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REHABILITATION FOR EXTENSOR HALLUCIS LONGUS
AND EXTENSOR DIGITORUM LONGUS TENDINOPATHY
– AN EXERCISE PACKAGE

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The purpose of this thesis was to create an exercise package containing research proven evidence based exercises for Extensor Hallucis Longus and Extensor Digitorum Longus muscles for strengthening purposes. The exercise package consists of eccentric exercises that have been proven to be beneficial in treating tendon problems. The exercise package will be provided to be implemented by the players and coaches of the co-operating bandy team.

The thesis was done in collaboration with Pori Narukerä Jääpalloseura (Pori's bandy team Narukerä) that competes in the Finnish national league. The exercise package was done by using recent studies that have shown the importance of different factors in rehabilitation of tendons. The thesis provides an evidence based background to support the use of eccentric exercises in treating and preventing different tendinopathies.

The theoretical part of the thesis contains an introduction to bandy including some of the rules used, the lower limb anatomy below the knee level, functions of Extensor Hallucis Longus and Extensor Digitorum Longus, tendon pathologies, tissue healing process, treatment guidelines for tendinopathy, the importance of therapeutic exercises in rehabilitation of Extensor Hallucis Longus and Extensor Digitorum Longus tendinopathy and the motor learning process. The theoretical base of this thesis has been gathered by searches from open access databases such as PubMed, ScienceDirect and Google Scholar. Part of the theoretical information has been obtained from literature and various books.

The end product of this thesis will be an individually implemented eccentric exercise package directed to the players and coaches of the Narukerä bandy team. The aim of the package is to help the players to overcome the problems caused by the extensor hallucis longus and extensor digitorum longus tendinopathy during the season. The exercise package has written instructions with coherent pictures in order to provide enough information for the players and coaches, to execute the given exercises correctly even when done independently without supervision. The exercise package has been planned so that the learning process is guided by the Mosston Spectrum of Teaching Styles that support independent learning (Mosston & Ashworth, 2012 Spectrum of Teaching Styles).

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1 INTRODUCTION

Overuse injuries are common among athletes who train with high volumes, out of which approximately 10% account for lower limb overuse injuries (Kjaer et al. 2003, 529). Tendon disorders are a major problem for participants in competitive and recreational sport (Khan, Cook, Bonar, Harcourt & Astrom 1999). Tendon problems are a common problem in the co-operating National bandy team, Narukerä. Most if not all players suffer from extensor hallucis longus and extensor digitorum longus tendinopathy at some point during the season. The highest peaks of occurrence are present in the beginning of the season, after short breaks in the training or after the use of new skates.

Injury to the tendons occurs when the mechanical forces on the tendon exceed the tissues maximum strain or stress. A tendon injury can be a result of an acute trauma, laceration, or of repetitive loading such as overuse. Compression on the tendon may have a role in insertional tendinopathy. (Miller & Thompson 2015, 4) Overuse would be the most probable cause for the symptoms and pain experienced by the bandy team members.

Previously the team has treated their tendon problems with corticosteroid injections. However as there is controversial information on the long-term use of corticosteroids a more appropriate approach was considered. There is evidence that in the case of peroneal tendinitis there is a good response to conservative treatment (Porter & Schon 2007, 132). Since the early 1980s eccentric strengthening has been advocated as a treatment of tendon overuse conditions. Clinical studies point to the efficacy of eccentric strengthening regimens. (Khan, Cook, Bonar, Harcourt & Astrom, 1999) During the recent years there has been emphasis on the effects of physiotherapy on tendinopathies. There is evidence of the effective management of mid-portion Achilles tendinopathy with use of eccentric exercises. (Rees, Stride & Scott 2013, 1)

The objective of this thesis is to provide the team with an exercise package that would help them treat and prevent the reoccurrence of extensor hallucis longus and extensor digitorum longus tendinopathy during the season. The thesis provides an evidence based background to support the use of eccentric exercises in treating and preventing different tendinopathies. The end product of this thesis will be an individually implemented exercise package directed to the players and coaches of the Narukerä bandy team. The aim of the package is to help the players to overcome the problems caused by the extensor hallucis longus and extensor digitorum longus tendinopathy during the season.

2 PURPOSE AND AIM

The purpose of this thesis is to create an exercise package containing research proven evidence based exercises for Extensor Hallucis Longus and Extensor Digitorum Longus strengthening. The exercise package will focus on these muscles and the rehabilitation of the dorsiflexors. The exercise package will be provided to be implemented by the players and coaches in the Narukerä men's bandy team.

The thesis is done in collaboration with Porin Narukerä Jääpalloseura (Pori's bandy team Narukerä) that competes in the Finnish national league. The exercise package is done by using recent studies that have shown the importance of different factors in rehabilitation of tendons. The thesis provides an evidence based background to support the use of eccentric exercises in treating and preventing different tendinopathies.

Due to the issue that corticosteroid injections are the most common way to treat tendinopathies in the Narukerä bandy team the objective of this thesis is to provide the players and coaches with an alternative tool for treatment and recovery. The aim of this thesis is to provide the bandy players and coaches a rehabilitation tool that would enable the players to play the season experiencing less tendon problems if not preventing all tendon problems. By providing them with an alternative the reoccurrence of tendinopathies would hopefully be reduced and possible ruptures due to overuse

of corticosteroids prevented. The end product of this thesis is to provide the team an exercise package all of the players can individually implement in their training sessions or at home with little effort.

3 BANDY

Bandy has long traditions in Finland as first championship was played in 1908. The Finnish national bandy league has nine teams. (Website of Suomen Jääpalloliitto) One of the teams is based in Pori, Porin Narukerä ry., was founded in 1964. Narukerä won their first championship in 1986. In 1999 Narukerä won the men's Finnish championship. (Website of Porin Narukerä)

Bandy is a winter sport played on ice between two teams consisting of 11 players. The game is played on a rectangular rink with the dimensions of length 90-110 meters and width 45-65 meters. In international tournaments the minimum dimensions of the rink are 100x60m. The goal is 2.1m in height, 3.5m wide and depth at least 1m. The ball should be bright in colour sized 63 mm +/-2 mm and weight of the ball should be between 60 - 65g. A straight wooden stick or similar approved material is used with maximum length 125cm measured along the outer side and the maximum height of the blade is 7.0 cm including tape. Mandatory protective equipment includes approved helmets, mouth guards and neck protection, with additional face guard for goal keepers. In addition players may use groin and shin protectors. Goal keepers leg protectors dimension are maximum 80 cm high and 30.5 cm wide and gloves with five separate fingers. (Federation of International Bandy 2013, 1-36)

The structure of the game is played in two halves each lasting 45 minutes, with a 20 minute break in between. Time lost due to disturbances or long breaks can be added to the end of each half but the match secretary and both team captains must be informed of the additional match time. If the score after the official time is tied overtime can be played for 2x 10 or 5 minutes. After the first half the teams change sides. Substitution of players, time and frequency is unlimited during the game. Penalties

during the game are decided by the referee some examples for penalty can include; striking, tripping, kicking or holding opponent. The penalties can be 5 or 10 minutes for each offense. Shoulder to shoulder contact is allowed if not considered violent or dangerous. (Federation of International Bandy 2013, 1-36)

4 BELOW KNEE ANATOMY

The kinesiological model attempts to explain the elements involved in the optimal function and interaction of movement (Sahrmann, 2002, 9). Based on kinesiology no one segment or region of the system can be affected in isolation (Sahrmann, 2011, 4-5). The kinetic chain consists of mechanically coupled segments in which the forces arising in one segment are transferred to other segments (Magee, Zachazewski & Quillen 2007, 477). The elements include the base, modulator, biomechanical, and support. The base which is also the foundation for the movement involves the skeletal and muscular systems. The modulator, which is the nervous system, regulates the movement by controlling the patterns and characteristics of muscle activation. Statics and dynamics are the components of the biomechanical element. The support elements contain the cardiac, pulmonary, and metabolic systems, which are not directly related to producing motion. (Sahrmann, 2002, 9)

