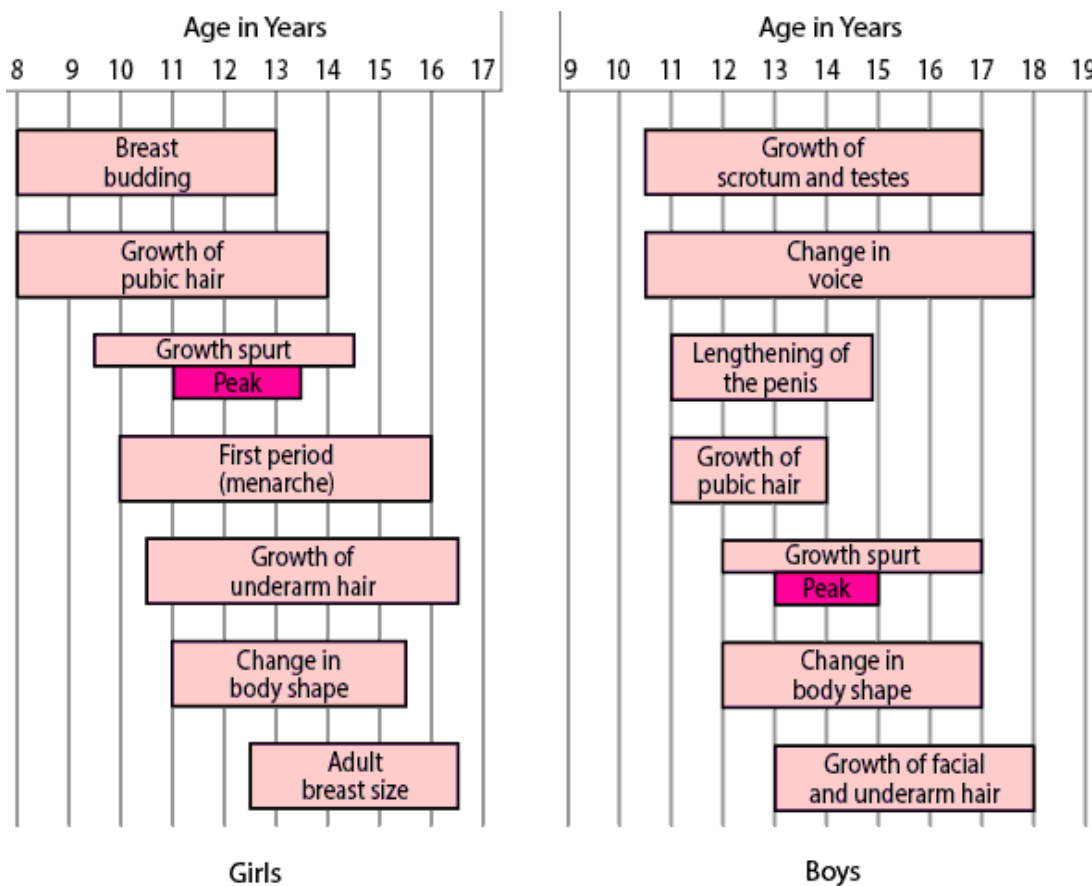


Figure 1 Changes during puberty and the timing of the changes (Hirsch 2019)

2.2 Adolescent growth spurt

The adolescent growth spurt happens as part of puberty and it affects all of the different structures of the body, but its effects are not limited to just structural changes and have a significant effect on the whole body of the adolescent (Komulainen 2016). During adolescence and adolescent growth spurt height, weight, body composition, muscle growth and strength, flexibility and bone mass are all changing (Brown, Patel & Darmawan 2017).

Growth spurt affects all children when growing up, but usually affects boys more due to more rapid growth. While the growth spurt affects all muscles, the most common tight muscle during a growth spurt is the hamstring muscle, which affects the ability to fully straighten the spine (Midwinter 2017). The length of the bones grow faster than the length muscles and tendons, which increases the tightness and traction of the affected structures and will eventually cause inflammation. If an adolescent is physically very active during the adolescent growth spurt, the affected muscles can become very stiff, which can further limit their ability to participate in physical activity as it increases the risk of injuries. (Ashburner 2019.)

3 PLAYING FOOTBALL DURING AN ADOLESCENT GROWTH SPURT

3.1 Football as a sport

Football is a physically demanding contact sport that involves walking, running, sprinting, fast changes of direction, tackles, jumping, heading and kicking. The average distance that an adult professional footballer covers during a match can vary between 10 and 15km, which contains multiple sprints as well as walking, jogging and running, which means that the fatigue caused by a football match is comparable to a half marathon for a 70kg person. (Website of The Science of Sport 2010.)

3.2 Adolescent growth spurts effects on playing football

Puberty and adolescent growth spurt affect the adolescents individually and the rate and timing of the physical and psychological development and the stage of the development have an effect on the individuals ability to participate in different sports. Boys ages 12-16 year are experiencing the peak of their physical development and significant increase in their muscle mass, strength and cardiopulmonary endurance. Time spent on sport specific attributes and activities becomes more beneficial during the middle stage of the puberty (14-16). (Brown, Patel & Darmawan 2017.)

Figure 2 displays the kinds of physical attributes that are part of exercises and training drills that football training sessions typically include. They aim to improve endurance, strength, speed, suppleness and coordination skills, which can be combined with other aspects of the training that aim to improve tactical awareness and ability with the ball. (Website of FIFA 2020, 121-123.)



Figure 2. Relations between different aspects of physical training in young players (Website of FIFA 2020, 122)

The FIFA Youth Football (Website of FIFA 2020, 122-123) manual highlights the importance of coordination training especially in youth football between the ages 8-13 and during periods of fast growth afterwards. Dedicated strength training should be reserved for 20 months after peak growth (i.e. 15-16 for boys), but should be an integral part of the training before that, especially for core and upper body muscles with body weight exercises as lower limb muscles get the necessary strength development from the regular training through running and jumping for example. Optimal endurance training for aerobic capacity should be initiated from the age of 11-12, and football specific strength-endurance training later gradually in ages 14-15. Suppleness can be trained in different stages of childhood and puberty for example between ages 12-14 due to the development of the mobility of the spine as it allows additional stimuli for the nervous system. Speed is a desired attribute in modern football, and while genetic attributes affect it, it is best trained with specific exercises. There are two major opportunities to train for increasing speed during growth which come between 7-9 and 13 to 15-16 for boys, but should be started in an early age due to the adaptability of the nervous system for children. (Website of FIFA 2020, 122-123.)

4 ANATOMY OF HAMSTRING

Hamstrings are located in the posterior part of the thigh and are a combination of three muscles: musculus biceps femoris (long and short head), musculus semitendinosus and musculus semimembranosus as displayed in Figure 3. They are responsible for extension of the hip and flexion of the knee and are essential in daily activities. (Tortora & Derrickson 2014, 384-385.)



Figure 3. Anatomy of the hamstring muscles (Website of American Academy of Orthopedic Surgeons 2015)

Figure 3 displays how semitendinosus, semimembranosus originate from ischial tuberosity and attach to medial side of tibia, semitendinosus to medial surface on superior part of tibia and semimembranosus to posterior part of medial condyle. While the long head of biceps originates from ischial tuberosity and inserts into the lateral condyle of tibia and to the head of fibula. Biceps femoris short head originates from linea aspera and lateral supracondylar line of femur and attaches to the lateral side of head of fibula and lateral condyle of tibia. (Agur & Dalley 2016, 503.)

The hamstring muscles are innervated by sciatic nerve, which originates from the sacral plexus (L4-S3) and its' branches, which descend through the posterior side of the thigh. The sciatic nerve bifurcates into the common fibular nerve and tibial nerve in the posterior side of the knee joint in the popliteal fossa. Biceps femoris' long head, semimembranosus and semitendinosus are all innervated by tibial division of sciatic nerve (L5, S1 and S2), while the short head of biceps femoris is innervated by the common fibular nerve division of the sciatic nerve (L5,S1 and S2). (Agur & Dalley 2016, 473, 503.)

The hamstring muscles span across two major joints, which are the hip joint and the knee joint. The hip joint is a ball and socket joint, which comprises the head of femur being the ball and the acetabulum (the concave surface of the pelvis) being the socket. The hip joint allows many movements, which include flexion, extension, adduction, abduction, external and internal rotations and circumduction. (Tortora & Derrickson 2014, 385-386.)

The knee joint is a modified hinge joint due to its primary movement being uniaxial hinge movement and it's made out of three different joints in a single joint cavity, which are: patellofemoral joint (between the patella and the patellar surface of the femur), lateral tibiofemoral joint (between the lateral condyle of the femur and the lateral condyle and lateral meniscus of the tibia) and medial tibiofemoral joint (between the medial condyle of the femur and medial meniscus and medial condyle of the tibia). The knee joint is the most complex joint in the body and it allows the movements of flexion, extension and slight external and internal rotation. (Tortora & Derrickson 2014, 282-284.)

5 HAMSTRING INJURIES

5.1 Summary of hamstring injuries

Physically active lifestyle and participation in sports is important in all age groups for multitudes of reasons, but it increases the risk of acute injuries and overuse injuries. There is a huge difference in the severity of sports injuries and their recovery times, which can vary between few days to permanent injuries or disabilities. (Bahr, McCrory, Laprade, Meeuwisse & Engebretsen 2012, 40-42.)

Hamstring injury is the single most common injury among professional footballers. There are two main types of hamstring injuries that occur when playing football. The first one happens during a high-speed running, which usually affects the long head of

m. biceps femoris and the second one occurs when the muscle is lengthened to maximal capacity for example during kicking motion or during a sliding tackle which affects the free proximal tendon of musculus semimembranosus. (Askling 2011.)

The recovery time for hamstring injury depends on the severity of the injury. Hamstring injuries are commonly muscle strains which can be given a grade 1-3 depending on the severity of the injury with the muscle injury classification system. The muscle injury classification system can be seen in Table 1. (Kilcoyne 2011.)

Table 1. Muscle injury classification system (Kilcoyne 2011)

Grade	Pathophysiology	Signs and Symptoms
1	Tearing of only a few muscle or tendon fibers	Minor swelling and discomfort with no or minimal loss of strength
2	More severe partial tear without complete disruption of the musculotendinous unit	Clear loss of strength with more discomfort
3	Complete rupture of the musculotendinous unit	A total lack of muscle function and commonly with massive hematoma

5.2 Risk factors and injury mechanism

“Hamstring muscle ruptures (ruptures semimembranosus, the semitendinosus, and the biceps femoris muscle) occur myotendinous junction deep within the muscle” Bahr, McCrory, Laprade, Meeuwisse & Engebretsen 2012, 52). A common cause of muscle ruptures is when the eccentric power generation and length of the muscle are at their maximum or during sprinting when resisting the flexion of the knee. Poor warm up of the muscle is one of the most well-documented risk factors for hamstring injuries in football, especially when followed by exercises that require near maximum performance like sprinting or kicking the ball. (Bahr, McCrory, Laprade, Meeuwisse &

Engebretsen 2012, 52.) Poor warm up and muscle extention are the most commonly stated risk factors for a hamstring injury, but muscle strength and imbalance of antagonist and agonist strength and lack of flexibility and lack of strength in lumbo-pelvic muscles surrounding the hamstring are mentioned to be among the intrinsic factors for hamstring injury. The contribution of lack of flexibility is not totally clear, but it is known that a shortened muscle-tendon units can cause a delayed response in the surrounding muscles in moments of destabilization, which can be connected to musculoskeletal injuries (Alvarez-Ponce & Guzmán-Muñoz 2018; Lahti et al. 2020.). The FIFA Youth Football publication (Website of FIFA 2020, 122-123) states that lack of recovery and training suppleness is also a way to decrease the risk of injury, even though it's not an essential physical factor. Lack of exposure to maximal velocity running, insufficient running kinematics and low sprinting performance have in recent studies been associated as risk factors for hamstring injuries in team sports, despite still lacking evidence (Lahti et al. 2020).