4.1 Bone structure

Tibia is the larger weight-bearing bone of the leg. The proximal end of the tibia articulates to the femur and fibula. The distal end articulates with the fibula and talus. Fibula helps stabilize the ankle joint. The ankle consists of seven tarsal bones, talus (ankle), calcaneus (heel), navicular, lateral, intermediate and medial cuneiforms and cuboid. The five metatarsal bones form the base of the toes. The distal component of the foot is formed by two phalanges on the big toe, hallux, and three phalanges on the rest of the toes. The phalanges include the proximal, middle and distal phalanges. (Tortora & Derrickson 2011, 277-280)

4.2 Joints

As there are 28 bones in the structure of the ankle and shin there are also numerous joints between these bones. The bones and joints of the ankle and foot are presented in Figure 1. The tibiofemoral joints connect the tibia to the femur. The fibula articulates to the tibia at the lateral condyle. The distal end of the tibia articulates with talus. The distal tibiofibular joint is the joint between the fibular notch and the fibula. Inter tarsal joints are the joints placed between the tarsal bones. Tarsometatarsal joint is located between the metatarsals and the cuneiforms and cuboid. The talocrural joint is the most superior joint of the ankle that is formed between the fibula and tibia and talus. The tarsometatarsal joint is formed between the metatarsals and the medial, intermediate and lateral cuneiforms and cuboid. Metatarsophalangeal joint is the joint between the proximal row of phalanges and the metatarsals. Interphalangeal joints are between the phalanges of the foot. (Tortora & Derrickson 2011, 277-280)

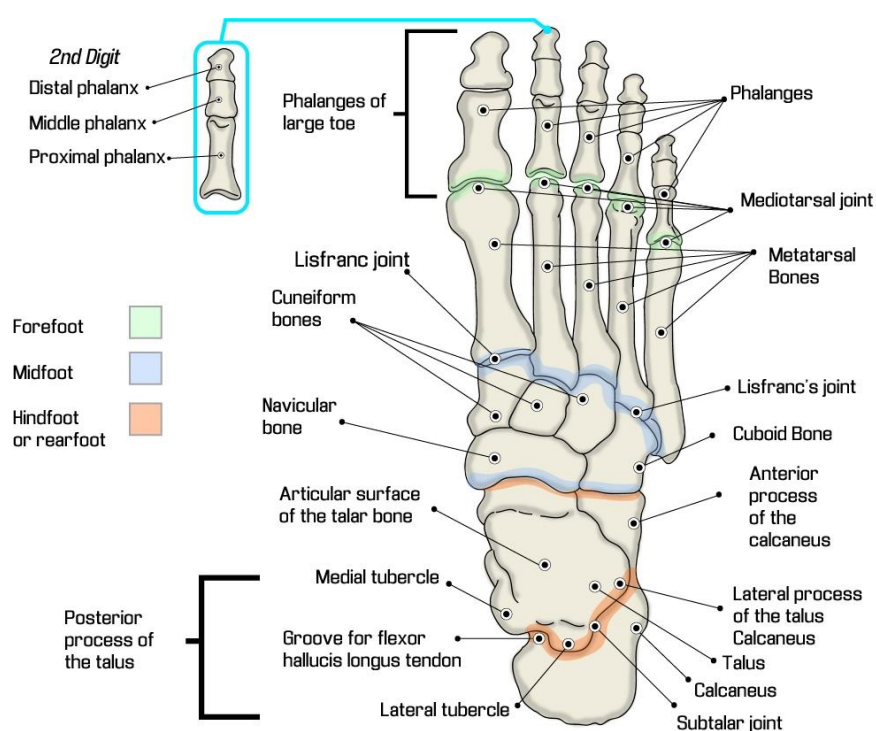


Figure 1. Joints and bones of the ankle. (Website of Anatomy Human Body 2016)

4.3 Tendons and ligaments

Tendons are located between muscles and bones, making joint movement possible (Khan, Cook, Bonar, Harcourt & Astrom 1999). Tendons are connective tissue that is regularly arranged with collagen fibers running in a parallel direction, extending throughout the entire tendon (Miller & Thompson 2015, 3).

At the ankle joint the extensor tendons are stabilized by two extensor retinaculae (Solomon, Ferris & Henneberg 2006, 932). The three retention tunnels formed by the superior extensor retinaculum and the superiomedial and inferomedial parts of the inferior extensor retinaculum hold the tendons of the anterior compartment of the foot in place. The superior extensor retinaculum is located in the distal leg above the ankle. The inferior extensor retinaculum is shaped like the letter Y. This Y-shaped structure forms three compartments for the tendons and their synovial sheaths. Tibialis anterior is located most medially in both arms of the Y, where also the extensor hallucis longus tendon is located. The tendons of the extensor digitorum and peroneus tertius are located in the medial part of the stem. (Lee et al. 2006, 161-163)

The long tendons of the muscles peroneus longus, peroneus brevis, flexor hallucis longus, tibialis posterior and flexor digitorum longus provide additional support for the ankle joint (Brockett & Chapman 2016, 232). Figure 2. demonstrates how the extensor digitorum longus and extensor hallucis longus tendons are in the fore foot.

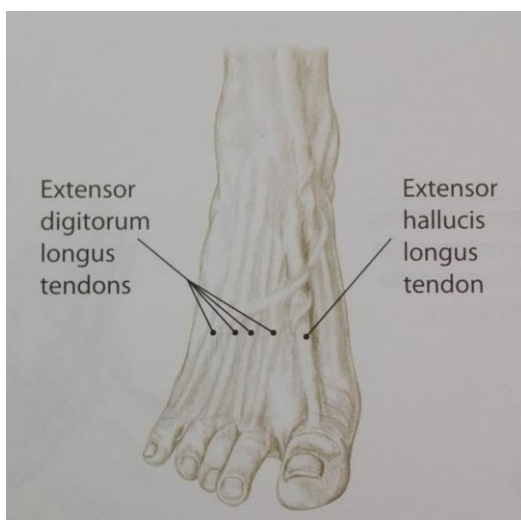


Figure 2. Tendons of the fore foot. (Biel, A. 2010, 378)

4.4 Muscles

The muscles of the leg are divided into three compartments by fascia. The three compartments are anterior, lateral and posterior compartment. (Tortora & Derrickson 2011, 432-433) A list of all the muscles involved in the movements of the ankle joint according to the different compartments is presented in Table 1.

Table 1. A list of muscles involved in the movements of the ankle joint by compartments. (Tortora & Derrickson 2011, 432-433)

Muscle	Produced movement of ankle
Anterior compartment of the leg	
Tibialis anterior	Dorsiflexion, inversion
Extensor hallucis longus	Dorsiflexion, extension of proximal phalanx of big toe
Extensor digitorum longus	Dorsiflexion, extension of phalanges
Fibularis /peroneus tertius	Dorsiflexion, eversion
Lateral compartment of the leg	
Fibularis /peroneus longus	Plantarflexion, eversion
Fibularis /peroneus brevis	Plantarflexion, eversion
Posterior compartment of the leg	
Gastrocnemius	Plantarflexion
Soleus	Plantarflexion
Plantaris	Plantarflexion
Popliteus	Flexes knee, medially rotates
Tibialis posterior	Plantarflexion, inversion
Flexor digitorum longus	Plantarflexion, flexion of phalanges
Flexor hallucis longus	Plantarflexion, flexion of great toe

The focus in this thesis is on the muscles located in the anterior compartment. The movement that these muscles produce is the dorsiflexion of the foot. The muscles in the anterior compartment include the tibialis anterior, extensor hallucis longus, extensor digitorum longus and peroneus tertius. (Tortora & Derrickson 2011, 432) The focus in this thesis is on the muscles located in the anterior compartment more specifically the extensor hallucis longus and extensor digitorum longus. The extensor digitorum longus arises from the upper three-quarters of the extensor surface of the fibula, the interosseous septum and from a small area of the tibia across superior tibi-

of fibular joint. It forms its four tendons which are restrained by the superior and inferior extensor retinaculum. (Lui 2011, 1-6) The extensor hallucis longus muscle is illustrated in Figure 3.