There is a lack of studies about how different hamstring injury risk factors interact with each other due to the complexity of the interactions and how the different risk factors individually contribute to hamstring injuries and therefore there is also a lack of understanding on why hamstring injuries occur. There are also inconsistencies in lists of prospective of risk factors, despite the vast amount of research and studies done about the topic, which leads to many different risk factors being studied simultaneously. Figure 4 displays common hamstring injury risk factors that have been studied in recent years. (Buckthorpe et al. 2019, 449.)

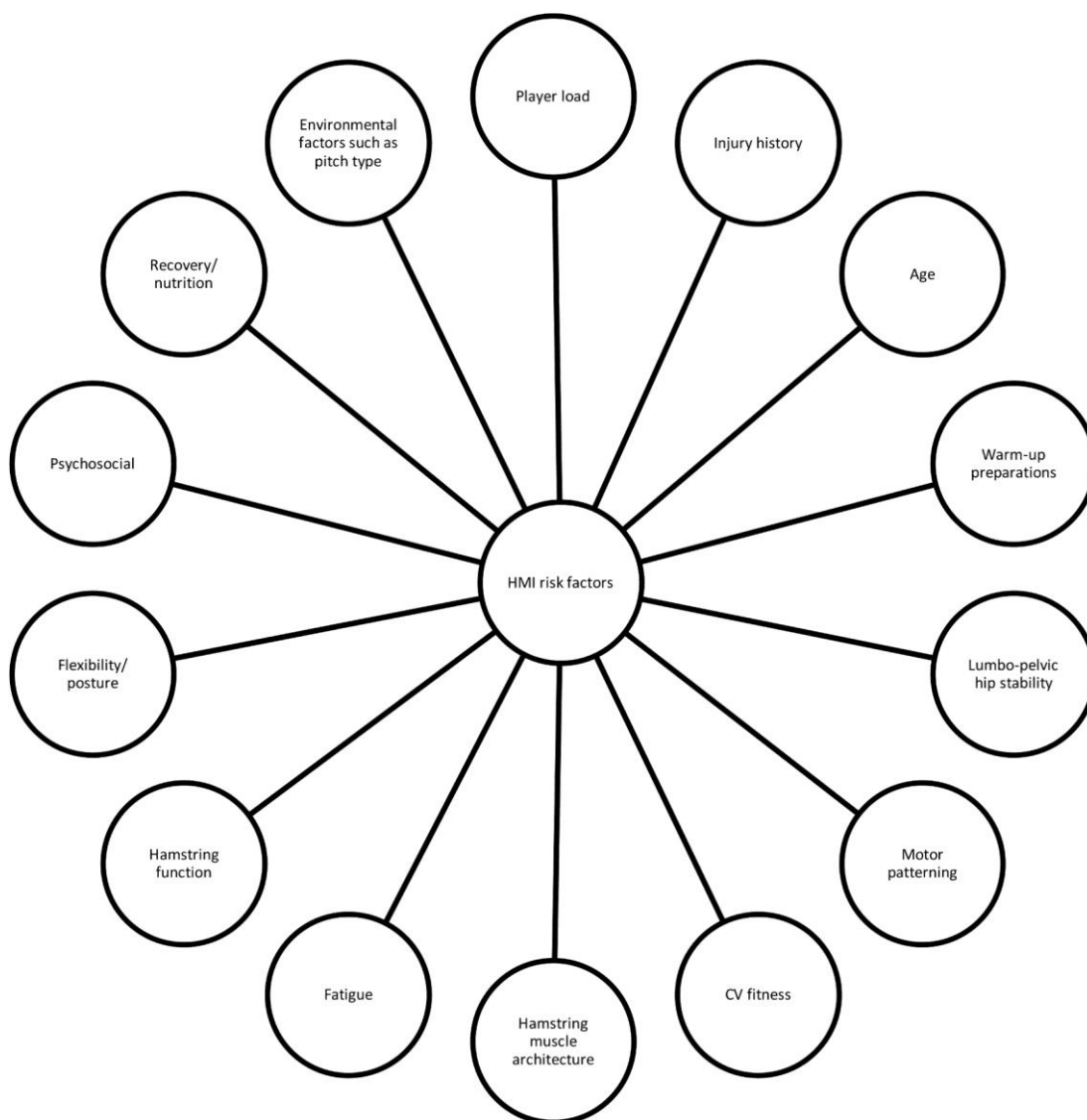


Figure 4. Common risk factors associated with hamstring injuries (Buckthorpe et al. 2019, 450.)

Figure 5 displays the results of a survey conducted by Woods et al. (2004) where they surveyed 91 professional football clubs during two seasons. Hamstring injuries accounted for 12% out of all the injuries. 91% of the hamstring injuries were non-contact injuries and out of those injuries 57% occurred while running. Out of all the 796 hamstring injuries 94% were hamstring strains and 53% of them affected the m. biceps femoris, 19% were unspecified, 16% m. semitendinosus and 13% m. semimembranosus. (Woods et al. 2004, 37-38.) Alvarez-Ponce & Guzmán-Muñoz (2018) state that hamstring injuries have a high re-injury rate of up to 12%-30% within 2 months of returning to sport.