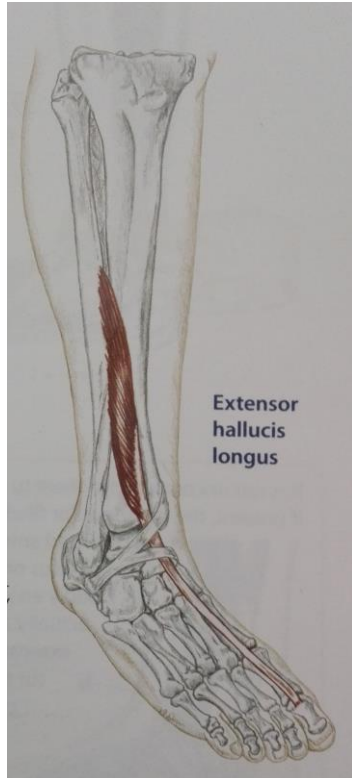


Figure 3. Extensor hallucis longus. (Biel, A. 2010, 378)

The extensor digitorum longus muscle and inferior extensor retinacula are illustrated in Figure 4.

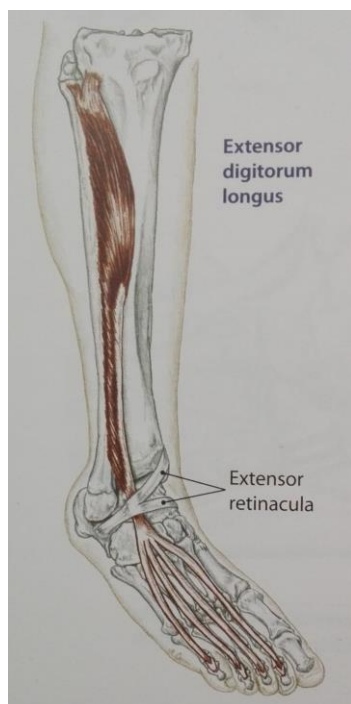


Figure 4. Extensor digitorum longus and inferior extensor retinacula. (Biel, A. 2010, 378)

5 TENDON PATHOLOGY

Kinesiopathology refers to how movement that is excessive, imprecise or insufficient contributes to the development of pathology. The repetitive use of specific segments of the body combined with high and rapid force development can exceed tissue tolerance resulting in microtrauma. (Sahrmann, 2011, 4-7) Sudden maximum muscle activation that results in larger than normal force that is applied to the tendon may cause a partial or complete rupture. Variation in loading within the tendon may also be related to motor control or muscle structure. A tendon is exposed to great loads during eccentric loading especially in rapid movements this is one connection to tendon injuries. (Maffulli, Renström, & Leadbetter 2005, 248)

When talking of different pathologies of the tendons the terms referred to can be very similar. For further clarification the following terms are explained in more detail. Tendon pathology may begin well before symptoms arise and that tissue damage is

already advanced when an athlete first notices tendon pain. (Khan, Cook, Bonar, Harcourt & Astrom 1999) The following will also explain the process that occurs in tendon healing as that is a crucial part of information in the rehabilitation process. The base knowledge of the tissue healing will help plan the appropriate exercise package and the timing.

5.1 Terms in tendon pathology

Tendinosis is intratendinous degeneration caused by ageing, microtrauma or vascular compromise with the absence of an inflammatory response both clinical and histological signs. Tendinitis, on the other hand is a symptomatic degeneration of the tendon with vascular disruption and inflammation response. However rarely the cause of overuse tendon conditions is caused by 'tendinitis'. Thus there is a suggestion to use the term 'tendinopathy' when describing common overuse tendon conditions. (Khan, Cook, Bonar, Harcourt & Astrom 1999)

Tendinopathy is referred as a general term for labelling chronic tendon insertion problems. General characteristics of tendinopathy include longstanding localized pain related to activity, (Fu, Rolf, Cheuk, Lui & Chan 2010, 1) however with the absence of degenerative process and inflammation. Although all tendinopathies should not exclude the presence of inflammation since that would be considered an oversimplification and possible misleading (Rees, Stride & Scott 2013, 1). Due to the nature of tendinopathy being a general term for chronic tendon insertion problems (Fu, Rolf, Cheuk, Lui & Chan 2010, 1) therefore this term will be used hereafter in this thesis to describe the referred conditions. This has also been the criteria that the theoretical background of this thesis is based on.

5.2 Tendinopathy

The primary mechanisms that trigger tendinopathy can be caused by overuse, repetitive strain or mechanical overload to tendons, with symptomatic presentation in various regions. There are other risk factors that have been linked to the development of an overuse tendinopathy besides quantitative increase in activities. The formation of

tendinopathy may be attributed to improper gait or training errors among the individuals. Repetitive tensile strain, stress-shielding, contractile tension overloads or compression includes some of the unfavourable mechanical stimulation. These mechanical stimulations may induce tendon inflammation or degenerative changes. (Fu, Rolf, Cheuk, Lui & Chan 2010, 3-5)

Since the early 1980s eccentric strengthening has been advocated as a treatment of tendon overuse conditions. Clinical studies point to the efficacy of eccentric strengthening regimens. (Khan, Cook, Bonar, Harcourt & Astrom, 1999) One of the most common treatments used with tendinopathies includes physical exercises including eccentric exercises or other progressive loading regimes for strengthening the tendon. During the recent years there has been emphasis on the effects of physiotherapy on tendinopathies. There is evidence of the effective management of mid-portion Achilles tendinopathy with use of eccentric exercises. However similar results have not been able to be replicated in less-athletic populations. In addition the use of eccentric exercises management has not been satisfactorily demonstrated in other tendons. Other rehabilitation methods include use of a variety of exercises such as gradually increasing the load and velocity when the patient tolerates the current load. (Rees, Stride & Scott 2013, 1)

6 TISSUE REPAIR OF TENDONS

The dynamic and biological characteristics of the components of the movement system enable the tissue to adapt to the demands placed on them. Specific tissue adaptations are normal biological responses to forms of stress but may contribute to deviations that may contribute to the development of musculoskeletal pain. (Sahrmann, 2011, 6-7) Exercise increases the blood flow to muscles by 20-fold and in tendons by 7-fold. Healing and normal tendons adapt to increased loads either structurally by becoming larger, and hypertrophying as muscle does, or by changing their material properties to become stronger per unit area. (Magee, Zachazewski & Quillen 2007, 56-57)

There are three stages related to the repair process of tissues. The first stage that occurs after the injury is the acute/subacute phase. The distinct factors of the acute/subacute phase are pain, swelling, joint effusion, reduced joint range of motion and muscle activation. (Kjaer et al. 2003, 202-203) Usually when the patient experiences pain, the damage of the tissues has already occurred. This would suggest that even patients who present with only a few days of symptoms may require relative rest to permit tendon damage to repair. (Khan, Cook, Bonar, Harcourt & Astrom 1999)

The healing of severed or injured tendons begins within days after the inflammatory response has started by glycosaminoglycan (GAG) synthesis (Maffulli, Renström, & Leadbetter 2005, 250). The initial stage of repair involves formation of scar tissue that provides continuity at the injury site. During the initial repair process and the inflammatory phase the increase in levels of growth factors and cytokines such as insulin-like growth factor-1 (IGF-1) stimulate the migration and proliferation of fibroblasts and inflammatory cells to the wound site. The recruitment of fibroblasts stimulates the local tenocyte population. The tenocytes synthesize collagen and other extracellular components that establishing the formation of scar tissue. Collagen is the basic structural unit that is synthesized by the tenocytes. (James, Kesturu, Balian & Chhabra 2008, 102-106)

This is followed by collagen synthesis which enables the wound to have low levels of force applied within few days. Applying low levels of tensile forces encourages the newly formed collagen fibrils to align in the direction of applied force. This is a crucial process in forming a firm tendon that can withstand high levels of loading. Thus healing tissues such as skin, muscle, ligament or tendon that are subjected to progressive loading are almost always stronger than unloaded tissue. (Maffulli, Renström, & Leadbetter 2005, 250)

Mechanical loading accelerates tenocytes metabolism and may speed repair (Khan, Cook, Bonar, Harcourt & Astrom 1999). Mechanical stimulus on the tendon is also essential during the repair process since the absence of it will cause proliferation of scar tissue and subsequent adhesions that are undesirable and harmful. Mobility and

mechanical loading are essential in decreasing the formation of adhesions and increasing the strength of the tendon. If there is a lack of mobility the formation of adhesions and scar tissue will affect the normal tendon function. Due to the damage in the tendon proinflammatory molecules attract inflammatory cells from the surrounding tissue. Fibroblasts recruited to the site begin to synthesize various components of the extracellular matrix. Angiogenic factors are released during this phase and initiate the formation of a vascular network. These processes include an increase in DNA and in Extra cellular matrix (EMC), which establishes continuity and partial stability at the site of injury. (James, Kesturu, Balian & Chhabra 2008, 105)

In the second, proliferative stage fibroblasts are recruited and their rapid proliferation at the wound site is responsible for the synthesis of collagens, proteoglycans, and other components of the Extra cellular matrix (ECM). These components are arranged in a random manner within the ECM that is mainly composed of type III collagen. At the end of the proliferative stage, the repair tissue is highly cellular and contains relatively large amounts of water and an abundance of ECM components. (James, Kesturu, Balian & Chhabra 2008, 102- 106) The second phase lasts 5-21 days in acute injuries (Magee, Zachazewski & Quillen 2007, 62). In the recovery phase the affected tissue are allowed to go through the healing and repair process. The aim of this phase is to restore the function of the tendon. The focus of this stage is in increasing strength and function. The symptoms and clinical signs should decrease and finally disappear, however pre-injury level of exercise should still be avoided. (Kjaer et al. 2003, 202-203)

The final stage of remodeling begins between 20 days post injury to 6 –8 weeks after injury (Magee, Zachazewski & Quillen 2007, 62). This phase is characterized by a decrease in cellularity, reduced matrix synthesis, decrease in type III collagen, and an increase in type I collagen synthesis. The Type I collagen fibers are responsible for the mechanical strength of the formed tissue. The Type I collagen fibers are organized longitudinally along the tendon axis. The interaction between collagen structural units leads to higher tendon stiffness and greater tensile strength. However repaired tissue will never reach the strength of a non-injured tendon. (James, Kesturu, Balian & Chhabra 2008, 105)

The third stage is the rehabilitation stage that leads to return to the sport. The final phase should focus on flexibility, strength, endurance, proprioception and neuromuscular control. Emphasis is on the prevention part of the rehabilitation process. The rehabilitation program should also take into consideration the affected balance and coordination. (Kjaer et al. 2003, 202-203)

The estimates of the rate of tenocyte repair vary, but some studies suggest that two to three weeks are required for a tissue response to occur. After that time, gradual tendon strengthening may be initiated. Therefore, recovery may take months, even in patients who present with recent onset of symptoms. If structural damage to the tendon is present such as partial tearing of collagen, a longer healing time may be required. Due to the fact that tendons must often bear the strain of more than 10 times the body weight in addition to a slow metabolic rate the tendon requires more than 100 days to synthesize collagen. Thus it is reasonable to consider that the repair of tendinopathies may take months rather than weeks. (Khan, Cook, Bonar, Harcourt & Astrom 1999)

7 TREATMENT GUIDELINES FOR TENDINOPATHY

The treatment guidelines differ slightly depending on the injury mechanism whether the case is an acute or chronic tendon injury. The following will present few conservative treatment methods in more detail. Since the common injuries among bandy players are of a chronic nature that will be the focus of the treatment guidelines. Resistance training that emphasizes the eccentric action of the muscles can enhance the individual's ability to absorb and dissipate energy during movement and consequently to control the amount of reactive forces flowing in through the kinetic chain. Eccentric exercises should be a part of prevention and treatment of musculoskeletal injuries, as it minimizes the stress to joints and connective tissue. (Magee, Zachazewski & Quillen 2007, 485)

7.1 Treating chronic tendon problems

With chronic tendinopathies it may be challenging to deduce what the healing process is at the current stage. The likely stage of individuals with chronic tendinopathy is the remodelling phase where force application is most effective. The injury mechanisms behind acute and chronic tendon injuries differ however there are some similar factors in treating both types of tendinopathies. The first step is to identify and remove all negative external factors or forces. (Maffulli, Renström, & Leadbetter 2005, 252) According to the Narukerä team official physiotherapist, Sten Oskar, for the bandy team members the first step in removing negative external factors would mean reducing the amount of training or adjusting the skates that cause pain.

Tissues respond differently to exercise but also the response may vary depending on the type of tissue. This also applies to tissue recovery. Junctional areas of ligaments respond more rapidly to immobilization than the mid substance but recovers slower. This may help explain why some tendon injuries occur at the bone-tendon junction. Due to variation in loading magnitude, number of cycles and accompanying stress endurance exercise seems to produce more variable results. (Maffulli, Renström, & Leadbetter 2005, 245) There are two approaches to rehabilitate a tendon, remove or reduce the tensile forces or to cause the tendon to become stronger. The repetitive strain injuries and chronic tendon pain are common among athletes as they are unwilling to reduce the amount of loading on the tendons. Thus intervention in the form of exercise would be more beneficial in inducing adaptation within the tendon to better withstand the loads. (Maffulli, Renström, & Leadbetter 2005, 247)

However if the symptoms of a chronic tendinopathy are severe the treatment approach should resemble the timing and loading used for an acute-onset tendon injury. More severe cases should be treated with relative rest, reduced loading, and other modalities for 10 to 14 days. Process follows by gradual stress increase as with acute tendon injuries or repair. If the injury is acute or has severe injury lower forces should be applied. Passive movements produce very low tensile forces thus they can be commenced immediately after injury. (Maffulli, Renström, & Leadbetter 2005, 252)

Hallux dysfunction can be the result of lacerations sustained over the dorsum of the foot in connection to Extensor hallucis longus (EHL) tendon injuries (Wong, Daniel and Raikin 2014). In the cases of lacerations or tears of the extensor hallucis longus reconstructive surgery is commonly used as a treatment method. Postoperative range of motion therapy and mobilization protocol has been successful on the patient population. The evidence of the effects was tested with The American Orthopaedic Foot and Ankle Society midfoot score, postoperatively after 3 and 6 months with the results 90 of 100. Reconstructive surgery may be a treatment method for extensor hallucis longus lacerations. The management also includes postoperative range of motion therapy and a mobilization protocol. (Joseph & Barhorst, 2012) Hallux tendon injuries, ruptures and lacerations, do not always require surgical repair. This depends on the mechanism and site of the injury in addition to timing and presence of other injuries. (Scaduto & Cracchiolo 2000) Therapeutic exercise and early controlled motion applied after flexor tendon repair decreases adhesion formation and improves repair site strength, permitting more complete recovery of tendon excursion and digital range of motion (Lieber, Amiel, Kaufman, Whitney & Gelberman 1996, 957).

7.2 Corticosteroids in treatment

In chronic tendinopathy corticosteroids are used for pain relief, reduction of swelling and functional improvement. These are backed up by substantial evidence although with short term effects and a greater risk of long-term recurrence. (Rees, Stride & Scott 2013, 4) However there is no consistent evidence on the long-term pain relief and restoration of pain-free function of corticosteroid injections on tendinopathies (Childress & Beutler 2013, 486-488).

Previously the team has used corticosteroid injections to treat tendinopathy as a first solution and to enable the players to play in the future games. However based on research the use of corticosteroids suppresses the formation of adhesions. The use of corticosteroids may lower the tensile strength of the damaged tendon and result in a subsequent spontaneous rupture. (Miller & Thompson 2015, 5) In treating tendinopathy there is evidence that does not recommend the use of corticosteroids based on catabolic effect and subsequent risk of rupture (Miller & Thompson 2015, 1423).

Some sources even suggest that the use of steroid injections may predispose the tendons to rupture especially in the weight bearing joints such as the patellar and Achilles tendon (Childress & Beutler 2013, 486-488).