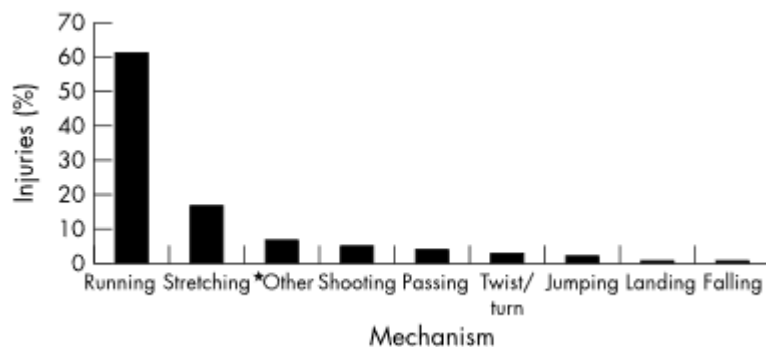


Figure 5. Mechanism of non-contact hamstring strains in adult professional footballers (Woods et al. 2004, 38)

6 INJURY PREVENTION

6.1 Exercises

Exercises are among the key methods in prevention and recovery process of hamstring injuries, in which studies have shown them to be successful in preventing subsequent hamstring injuries, and eccentric hamstring exercises are especially good for football players in preventing muscle strains. (Bahr, McCrory, Laprade, Meeuwisse & Enggebretsen 2012, 52-53.) Both senior and youth athletes with less eccentric hamstring strength have been shown to have increased risk for hamstring injury compared to athletes that have more eccentric hamstring strength.

Nordic Hamstring Exercise is at the moment one of the most reliable and effective ways to prevent hamstring injuries as it has been shown to increase eccentric hamstring strength with a high compliance rate in elite football players. However, in a field study the compliance rate (65%) was considerably higher in athletes that had been compliant with the program when compared to the studies overall compliance rate (45%), which suggest that the required compliance with the exercise could prove to be a barrier for its overall effectiveness in injury prevention. (Freeman, Young, Talpey, Smyth, Pane

& Carlon, 2018.) A study conducted by Van der Horst et al. (2014) concludes that amateur footballers who started including Nordic Hamstring Exercise in their training had a significant decrease in the risk of hamstring injuries, but it did not affect the severity of the injuries.

Implementation of lumbopelvic hip stability training is considered an important hamstring injury prevention tool in football, but also in other elite sports. Especially uncontrolled anterior pelvic tilt has been associated with increased risk of hamstring injury during high-speed sprinting, as it both increases the loading of the hamstring muscle and increases the amount the muscle stretches during late swing phase. Anterior pelvic inhibits the gluteus maximus, which has also been associated with increasing the loading of the hamstring muscles. (Buckthorpe et al. 2019, 453.) High amount of gluteal and trunk muscle activity during running and sprinting has been associated with reduced hamstring injury risk, which promotes the use exercises and drills that focus on the neuromuscular control of the gluteal and trunk muscles (Schuermans, Danneels, Van Tiggelen, Palmans & Witvrouw 2017).

Multifactorial approach is currently being considered as the optimal hamstring injury prevention strategy. Individualizing the multifactorial injury preventions programs that are being used for each player is also currently agreed to give the best outcomes for hamstring injury prevention programs. The individualization is easily achieved for example by modifying the exercise volume or some of the exercises that are being used for each player depending on the situation. Some of the risk factors can be identified through different types of screening and monitoring processes, for example lumbo-pelvic control tests. (Lahti et al. 2020.)

6.2 Sprint training

Although running and sprinting are the biggest cause of hamstring injuries in football, sprinting can also be considered an irreplaceable part of hamstring injury prevention. Most hamstring injury prevention strategies rely on isolated risk factors such as

strength and consist of single joint, isolated, low-velocity, torque and non-sprint specific range of motion evaluations that are not accurate or reliable enough for predicting the risk of hamstring injuries. Sprinting is a complex and unique movement for example in terms of the interaction of different structures, kinematics, kinetics and elastic energy transfer. Therefore sprinting is the only exercise that induces the correct amount of hamstring muscle activation with the right timing, and can only be replicated up to 18%-75% with other methods in terms of electromyographic activity. (Edouard, Mendiguchia, Guex, Lahti, Samozino & Morin 2019.)

Studies have shown that athletes that have engaged in near maximum intensity sprinting >95% of their maximal velocity during training or practise have lower risk for injury than those who only produced >85% of their maximal velocity, but a sudden acute increase in sprinting load can lead to a large increase in risk of hamstring injury. This means that the sprinting load and velocity have to be well planned and monitored in order to gain benefits of positive tissue adaptation and the likely increase in tissue repair and healing that can be gained from sprint training. (Edouard, Mendiguchia, Guex, Lahti, Samozino & Morin 2019.)

Sprint training has been shown to produce enough stimulus to promote an increase in eccentric hamstring strength and performance, but also states that sprint training still has relatively low amount of literature to support it as a direct injury prevention tool. Sprint training shows a lot of promise and could be an alternative for Nordic Hamstring Exercise in gaining eccentric hamstring strength, especially when focusing on sprinting technique, which gave more merit to the eccentric strength gain benefit of it. (Freeman, Young, Talpey, Smyth, Pane & Carlon, 2018.)

6.3 Warmup and stretching

The two main functions of warmups are injury prevention and preparing the body for the following physical activity by increasing the muscles' dynamics and by increasing its temperature, while not hindering the performance of the targeted muscles. Warmup

can be either passive, which means that the temperature of the targeted muscle is increased through an external source (i.e. sauna or hot shower) or active which happens through physical activity. Warmup generally includes light aerobic exercises, for example jogging combined with more specific activities that aim to prepare the body for the sport, for example certain stretches or warmup drills. Warmup has been shown to increase strength and performance capabilities of the targeted muscles due to making muscle contractions faster and smoother with faster metabolism and reducing internal viscosity. Warming up protects the muscle from tearing injuries by providing it a protective mechanism that gives it greater capability to sustain stretch and force. (Woods, Bishop & Jones 2007, 1090-1091, 1094.) Team sports are rarely the focus of studies related to warm up, but it has been shown that warmup has a positive effect on sprint and agility performance capabilities of the team sport players, although studies haven't been able to find an optimal way of warm up for team sports (Turki et al. 2019).