8 THERAPEUTIC EXERCISES

Therapeutic exercise is intended to remediate or prevent impairments, improve, restore or enhance physical function. The means used to achieve this include systematic, planned bodily movements and physical activities. (Kisner & Colby 2007, 2) When planning the exercises they should be task specific, focusing on the cause of the impairment with similar movement patterns. Effective improvement of functional ability should include progressive and more challenging functional exercises as the patient improves. (Kisner & Kolby 2007, 21)

Dynamic muscle contraction consists of a concentric and eccentric contraction. The concentric contraction is the part where the muscle contracting shortens. Whereas the eccentric portion of the contraction is when the muscle lengthens and the muscle attempts to control the lowering of for example a weight. Rehabilitation and conditioning programs use both concentric and eccentric exercises. In rehabilitation eccentric training is an essential component in reducing the risk of musculoskeletal injury and re-injury during activities that require deceleration. This includes activities that require rapid change of direction and high-intensity deceleration. (Kisner & Kolby 2007, 170)

The use of eccentric resistance training is advocated during rehabilitation due to the evidence that supports its benefit. However chronic muscle-tendon disorders are commonly associated to eccentric muscle contractions and activities with high repetition. Eccentric exercises done with high-intensity have been thought to improve sport related performance. (Kisner & Kolby 2007, 170) There are implications in specific that the prevention of injury to the muscle-tendon unit could be possible by eccentric resistance exercise. The use of eccentric resistance exercise has thought to improve

the muscle's ability to absorb more energy before failing. (LaStayo, Woolf, Lewek, Snyder-Mackler, Reich & Lindstedt 2003, 562)

The main components associated with tendinosis are pain and weakness, especially in the eccentric-strength component. Resolving the problem in this component may take up to a year. Experimental and anecdotal evidence support that in the treatment and rehabilitation of tendinoses eccentric resistance exercises are recommended treatment methods. (LaStayo, Woolf, Lewek, Snyder-Mackler, Reich & Lindstedt 2003, 563)

Based on current literature eccentric exercises are effective in the treatment of pain and restoring function among a population with Achilles Tendinopathy. The research is extensive with numerous potential explanations supporting the effectiveness of eccentric exercise regimes. However many of the suggested explanations require further investigation. (O'Neill, Watson & Barry 2015, 558)

A study was conducted on fifteen recreational running athletes who experienced Achilles tendon pain and had decreased eccentric and concentric calf strength, mean age 44, 12 males and 3 females. The participants underwent an eccentric resistance exercise program with progressively increasing loads. The eccentric resistant group was compared to a similar group, mean age 40, 11 males and 4 females with uncontrollable Achilles tendon pain. The control group was treated with rest and non-steroidal anti-inflammatory drugs, orthotics, and physical therapy that included an ordinary training program. (LaStayo, Woolf, Lewek, Snyder-Mackler, Reich & Lindstedt 2003, 564-565)

The high- force eccentric exercise program consisted of calf raises, done two times per day every day of the week. The amounts were three sets of 15 repetitions. The aim of the exercise was to bilaterally perform the concentric part, which is raising the heels. Lowering the heels, thus the eccentric part was done only with the affected side slowly and in a controlled way. As the participants progressed to the point where the exercises inflicted little or no pain, resistance was added by the means of additional weight. The results showed that all of the participants in the eccentric-training program returned to pre injury levels of running activity after 12 weeks. Compared to

the control group, conventional exercise group that ultimately required surgery. These results clearly suggest that high-force eccentric loading can be beneficial. (LaStayo, Woolf, Lewek, Snyder-Mackler, Reich & Lindstedt 2003, 564-565)

However there is a consensus that eccentric muscle re- training is essential but it is still questionable what the optimal dosage of eccentric exercise is. Chronic high-force eccentric exercise for 6 to 12 weeks can be recommended for the return of muscle mass, strength, and for muscle spring adaptations. This method has also been favourable in the rehabilitation of the muscle-tendon structure. (LaStayo, Woolf, Lewek, Snyder-Mackler, Reich & Lindstedt 2003, 566)

A research tested the effects of an isokinetic exercise program on the ankle evertors and dorsiflexors, peroneus longus and tibialis anterior that combined eccentric–concentric mode for 3 days per week for 6 weeks. After the six week training program there was a significant increase in eccentric peak torques for the ankle evtor and dorsiflexors in the exercise group compared to the control group. (Keles, Sekir, Gur & Akova, 2013)

Two separate methods for ankle evtor muscle reinforcement were tested after ankle sprain. First randomized group used concentric reinforcement of the evtor ankle muscles and conventional physical therapy. The second randomized group underwent eccentric reinforcement. The 18 subjects experienced their first episode of ankle sprain. The strength of the evtor muscles was tested at the end of the physical therapy as peak torques in concentric and eccentric modes and as ankle strength deficits. The testing was done by using an isokinetic dynamometer. (Collado, Coudreuse, Graziani, Bensoussan, Viton & Delarque, 2010)

The first group showed significant concentric strength deficit and an eccentric strength deficit on the injured side in comparison with the healthy side. The eccentric exercise group showed significantly greater muscle strength during concentric movements. The eccentric rehabilitation method restored the strength of the injured evtor muscles. These results are significant in providing supporting evidence in the use of eccentric exercises in rehabilitation. Especially as weakness is a major risk

factor contributing to instability and recurrent sprains. (Collado, Coudreuse, Grazi-ani, Bensoussan, Viton & Delarque, 2010)

Alfredson et al. conducted a study with the aim to find out the short-term effect of heavy-load eccentric calf muscle training on tendon pain during activity in correlation to calf muscle strength among chronic Achilles tendinosis patients selected for surgical treatment. The participants consisted of 15 recreational athletes 12 males and 3 females who had Achilles tendinosis and had experienced pain during running for an extensive period of time. The participants had tried other conventional treatments such as rest, nonsteroidal anti-inflammatory drugs, changes in shoes or orthoses, physical therapy and ordinary training programs with no effect on the Achilles tendon pain. (Alfredson, Pietilä, Jonsson & Lorentzon 1998, 360-366)

The intervention group was compared to a control group with similar participants who underwent surgical treatment. The peak torque and total work were evaluated with a Biodex isokinetic dynamometer (Biodex Co., Shirley, New York) before starting the exercise program and after finishing the regimen at 12 weeks. The control group was tested pre-surgery and 24-weeks post-surgery. (Alfredson, Pietilä, Jonsson & Lorentzon 1998, 360-366)

The eccentric exercise program included 3 sets of 15 repetitions performed 2 times per day, every day of the week for a 12 week period, with a control check at the 6 week period. During this regimen running was allowed if it did not exceed mild discomfort with no pain. The exercises consisted of two different movements. Calf muscle eccentrically loaded with knee straight and knee bent. The patient started the movement by standing with full weight on the fore foot, then lowering the heel below the forefoot. There was no concentric loading done with the affected side. The non-affected side was used to get to the starting position. Pain was allowed to occur to a certain limit but they were advised to stop if pain was disabling. When the exercises were performed with minor pain or discomfort weight was added. When very high weights were needed patients were advised to use a weight machine. (Alfredson, Pietilä, Jonsson & Lorentzon 1998, 360-366)

All participants in the eccentric exercise group returned to their pre-injury level with full running activity after 12 weeks. The concentric plantar flexion strength at 90 and 225 deg/sec and eccentric plantar flexion strength on the injured side showed significant increase. There was no significant difference in concentric and eccentric plantar flexion strength between the injured and non-injured sides. (Alfredson, Pietilä, Jonsson & Lorentzon 1998, 360-366) There is an ongoing debate on the optimal load, frequency and duration of eccentric exercises. The exact mechanism involved in the eccentric exercises is also still unclear. The exercises used in this intervention are very time-consuming, consisting of 180 repetitions per day for 12 weeks.