There are three different techniques of stretching: static stretching, dynamic stretching and proprioceptive neuromuscular facilitation (PNF). Static stretching refers to methods where slow or passive techniques or methods are used and held, usually for a time period between 20-30 seconds for the lengthening of the muscle. (Woods, Bishop & Jones 2007, 1091, 1093.) Static stretching during warm up has previously been shown to reduce performance, especially in anaerobic movements such as sprinting, but in more recent studies it has been shown that static stretching would have no negative effect on performance (Kendall 2017, 53). “Dynamic stretching is defined as repetitive and controlled movements around the active range of motion of each joint” (Turki et al. 2019). An average increase of 1.3% has been reported in athletic performance, especially in activities that include strength, power or quick changes of direction when dynamic stretching has been properly implemented into the warmup routine. There have also been recent studies that show an increase in the performance of sprinting, jumping and agility after the inclusion of dynamic stretching. (Turki et al. 2019.)

6.4 Recovery

Physical activity exhausts both physical and psychological energy and recovery is needed for the body to regain its energy levels. Sufficient recovery requires time, but it can be made more efficient with various methods such as nutrition, rest, swimming, hot and cold methods (i.e. sauna or ice bath), hydration, massage, sleep and physical activity and exercises that are designed to boost recovery. Recovery is an important tool in prevention of injury as it's a well-documented risk factor for injuries in addition to preventing overtraining. (Website of FIFA 2020, 155.)

Nutrition and hydration are vital part of recovery and proper nutrition is required for optimal recovery and tissue remodeling as well as cognitive function. Adequate protein intake is needed in order for a balance between protein synthesis and protein degradation, as muscle mass can only be increased if protein synthesis exceeds the degradation. Hydration is important because if the player isn't well hydrated it will affect their cognitive, physical and technical football performance and increase the cardiovascular strain on the body. 70kg footballer should intake around 120g of protein a day divided to around 20g per meal. (Rollo & van Loon 2018.) The protein intake requirement doesn't change in adolescents due to increased rate of protein accretion (Soliman, De Sanctis & Elaily 2014). Carbohydrate intake should also be a priority, especially after physical activity as refilling the glycogen storage is essential for the recovery process, but having a sufficient storage of carbohydrates before a football game and training sessions is also important (Fenn 2016).

Sleep is as important as physical conditioning and nutrition for an athlete, and its especially important for a youth player. Sleep promotes tissue healing process and allows it to regenerate, repair and re-energize, while lack of sleep increases cortisol levels, which is harmful for tissue growth and makes appropriate amount sleep an important tool for prevention of injuries. Lack of sleep is also known to affect concentration. A teenager should sleep an average of 9-10 hours a night especially during an adolescent growth spurt. (Gallucci 2019.)

7 INFORMATION PACKAGE

7.1 Thesis process and study method

The thesis process began in November of 2019 when the author of the thesis had the idea for the topic. The topic of hamstring injury prevention during adolescent growth spurt due to its prevalence as the most common injury in football and due to how the adolescent growth spurt affects the hamstring muscle. A study plan was made and proposed and accepted to the mentoring teacher and student peers in December of 2019. Boys aged 13-15 were chosen as the target group in order to narrow the topic further. After choosing the topic the author of this thesis contacted a local football club FC Jazz to find out if they would be interested about the information package. After a meeting with the teams' representative, an agreement for the information package and a discussion about possible training session led by the author of this thesis was agreed on in December of 2019.

Searching for literature and other sources for the thesis was done between January and March of 2020 and the writing process properly begun in April 2020 with the goal of having the thesis completed by the end of August 2020. Most of the theoretical background was done by the end of July 2020. The first version of the information package was completed during August of 2020 as originally planned, but it was then revised to the final version between September and October and completed in late October 2020 and given to FC Jazz in early November 2020.

This thesis is considered a practice-based thesis, and as customary for a practice based thesis it includes the theoretical section and a report of how the practical part was done, which in this thesis is the information package about injury prevention during adolescent growth spurt for boys between the ages of 13-15. Theoretical background was collected from studies, books and online publications. The author of this thesis and FC Jazz agreed that the information package would contain the latest methods available or that the author of this thesis was able to find for hamstring injury prevention during an adolescent growth spurt. The football team FC Jazz didn't have specific wishes or requirements for the information package so the author of this thesis had complete

control of the way the information package was completed and what it would contain. Even though the thesis is written in English, the language of the information package is Finnish.

7.2 Creation process of the information package

The first version of the information package was completed in late August of 2020 and it was designed in a way that it could be given directly to the players and their parents or guardians. The information package was based around the main points of the theoretical background of the thesis about adolescent growth spurt and how it affects the training and playing of football in addition to knowledge about hamstring injuries, risk factors of hamstring injuries and how to prevent them. The first version of the information package also had evidence-based exercises such as Nordic Hamstring Exercise and an example of sprint training and dynamic stretching with pictures and instructions for the exercises. The original plan was to have a training session with the football team, where the exercises from the information package would have been instructed, but the training session was removed from the plan due to the complications made by the COVID-19 pandemic. This was the main reason for changing the design of the information package to a version without pictures or instructions for specific exercises.

7.3 Final version

The second and final version of the information package (Appendix 1) has a lot of similarities with the first version. The style of language used in the information package was chosen to be simple and to not contain a lot of professional vocabulary in order to be easy to read as the information package is targeted for the 13-15 year old players and their parents or guardians. The information package was also designed to be compressed into 5 pages to not make it excessively long and thus tedious to read. This limits the amount of information and theory that is used in the information package, but relies on the reader to find additional more in-depth information about some of the topics, for example nutrition after training, that is nowadays easy to find from various different literature and online sources.