A 5-year follow-up was performed on a previously published randomized controlled trial (RCT). The follow-up evaluated the effect of eccentric exercise in patients with Achilles tendinopathy. The baseline included 58 patients, total of 70 tendons with chronic mid-portion Achilles tendinopathy. Inclusion consisted of symptoms present for more than 2 months and participation in sporting activities. All patients in the trial performed the heel-drop program as described by Alfredson et al. (1998) Half of the group received a night splint which had no significant influence in the VISA-A score in the 3-month and 1-year follow up. Thus these two groups were merged for the 5-year follow up. Post completing the eccentric exercise program the patients were given the choice to choose additional treatment, with instructions or recommendations given. The amount of patients who responded to the follow up included 58 tendons and 46 patients, including 12 bilateral and 35 unilateral cases. (van der Plas et al. 2011, 1-5)

At the 5-year follow-up 39.7% of the patients reported being completely pain-free and the remaining 60.3% experienced some degree of pain. The experience of pain varied from only during extensive exercise to permanent pain. Out of the patients 56.7% that did not receive further treatment were completely pain free. Majority, 67.2% from the original 3 month heel-drop program never performed the eccentric exercises again. There was no correlation found between the pain statuses between patients who continued the eccentric exercises compared to those who did not continue. (van der Plas et al. 2011, 1-5)

The use of eccentric exercises dominates the rehabilitation programs for Achilles tendinopathy. These programs do not primarily focus on increasing muscle strength as a resistance exercise program. In addition to the eccentric exercises well planned resistance training and sport-specific rehabilitation such as sport-specific functional strengthening and endurance training should be considered. The non-athletic population has shown to have a poorer response rate to eccentric exercises used as rehabilitation for Achilles tendinopathy. Despite the amount of research conducted on eccentric resistance exercises for the Achilles tendinopathy it still remains unclear why eccentric exercises have more utility in strengthening when compared to other training programs. (Allison & Purdam 2009, 278)

In chronic tendinopathies it may be challenging to define the point of healing process with chronic injuries. Pain of the individual is used to control the amount of load applied to the tendon. When pain decreases loads are increased, however there is no direct evidence what the correct time is, the timing is done through trial and error. Training requires the appropriate structure, load and movement specificity with a motor pattern that resembles the patient's activity. As the tendon heals maximal loads need to be added continuously, this can be done by increasing the speed of the movement or by increasing the magnitude of the tensile force through external forces. The ideal treatment needed to be something based on exercise science but able to be completed independently by the patient at low cost. Eccentric exercise program meets the criteria. (Maffulli, Renström, & Leadbetter 2005, 255-259)

9 EXERCISE PACKAGE

All studies examining the eccentric exercise program have found it effective in treating chronic tendinopathy, although the design may have varied (Magee, Zachazewski & Quillen 2007, 72). This is the main reason why eccentric exercises were chosen for this extensor hallucis longus and extensor digitorum longus exercise package for the Narukerä bandy team. Chronic high-force eccentric exercise for 6 to 12 weeks can be recommended for the return of muscle mass, strength, and for muscle spring

adaptations. Evidence indicated that all of the participants in the eccentric-training program returned to pre injury levels of running activity after 12 weeks. These results clearly suggest that high-force eccentric loading can be beneficial. (LaStayo, Woolf, Lewek, Snyder-Mackler, Reich & Lindstedt 2003, 564-566) Thus based on evidence the exercise program should be followed for a minimum of 6 weeks. Preferably up to 12 weeks or more.

The exercise package consists of one main exercise with three different stages for increasing the load and difficulty level. The stages are planned to increase the loading on the targeted muscles as the individual progresses. Once the individual can perform the exercise at the first stage without experiencing increasing pain the individual may move on to the next stage. There is a reason why the loading should not be increased too early. High level of pain 8-9/10 on visual analog scale or pain too early in the program before 20 repetitions can cause worsening of symptoms during functional activities (Magee, Zachazewski & Quillen 2007, 72). Thus it is advised that the next stage should be started only when the current stage does not cause pain.

When planning an exercise package it is important to consider the reason why individuals would be committed in following the program. Initially the motivation to use the exercise package is the player's individual decision. However since the tendinopathy of the extensor hallucis longus and extensor digitorum longus affect majority of the Narukerä bandy team members there is a higher probability that the players will implement the exercise program in their typical training routines. The exercise package is planned and structured in a way that it supports individual learning and implementation.

Learning is a complex process. Movement patterns become established after repetition and the pattern is reinforced by changes in both the nervous and muscular systems. Motor learning consists of different stages. In motor performance conscious effort is the key in learning a new skill. Motor learning is the result of performing a skill without it requiring conscious effort in executing in repeating the movement. (Sahrmann, 2011, 12)

Motor control is divided into four types of skills continuous, discrete, closed or open skills either depending on the organization or respect to environment. Discrete skills have a certain starting and endpoint in the movement pattern whereas continuous skills have a more extensive pattern that is continuous such as walking. The motor skills related to environment are closed or open skills. Closed skills are performed in a relatively stable environment as compared to open skills that take place in an environment that changes and is unpredictable. (Magee, Zachazewski & Quillen 2007, 378-379)

The development of a motor skill is divided into different stages. In order for an individual to learn a new motor skill the following stages must occur. The first stage of learning that requires great concentration and that is filled with errors is the cognitive stage. The movements in this stage are still rough and undefined with some errors involved. The second stage is the associative stage where less effort is required in recalling the movement and the details involved hence movements become smoother and more consistent, in this stage the learner has discovered the most efficient way of performing the exercise. The final stage is the autonomous stage where the movement becomes efficient and automatic. Reaching the autonomous stage could be considered the stage where the learning has been achieved. (Magee, Zachazewski & Quillen 2007, 378-379)

Proprioception and postural control are two components of neuromuscular control. Joint movement sense and joint position sense are physiological processes in the sensorimotor system and are often connected to the term proprioception. (Magee, Zachazewski & Quillen 2007, 375-376) These factors can be used to aid and influence the learning process as external feedback. Proprioception is connected to the increased awareness of correct movement patterns and maintaining voluntary control of those movement patterns. (Magee, Zachazewski & Quillen 2007, 408) In order to add the proprioception to the exercise package the exercises are instructed to be performed bare foot. This should add an aspect into the learning process.

The structure of the exercise package is intended to lead the reader to the learning experience and to ensure that they would remember the information presented. The different teaching styles of Mosston's Spectrum of teaching were implemented in

designing the instructions. The styles that were focused on support individual learning processes in physical activity and thus suite the purpose of an exercise package. The combination of the guided discovery (F), Learner-designed individual program (I), Learner initiated (J) and Self teaching (K) styles were used. These styles all support and guide independent learning. (Mosston & Ashworth, 2012 Spectrum of Teaching Styles)

Guided discovery provides the information where the learner should discover the answer. Decisions made by learner should lead to the discovery of the predetermined concept principle, relationship or rule that was previously unknown. This results in learning. The Learner-designed individual program focuses on the learner's motivation and cognitive intentions for them to take charge of the learning process. This relates to the exercise in the case of motivation of the players and their decision to use the rehabilitation program. Motivations are also connected to the Self-teaching style where the decisions to learn are entirely made by the learner based on their expectations and desires. Hence translated to whether the individuals will have the motivation to use the provided exercises. The style that is mostly related to motivation is the learner initiated style through cognitive intentions to design their own learning experience. This Learner Initiated (J) style is the main target as the learner initiates the learning process by pursuing the complexities of learning by making the decisions, defining their own learning objectives, and producing results. (Mosston & Ashworth, 2012 Spectrum of Teaching Styles)

10 PROCESS OF THE THESIS

The idea for the thesis process started through co-operation with Pori's bandy team Narukerä. During the beginning of the season several players had experienced pain in the fore foot. The pain usually subsided as the season went on but there were reoccurrences when the players changed their skates or as the playoffs approached at the end of the season. After a short break in the games over the Christmas holidays as the tendon problems reoccurred one of the players brought up this matter.

The team libero Markku Arola explained that all players have the pain in the fore foot at some point during the season. Previously the team has treated this issue with corticosteroid injections to the site, which was confirmed by the team doctor. After continuing the discussion with team libero Markku Arola he hoped that there would be some way to solve the problem and to provide another option for the players. Rather than relying on the corticosteroid injection every time as previously. The discussions continued and the solution for the players seemed to be an exercise package or something similar to help them recover or treat the tendon problems. Thus the idea of implementing the theory based exercises for the players and coaches in the form of an exercise package was formed. The step to step process of this thesis is demonstrated in Figure 5.

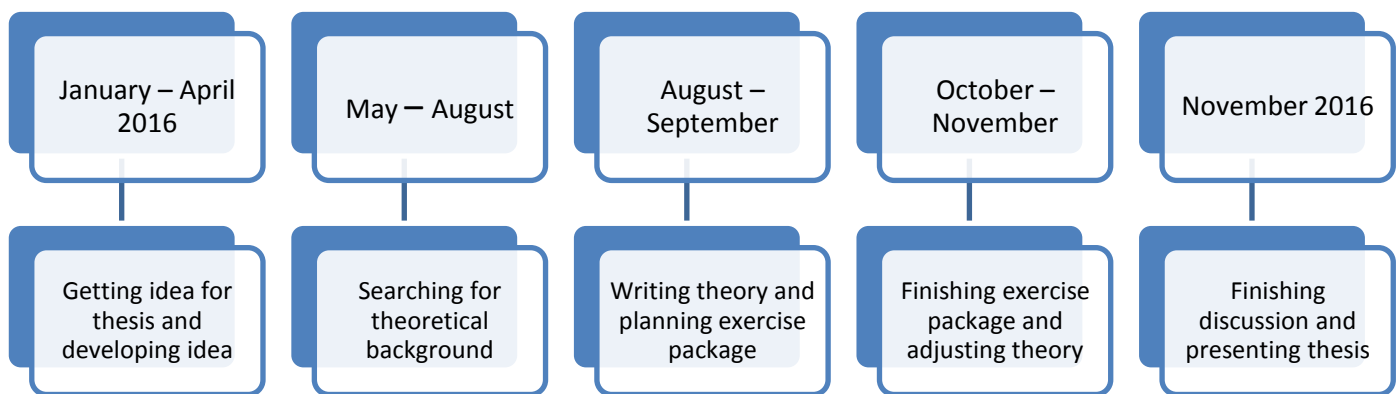


Figure 5. Thesis process

The theoretical base of this thesis has been gathered by searches from open access databases such as PubMed, ScienceDirect and Google Scholar. Part of the theoretical information has been obtained from literature and various books. The final steps of finishing the thesis has been producing the end product, which is the exercise package and writing the discussion of the thesis.

11 DISCUSSION

Bandy is a popular winter sport played on skates. Almost all of the players of the Narukerä team in Pori experience pain in the tendons of the forefoot at some point during their career. This pain is usually present after an increase of training volumes after the summer or other period of inactivity.

Due to tendinopathies mostly being of the chronic nature it may be challenging to define the point of healing process with chronic injuries, as referred Maffulli, Renström, & Leadbetter (2008, 255). This poses some challenges when planning the exercise package to the bandy players since there is no way of confirming the diagnosis or the current stage of the tendinopathy without further medical examination. The exercise package focuses on the stage where the player is able to load the tendons and remodeling phase where loading can be gradually increased.

Since there are no methods available for the individuals to know what tissue healing stage they are in currently most of the references used pain as the controlling factor. The pain of the individual is used to control the amount of load applied to the tendon. When pain decreases loads are increased. There is no direct evidence on the amounts that a tendon can stand and this may vary with every individual. Thus the process involves some trial and error on the behalf of each individual finding the appropriate amount for themselves. (Maffulli, Renström, & Leadbetter 2005, 255) This has thought to be the best option as high level of pain 8-9/10 on visual analog scale or pain too early in the program before 20 repetitions can cause worsening of symptoms during functional activities (Magee, Zachazewski & Quillen 2007, 72).

There are several studies that support the use of eccentric exercise programs on various tendinopathies of the lower limb. One reason as to why the majority of the researches tend to focus on Achilles tendinopathy may be due the higher occurrence rate of this specific pathology. The reason why there may be less researches on for example tendinopathies of the extensor hallucis longus and extensor digitorum longus may be due to the specificity if the pathology. This pathology may be more common among athletes who use skates. Thus focusing on the extensor hallucis lon-

gus and extensor digitorum longus tendinopathies would narrow the target population. Researches that have a narrow and specific target population cannot be generalized on the general public.

The eccentric rehabilitation method restored the strength of the injured evtor muscles. These results are significant in providing supporting evidence in the use of eccentric exercises in rehabilitation. Especially as weakness is a major risk factor contributing to instability and recurrent sprains. (Collado, Coudreuse, Graziani, Bensoussan, Viton & Delarque, 2010)

The writing process has been challenging, especially from the aspect of finding valuable research material to build the exercise package on. The evidence based research is mostly written on Achilles tendinopathy rather than focusing on any other tendon. This does bring some limitations to as how the methods used to treat Achilles tendinopathies can be carried over in use with tendinopathies of other tendons. This same issue was discovered when planning the different stages for progression of the exercise package. With the exercises targeted at the Achilles tendon it may be slightly easier to add the loading. The amount of loading that the tendon can stand is also greater than compared to the ankle dorsiflexors.

The progression of the different stages was considered to be similar in structure in order to enhance the learning and recall of the players. The use of equipment, such as therabands, for the most advanced stage was considered but for the convenience and variability of available equipment it was discarded. The decision was made to use equipment that would be available almost everywhere and accessible for all of the players and coaches. Thus this would hopefully increase the probability of implementing the exercises presented in the package as there would be no extra effort involved in acquiring the necessary equipment.

The repetition amounts of the exercise package were considered and the decision of choosing 3x15 repetitions was made based on evidence. Chronic high-force eccentric exercise for 6 to 12 weeks can be recommended for the return of muscle mass, strength, and for muscle spring adaptations. This method has also been favourable in

the rehabilitation of the muscle-tendon structure. (LaStayo, Woolf, Lewek, Snyder-Mackler, Reich & Lindstedt 2003, 566)

The validity of this research has been considered all the way during the process. The reliability of the researches is increased by the use of various sources including journals, books and articles. The reliability of the studies was considered and kept in mind that not all beneficial methods for rehabilitating the Achilles tendon could be directly applied to the extensor hallucis longus and extensor digitorum longus. Reliability is also increased with the use of several sources in gathering the theoretical background.

The strength of this thesis is the decision to use eccentric exercises in the exercise program as there is high indication of its beneficial effects throughout the literature. The evidence supports that most individuals using eccentric exercise will probably experience marked or complete relief of pain and dysfunction within 6 to 14 weeks after starting an eccentric exercise program (Magee, Zachazewski & Quillen 2007, 77). The aim of the package was to emphasize on the prevention part of the rehabilitation process.

A limitation of this study could be the lack of researches that have been conducted on the extensor hallucis longus and extensor digitorum longus. Thus the theoretical background of this research is mainly based on researches conducted on the Achilles tendon. This is due to the fact that most of the research available on tendinopathies and treatment are focused on the Achilles tendon.

Further research should be conducted on the effects of eccentric exercise on the extensor hallucis longus and extensor digitorum longus tendinopathies. There is also limited amount of research on chronic tendon problems among athletes who skate as the focus tends to be on laceration of tendons in these sports. A more detailed level for further research could include finding out the exact mechanisms behind the formations on tendinopathies. That would help further researches in planning new treatment methods for the individuals suffering from chronic tendinopathy.