The information starts with a cover page followed by an introduction page for the reader about the information package. The first content page of the information package, which contains an overview about theory of prevalence of hamstring injuries in football, adolescent growth spurt, how it affects the body and playing football and also the information about hamstring injuries and risk factors, which all remained similar to the first version. Rather than having specific exercises with instructions and pictures, the rest of information package contains general information about hamstring injury prevention during adolescent growth spurt divided into recovery related methods, which were also part of the first version and exercise related methods. The exercise section now contains more general level information about what kind of exercises are used in prevention of hamstring injuries and what to take into consideration while doing the exercises during an adolescent growth spurt. Some specific exercises such as Nordic Hamstring Exercise are still mentioned and covered, due to it having the highest evidence as a single exercise for hamstring injury prevention and sprint training, because of it being a relatively new intervention as a hamstring injury prevention tool despite lacking evidence. In the end of the information package there is a summary of the key points for hamstring injury prevention during an adolescent growth spurt. FC Jazz was thankful for the information package. The way the information package is implemented, used and distributed to the players depends on FC Jazz.

8 DISCUSSION

The interest for this thesis came from its authors' interest towards the sport injuries and especially the sport of football. The prevalence of hamstring injuries in football and it being the most common injury in the sport and the way that the adolescent growth spurt affects the hamstring muscles were the main points of interest that led into the author choosing this topic and into making of this thesis.

The author found that searching for the theoretical background about hamstring injuries wasn't challenging due to football being a popular sport and hamstring injuries

being a common injury in all sports that include lots of sprinting and running. There has also been many studies done about hamstring injuries, which meant that up to date studies were easy to find. Finding studies for football training during adolescent growth spurt specifically was a bit more challenging. This is why the theoretical background about the adolescent growth spurt focuses more on how it affects the structures of the body, exercising and playing football during the adolescent growth spurt, while most of the injury prevention part could be applicable for football players regardless of their age. The author of this thesis decided not to include screening tests and similar injury prevention strategies to the thesis, since the information package is aimed for the players and their parents or guardians and the screening tests are mostly conducted by teams.

Although 13-15 year old boys might not be very motivated to put effort into injury prevention, and the usefulness of the information package is completely up to how FC Jazz uses it and how the players, parents or guardians implement the information in it, the author considers that the final information package contains the necessary information to be used as an useful tool for preventing hamstring injuries during an adolescent growth spurt. Thus the author of this thesis thinks that the thesis is successful as the information package matches what was initially planned and discussed with FC Jazz. The author of this thesis feels like anyone who reads through the theoretical background or the information package of this thesis should learn a lot of useful information about exercising or playing sports during adolescent growth spurt and also about hamstring injuries and their prevention in general and in football specifically, but also about injury prevention in general.

The author considers creating the information package harder than anticipated, due to the complications caused by the COVID-19 pandemic and having to redesign and change the information package to a completely text based format, which was considerably different from the original vision. The author also feels like it might have negatively affected the overall quality of the information package and the possible usefulness of the information package for the team as it is less specific and practical, however at the same time the final version might be more beneficial than the original one especially in long term use, since it's also easier to use and give to players and their parents or guardians as it's less reliant on the specific exercises and focuses more into general

information. Also the fact that as of writing of this thesis, there is no optimal exercise compilation or way of preventing hamstring injuries in football, made the creation of the package harder and increases the chance of information package becoming obsolete in the future. Other improvements would have been feedback from the players, parents or guardians about the information package.

The lack of an optimal method of hamstring injury prevention in general, but also during adolescent growth spurt is the biggest factor that affects the reliability of this thesis as it also contains methods such as sprint training as a hamstring injury prevention tool even though its effectiveness is still uncertain at the time of writing this thesis, which means that if the thesis was done at a later point in time the theoretical background for this thesis would no longer be accurate. The majority of the theoretical background is based on recent studies and the author believes that if the thesis would have been done by another author the theoretical background would have been similar in terms of content, thus making the thesis reproducible.

In terms of validity the author of this thesis thinks that the main concern that would affect the validity of this thesis is that there is a possibility that, even though most of the hamstring injury prevention methods used in this thesis are well documented and evidence based, there might have still been something that was missed due to the high volume of data available about hamstring injury prevention. Another concern is that if there would have been more optimal methods for preventing hamstring injuries during adolescent growth spurt specifically, as most of the theoretical background in this thesis for hamstring injury prevention is based on professional footballers rather than youth players.

Based on this thesis, further studies that would include instructing exercises or include a hamstring injury prevention program could be conducted, in which case studying the compliance rate of the adolescents participating could be followed or studied. In general, more studies could be made about the hamstring injury prevention during an adolescent growth spurt.

The author feels like the process was incredibly educational and sparked an interest especially towards sprint training as an injury prevention tool. Based on the theoretical

background of this thesis sprint training and its usefulness could also be studied further and the author of this thesis will continue to follow the sprint trainings progression as an injury prevention tool, but also how hamstring injury prevention develops in general.

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APPENDIX 1

Infopaketti takareisivammojen ehkäisyyn kasvupyrähdysten aikana

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LUKIJALLE

Tämä infopaketti on suunniteltu niin kasvupyrähdys ikäiselle nuorelle, nuoren vanhemmalle tai nuoren valmentajalle. Sen tehtävä on antaa tietoa jalkapallossa tapahtuvista takareisivammoista ja niiden ehkäisystä kasvupyrähdysten aikana. Oppaassa käsitellään, miten kasvupyrähdys voi vaikuttaa jalkapallon harrastamiseen, kuin myös tietoa palautumiseen sekä takareisivammojen ehkäisyyn liittyvistä tavoista sekä harjoitteista.

Infopaketti on tehty osana Satakunnan Ammattikorkeakoulun kansainvälisen koulutusohjelman opinnäytetyötä. Infopaketin tekoon käytetty teoria pohjautuu lähdemateriaaliin ja se on osa opinnäytetyöhön kuuluvaa englanninkielistä kirjallista osuutta, jonka löytää Theseus-verkkosivulta. Lähdeluettelon löytää osana kirjallista osuutta.

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Takareisivimmat jalkapallossa kasvupyrähdyksen aikana

Takareisivimmat ovat yleisimpiä lihasvammoja jalkapallossa ja niiden osuus on keskimäärin 12 % - 16 % kaikista jalkapallo vammoista. 91 % takareisivammoista ei liity kontaktia ja näistä vammoista suurin osa (57 %) tapahtuu juostessa ja loput esimerkiksi hypätessä, palloa potkaistessa, nopeissa suunnanmuutoksissa ja liikutaklauksissa, mutta loukkaantumisia tulee myös taikareittä venyteltäessä niin ennen kun jälkeen jalkapalloharjoituksia ja jalkapallo-otteluita. Yleisimmin takareisivamma tapahtuu polven ojentuessa, liikeradan loppuosassa eli esimerkiksi juoksussa jalan suoristuessa ”loppuheilahduksen” aikana juuri ennen kuin kantapää osuu maahan, jolloin takareisi usein revähtää. Takareisivammoille altistavia riskitekijöitä ovat: huono lihasvoima, huono alkulämmittely, maksimivoimalla tehdyt liikkeet (esim. juoksu tai pallon potkaisu), väsynyt tai huonosti palautunut lihas, huono keskivartalon hallinta ja huono lihastasapaino, joka tässä tapauksessa tarkoittaa usein sitä että etureiden lihakset tai pakarat ovat takareisiä vahvempia. Takareisivamman palautumisaika vaihtelee vamman vakavuudesta riippuen. Keskimääräinen paluu jalkapallo harjoittelun pariin vaihtelee n.8-25. päivän välillä, mutta vakavissa revähdyksissä vamma saattaa vaatia leikkaushoitoa, joka estää harjoittelua pidempään. Takareisivimmat ovat myös helposti uusiutuvia, joka korostaa ennaltaehkäisyn tärkeyttä.

Kasvupyrähdyksen aikana nuoren kehossa tapahtuu paljon muutoksia, jotka vaikuttavat liikuntaharrastuksiin ja voivat kasvattaa loukkaantumisriskiä mm. lihaskireyden kasvaessa ja lihasvoiman heikentyessä, joka johtuu siitä että luusto kasvaa kasvupyrähdyksen aikana nopeammin kuin lihakset. Lihakset saattavat väsyä nopeammin kuin aikaisemmin ja kasvupyrähdys vaikuttaa myös motoriikkaan, minkä vuoksi kasvupyrähdyksen aikana nuori saattaa kokea itsensä aiempaa kömpelömmäksi. Kasvupyrähdys vaikuttaa kaikkiin lihaksiin, mutta takareisi on yleisin kireä lihas kasvupyrähdyksen aikana, joka voi vaikuttaa itse lihaksen lisäksi mm. alaselän terveyteen ja keskivartalon hallintaan, jotka ovat takareisivammojen riskitekijöitä. Kasvupyrähdyksen aikana on suositeltavaa harrastaa liikuntaa, mutta sen ja erityisesti suurimpien kasvupiikkien aikana on hyvä seurata lihaksistoa (lihasten kireyttä ja väsymystä) tarvittaessa levätä normaalia enemmän ja keskittyä hyvään lihashuoltoon.

Takareisivammojen ehkäisy

Vammojen ennaltaehkäisyssä käytetään ammattilaisjalkapallossa erilaisia testejä, joilla voidaan mitata lähinnä eriliikkeiden liikeratoja, lihasvoimaa, tasapainoa sekä aktivoitumista ja muita tekijöitä, joilla pystytään mahdollisesti havaitsemaan mahdollisen loukkaantumisriskin kasvua, testeistä huolimatta läheskään kaikkia takareisivammoja ei pystytä estämään. Takareisivammojen ehkäisemiseksi ei ole vielä löydetty optimaalista keinoa, mutta niiden todennäköisyyttä pystytään vähentämään monimuotoisen vamma ehkäisyn avulla, johon yhdistetään eri elementtejä. Jalkapalloa harrastavalle oikeanlaiset harjoitteet, kehonhuolto ennen liikunta suorituksia ja palautuminen sen jälkeen ovat tämän hetken tutkimusten mukaan niitä keinoja, joilla voidaan laskea takareisivammojen todennäköisyyttä. Suurin osa harjoitteista tulee tehtyä ja sisältyvät usein jalkapalloharjoituksiin, mutta joitain harjoitteita olisi hyvä tehdä myös kotiloissa, joissa tapahtuu myös vammojen ennaltaehkäisyn kannalta tärkeät kehonhuoltoon ja palautumiseen liittyvät asiat, joiden tärkeys korostuu entisestään kasvupyrähdyksen aikana.



Palautuminen

Palautumisessa tärkeimpiä asioita varsinkin kasvupyrähdysten lihashuollon lisäksi aikana ovat ravinto ja lepo. Ravinto on palautumisen kannalta todella tärkeä asia liikuntasuoritusten esim. jalkapalloharjoitusten tai pelin jälkeen onkin hyvä pitää huoli, siitä että seuraava ateria olisi mahdollisimman nopeasti suorituksen jälkeen ja että se sisältäisi hyvän määrän hiilihydraatteja (esim. peruna, pasta tai riisi) ja proteiinia, sillä ne ovat tärkeimpiä ravintoaineita palautumista varten. Levolla tarkoitetaan niin fyysistä lepoa kuin tarvittavaa määrää unta. Unen merkitys palautumiselle ja loukkaantumisten välttämiseksi on suuri ja sen tärkeys korostuu erityisesti kasvupyrähdysten aikana. Lihasien palautumista voi myös edistää kevyellä liikunnalla (esim. kävelylenkki) ja erilaisilla ”lämpöhoidoilla” kylmä/kuuma suihku, kylmäpussi/geeli ja sauna. Lihashuoltoa (varsinkin venytyksiä tai putkirullausta) on suositeltavaa tehdä useamman kerran viikossa tai jopa päivittäin.