REFERENCES

- Alfredson, H., Pietilä, T., Jonsson, P. & Lorentzon, R. 1998. Heavy-Load Eccentric Calf Muscle Training For the Treatment of Chronic Achilles Tendinosis. *The American Journal of Sports Medicine*, Vol. 26, No. 3, 360-366 Referred 2.9.2016
http://www.cme.northwestern.edu/docs/Training/LL091216_Alfredson_1998_Achilles_Tendinosis.pdf
- Allison, G. & Purdam, C. 2009. Eccentric loading for Achilles tendinopathy — strengthening or stretching? *British Journal of Sports Medicine*. 2009, 43, 276-279
 Published online 11.02. 2009. Referred 5.9.2016
<http://bjsm.bmj.com/content/43/4/276.full.pdf+html>
- Biel, A. 2010. *Trail guide to the body*, fourth edition. Colorado: Books of Discovery.
- Brockett & Chapman 2016. Biomechanics of the Ankle. *Orthopaedics and Trauma*, 30, 3, 232-238 Referred 5.9.2016
[http://www.orthopaedicsandtraumajournal.co.uk/article/S1877-1327\(16\)30048-3/pdf](http://www.orthopaedicsandtraumajournal.co.uk/article/S1877-1327(16)30048-3/pdf)
- Childress, M. & Beutler A. 2013 Management of Chronic Tendon injuries. *American Family Physician*. 2013, Vol 86, 7, 486-490 Referred 5.9.2016
<http://www.aafp.org/afp/2013/0401/p486.pdf>
- Collado, H., Coudreuse, J., Graziani, F., Bensoussan, L., Viton, J. & Delarque, A. 2010 Eccentric reinforcement of the ankle evertor muscles after lateral ankle sprain. *Scandinavian Journal of Medicine & science in sports*. April. 20, 241-246. Referred 1.9.2016
- Federation of International Bandy, 2013. Bandy playing rules. Referred 10.7.2016
http://worldbandy.com/wp-content/uploads/2015/11/Bandyrules_FIB_Sept_2013.pdf
- Fu, S-C., Rolf, C., Cheuk, Y-C., Lui, P., & Chan, K-M. 2010. Deciphering the pathogenesis of tendinopathy: a three-stages process. *Sports Medicine, Arthroscopy, Rehabilitation, Therapy & Technology* 2010. Referred 1.9.2016
<http://bmc sportsscimedrehabil.biomedcentral.com/articles/10.1186/1758-2555-2-30>
- James, R., Kesturu, G., Balian, G. & Chhabra, B. 2008 Tendon: Biology, Biomechanics, Repair, Growth Factors, and evolving treatment options. *Journal of hand surgery*. 2008 102-112. ASSH Referred 18.10.2016
https://www.researchgate.net/profile/Bobby_Chhabra/publication/5589902_Tendon_Biology_Biomechanics_Repair_Growth_Factors_and_Evolving_Treatment_Options/links/0deec53ada9e20dd54000000.pdf
- Joseph, R. & Barhorst, J. 2012. Surgical reconstruction and mobilization therapy for a retracted extensor hallucis longus laceration and tendon defect repaired by split extensor hallucis longus tendon lengthening and dermal scaffold augmentation. *The*

Journal of foot and ankle surgery. 51, 509-516. Referred 17.8.2016
<http://www.ncbi.nlm.nih.gov/pubmed/22658790>

Keles, S., Sekir, U., Gur, H. & Akova, B. 2013. Eccentric/concentric training of ankle evertor and dorsiflexors in recreational athletes: Muscle latency and strength. *Scandinavian Journal of Medicine and Science in Sports*. 2014. 1, e29-38 Referred 17.8.2016

Khan, K., Cook, J., Bonar, F., Harcourt, P. & Astrom, M. Histopathology of Common Tendinopathies: Update and Implications for Clinical Management. 1999. *Sports medicine* 27, 393-408. Referred 17.8.2016
<http://www.eswtusa.com/files/tendonosisreport.pdf>

Kjaer, M., Krogsgaard, M., Magnusson, P., Engebretsen, L., Roos, H., Takala, T. & Woo, S. 2003 *Textbook of Sports Medicine, Basic science and clinical aspects of sports injury and physical activity*. Blackwell Publishing Company: Massachusetts

LaStayo, P., Woolf, J., Lewek, M., Snyder-Mackler, P., Reich, T. & Lindstedt, S. 2003. Eccentric muscle contractions: their contributions to injury, prevention, rehabilitation, and sport. *Journal of Orthopaedic Sports Physical Therapy* 33(10), 557–571, 2003. Referred 17.8.2016 <http://www.iwacourses.com/wp-content/uploads/2012/11/LaStayo200913.pdf>

Lee, M., Chung, C., Cho, J., Mohana-Borges, A., Pretterklieber, M., Trudell, D. & Resnick, D. 2006. Tibialis Anterior Tendon and Extensor Retinaculum: Imaging in Cadavers and Patients with Tendon Tear. *American Journal of Roentgenology*. 2006, 186, 2, (W161-168) Referred 10.9.2016
<http://www.ajronline.org/doi/pdf/10.2214/AJR.05.0073>

Lieber, R., Amiel, D., Kaufman, K., Whitney, J. & Gelberman, R. 1996. Relationship between joint motion and flexor tendon force in the canine forelimb. *The Journal of Hand Surgery*. 1996. 21A, 957-962 Referred 17.10.2016
http://muscle.ucsd.edu/More_HTML/papers/pdf/Lieber_JHS_1996b.pdf

Lui, T. 2011. Extensor tendoscopy of the ankle. *Foot Ankle Surgery*. March 17 (1), 1-6. Referred 17.8.2016. <http://www.ncbi.nlm.nih.gov/pubmed/21276553>

Maffulli, N., Renström, P., & Leadbetter, W. 2005. *Tendon Injuries, Basic science and clinical medicine*. Springer-Verlag London Limited

Magee, D., Zachazewski, J. & Quillen, W. 2007. *Scientific foundations and principles of practice in musculoskeletal rehabilitation*. Missouri: Saunders Elsevier

Miller, M. & Thompson, S. 2015. *DeLee & Drez's Orthopaedic sports medicines: Principles and practice, fourth edition*. Philadelphia: Elsevier Inc. Saunders

Mosston, M. & Ashworth, S. 2012 *Spectrum of Teaching Style* Referred 24.10.2016
<http://www.spectrumofteachingstyles.org/index.php>

O'Neill, S., Watson, P. & Barry, S. 2015 Why are eccentric exercises effective for Achilles tendinopathy? *International Journal of Sports Physical Therapy*. 2015 Aug. 10, 552-562 Referred: 1.9.2016

<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4527202/pdf/ijsp-08-552.pdf>

Porter, D. & Schon, L. 2008, *Baxter's The Foot and Ankle in Sport*. Philadelphia: Mosby Elsevier.

Reese, J., Stride, M. & Scott, A., 2013. Tendons – time to revisit inflammation. *British Journal of Sports Medicine* 2014, 48, 1553-1557. Published online March 2013.

Sahrmann, S., 2002. *Diagnosis and treatment of movement impairment syndromes*. Missouri: Mosby Inc.

Sahrmann, S., 2011. *Movement system impairment syndromes of the extremities, cervical and thoracic spines*. Missouri: Mosby Inc.

Scaduto, A. & Cracchiolo, A. 2000. Lacerations and ruptures of the flexor or extensor hallucis longus tendons. *Foot Ankle Clinics*. 2011, 5(3), 725-736 Referred 17.8.2016 <http://www.ncbi.nlm.nih.gov/pubmed/11232406#>

Solomon, L., Ferris, L. & Henneberg, M. 2006. Anatomical study of the ankle with view to the anterior Arthroscopic portals. *ANZ Journal of Surgery*, 2006, 1, 76, 932-936. Referred: 1.8.2016

Tortora & Derrickson 2011, *Principles of Anatomy and physiology*. Asia: John Wiley & Sons. Inc. 277-432

van der Plas, A., de Jonge, S., de Vos, R., van der Heide, H., Verhaar, J., Weir, A. & Tol, J. 2011. A 5-year follow-up study of Alfredson's heeldrop exercise programme in chronic midportion Achilles tendinopathy. *British Journal of Sports Medicine*. 2011. 1-5 Referred 1.9.2016 <http://bjsm.bmj.com/content/early/2011/11/10/bjsports-2011-090035.full.pdf+html>

Website of Anatomy Human Body. 2016. Referred 24.10.2016.

<http://www.anatomy-diagram.info/bones-of-the-left-ankle-with-diagram/bones-of-the-left-ankle-with-diagram-anatomy-of-left-foot-and-ankle-skeleton-human-anatomy-diagram-2/>

Website of Porin Narukerä ry. Referred 1.8.2016

<http://www.porinnarukera.fi/seura.asp>

Website of Suomen Jääpalloliitto. 2013 Referred 1.8.2016

http://www.finbandy.fi/fi/?page_id=242

Wong, J., Daniel, J. & Raikin, S. 2014. Repair of acute extensor hallucis longus tendon injuries: a retrospective review. *Foot & Ankle specialist*. 2014 7, 45-51. Referred 17.8.2016 <http://www.ncbi.nlm.nih.gov/pubmed/24334369>