Harjoitteet sekä kehonhuolto takareisivammojen ehkäisemistä varten

Alkulämmittely on tärkeä osa takareisivammojen niin kuin muidenkin lihasvammojen ennaltaehkäisyä. Alkulämmittelyssä olennaista on tehdä liikkeitä lajinomaisia harjoitteita, sekä muita liikkeitä, jotka valmistavat liikuntasuoritusta varten esimerkiksi takareisien kannalta jalkapallossa juoksu, sekä takareittä ympäröiviä lihaksia esimerkiksi etureisiä ja pakaroita aktivoivia liikkeitä, mutta myös keskivartalon hallintaa sekä sitä aktivoivia harjoitteita. Lajinomaiset harjoitteet alkulämmittelyssä ovat myös hyviä valmistamaan lihaksia varsinaista harjoitusta tai jalkapallo-ottelua varten.

Venyttelyllä pystytään lisäämään liikkuvuutta, joka on varsinkin kasvupyrähdysten aikana tärkeää. Dynaamiset venytykset ovat hyödyllisiä erityisesti osana alkulämmittelyä ennen liikuntasuoritusta, koska ne auttavat valmistamaan lihakset suoritusta varten ja nostavat myös suorituskykyä ja näin vähentämään loukkaantumisriskiä. Dynaamiset venytykset on hyvä tehdä hallitusti, huolellisesti ja mahdollisimman puhtaasti noin 5-10 kertaa per venytys. Staattiset venytykset ovat ns. ”perinteisiä” pitkäkestoisia venytyksiä. Staattisia venytyksiä on parasta tehdä varsinkin urheilusuoritusten jälkeen tai päivittäin kehonhuoltona, jolloin on hyvä muistaa lämmitellä ennen venyttelyä, koska kylmän lihaksen venyttäminen ei ole koskaan suositeltavaa. Takareittä voi venyttää monella eri tavalla, mutta kasvupyrähdysten aikana selinmakuulla tehty venytys on hyvä alaselän terveyden kannalta, sillä siinä alaselkä ei pääse kaareutumaan. Staattisen venytyksen ei kuulu tuntua kivuliaalta.

Lihaskunto ja voimaharjoitteet, joilla on parhaat tieteelliset näytöt takareisivammojen ehkäisemiseksi ovat ns. eksentristä voimaa kehittäviä harjoitteita, sillä eksentrisen voiman puutteen on todettu olevan yksi suurimmista takareisivammoille altistavista tekijöistä. Esimerkiksi takareisinosto (englanniksi Nordic Hamstring Exercise) on tehokas ja tutkimustulosten perusteella tehokkain yksittäinen liike takareisivammojen ehkäisemiseksi. Liikkeestä löytää hyviä video-ohjeita Internetistä (esim. Youtube) liikkeen englanninkielisellä nimellä. Myös muut takareiden voimaa kehittävät liikkeet ovat takareisivammojen ehkäisyn kannalta hyviä. Keskivartalon hallintaan ja juoksuun osallistuvien lihasten kuten pakaroiden, etureisien ja vatsalihasten harjoittelu on myös kannattavaa takareisivammojen ehkäisemiseksi, sillä huono lantion hallinta varsinkin juoksun aikana nostaa takareisivammojen riskiä. Lihaskuntoharjoitteista on hyötyä myös yleisesti niin jalkapalloa pelatessa kun yleiskunnonkin puolesta.



Viime vuosina on löydetty todisteita siitä, että sprinttien eli maksimi- tai lähelle maksiminopeudella tehtävien juoksupyrähdysten harjoittelu itsessään voisi vähentää takareisivammojen riskiä varsinkin juostessa sen lisäksi, että niiden on tiedetty jo pitkään olevan erinomainen liike voiman ja sitä kautta nopeuden kehittämiseen. Takareisivammojen ehkäisy sprinttien avulla perustuu siihen, että sprinttien säännöllisellä harjoittelulla, varsinkin hyvällä juoksutekniikalla on pystytty saamaan näyttöjä takareisivammojen ehkäisemiseksi. Harjoittelussa käytetään ns. "lentävää lähtöä" eli aloittaa harjoitus kevyemmästä juoksusta, jonka jälkeen kiihdytetään vauhti haluttuun nopeuteen ja sitten hidastaa vauhti uudelleen ennen pysähtymistä. Sprinttejä ei kannata harjoitella useampana päivänä peräkkäin, eikä esimerkiksi jalkapallo-otteluiden tai harjoitusten, joissa juosti paljon jälkeisinä päivinä, sillä varsinkin huonosti palautuneilla lihaksilla kovaa juokseminen on iso riskitekijä takareisivammoille. Määrällisesti sprinttejä kannattaa varsinkin aluksi harjoitella maltillisesti ja suhteellisen lyhyitä esim. 15-25m matkoja muutamia toistoja kerrallaan, antaen kehon palautua hetken toistojen välissä.

Tärkeimmät asiat takareisivammojen ehkäisemiseksi kasvupyrähdyksen aikana:

- **Palautuminen:** kehonhuolto, lepo, uni ja ravinto
- **Lihasharjoitteet:** Takareiden yleisen lihasvoiman ja erityisesti eksentrisen voiman kehittäminen, keksivartalon hallintaan ja juoksuun osallistuvien lihasten vahvistaminen, sekä vartalonhallinnan parantaminen.
- **Sprinttiharjoittelu:** Säännöllinen sprinttien harjoittelu, juoksutekniikan harjoittelu
- **Kasvupyrähdyksen huomioiminen harjoittelussa:** Muutokset lihasvoimassa, kireytyneet lihakset tai heikentynyt motoriikka.

