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SYNDESMOTIC ANKLE INJURY REHABILITATION
EXERCISE PACKAGE FOR ICE HOCKEY PLAYERS

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The purpose of the thesis was to collect new information about syndesmotic ankle sprain treatment with therapeutic exercises, criteria to progression between rehabilitation phases and overall fitness maintenance during the rehabilitation. Most effective therapeutic exercise methods used in syndesmotic ankle sprain rehabilitation and ankle re-injury prevention were identified. As a result of collected data analysis the exercise package can be created and accommodated to be used in injury prevention and rehabilitation for ice hockey players.

A literature search was conducted on PubMed and EBSCO database. The literature analyzed in thesis was published between years 2000-2013.

The theoretical part of thesis consists of description of ice hockey, ankle anatomy, kinesiology and biomechanics, ankle injury and ankle sprain epidemiology in sports and ice hockey. Ankle injury incidence in ice hockey is described. The rehabilitation models and progressions in syndesmotic sprain are explained. The main outcome of the study is the guidelines how rehabilitation should be progressed to avoid complications and provide full recovery with minimal time. Increased knowledge which is based on the collected data makes it possible to create the more effective therapeutic exercise programs for ice hockey players.

CONTENTS

1. INTRODUCTION	5
2. PURPOSE	6
3. METHODS	7
4. ICE HOCKEY	8
4.1 History and description of the game	8
4.2 Physiology of ice hockey	8
5. ANKLE ANATOMY	9
5.1 Bones, articulations and articular surfaces of the ankle joint.....	9
5.2 Ligaments of the ankle joint.....	10
5.3 Syndesmosis.....	13
6. ANKLE KINESIOLOGY, FUNCTIONAL ANATOMY AND BIOMECHANICS	13
7. MECHANISM OF ANKLE INJURY	15
7.1 Lateral ankle sprains	15
7.2 Medial ankle sprains	15
7.3 Syndesmotic ankle sprains	15
8. ANKLE INJURY IN SPORTS	17
9. ANKLE INJURY IN ICE HOCKEY.....	18
9.1 Statistics of ankle injury in ice hockey	18
9.2 Etiology of high ankle sprain in ice hockey.....	19
10. EVALUATION OF SYNDESMOTIC ANKLE INJURY	20
11. ANKLE INJURY REHABILITATION.....	22
11.1 Main principles of ankle injury rehabilitation.....	22
11.2 Operative treatment of ankle sprain	23
11.3 Functional rehabilitation	23
12. THERAPEUTIC EXERCISE FOR ANKLE INJURIES AND RE-INJURY PREVENTION FOR ICE HOCKEY PLAYERS	24
13. RESULTS AND CONCLUSIONS.....	28
13.1 Syndesmotic ankle sprain rehabilitation progression from one phase of repair and remodelling to another	28
13.2 Methods to prevent the loss of cardiovascular fitness during the rehabilitation of syndesmotic ankle sprain.....	29

13.3 Most effective exercises in each rehabilitation phase of syndesmotoc ankle sprain	29
14. DISCUSSION	31
14.1 Topic of the thesis	31
14.2 Research methods and limitations.....	33
14.3 Writing process	33
14.4 Further research.....	34
APPENDIX 1	40
APPENDIX 2.....	42

1. INTRODUCTION

Ice hockey is one of the fastest and most physical team sports in which injuries are quite frequent. Nowadays the training load is increased constantly and this puts big demands on the neuromuscular system of athletes. Load from powerful, intensive trainings stresses the joints, muscles, tendons and ligaments. As a result of that changes in musculoskeletal systems occur, such as increased tension in muscles and tendons. Also cardiovascular system is affected with intensive training. All this could lead to increasing rate of the injuries.

In recent years, ice hockey has grown tremendously in popularity, and this expanding interest has led to an increase in the number and severity of injuries. Injury is a serious problem in the ice hockey playing which may lead to interruption of training and competition activity. Also recovery from injury is an expensive process. The repetitive injury can become a significant financial burden as each ankle sprain injury may cost approximately 360 euros in medical expenses and every year about 184 million euros is spent on treatment of sports-related ankle sprains. (Janssen et al 2011.)

Ankle sprains are considered to be one of the most common sports-related injuries treated by rehabilitation professionals. Ankle sprains do not only cause a pause in training and competition. These injuries often become chronic and this makes prevention of the injuries important. Knee cruciate ligament injury prevention programs have already shown their effectiveness. Evidence shows that specific training programs might also be beneficial in prevention of other lower extremity injuries, like ankle sprain. (Valovich 2008).

The most common injury according to literature was knee internal derangements consisting of 13.5 % of all game injuries. In practice 13.1% of the injuries were pelvic and hip muscle tendon strains. The ankle and lower leg injuries in ice hockey players reviewed as an area of concern. It is suggested that these injuries continue to occur. (Agel & Harvey 2010).

Ligament damage to the lower leg and ankle constituted 14% of all injuries in elite Finnish hockey players. The lateral ankle ligaments were the second most sprained ligaments in Junior A hockey players and 10.5% of all sprains in elite Finnish ice hockey players. The raise of injury rate emphasises the need to prevent injuries. (Mölsa & Airaksinen 2000).

2. PURPOSE

The aim of the thesis is to increase the knowledge about the incidence, pathomechanics, diagnostics and treatment of syndesmotic ankle injury through maximally beneficial exercises. The gathered information could be used to create and accommodate properly designed therapeutic exercise package to individual needs of the ice hockey players and possibly other athletes.

As a result of the thesis answers to the following questions should be found:

1. How should rehabilitation of syndesmotic ankle sprain be progressed from one phase of repair and remodelling to another?
2. Which methods can be used to prevent the loss of cardiovascular fitness during the rehabilitation of syndesmotic ankle sprain?
3. What kinds of exercises are found to be most efficient in each rehabilitation phase of syndesmotic ankle sprain?

The thesis would highlight the importance of exercise for the patients with syndesmotic (high) ankle sprains. Properly designed exercise training programme based on gathered knowledge would hopefully help to provide faster full recovery after syndesmotic (high) ankle sprains and prevent re-injuries and complications.

3. METHODS

A literature search in PubMed and EBSCO database was conducted to collect the articles for thesis formation. The search terms used were following MeSH terms: ankle, ice hockey, ice hockey injuries, syndesmotic ankle sprain, syndesmotic ankle sprain rehabilitation, proprioception, balance, high ankle injury prevention, ankle injuries.

Articles included in thesis were published between last 13 years 2000-2013. One article that was included into study was published in 1995. Articles used were published in English. Full-text articles and abstracts were both used. All articles that were included in the study were selected after reading the titles and abstracts of the articles. Unfortunately, in current topic there is a lack of accessible free randomised controlled trials. Existing trials were either not accessible through available databases or the results were not published yet. As a result of small number of accessible randomised controlled trials mainly clinical trials and literature reviews were used in thesis formation.

In table 1 the number of articles that were included in the theses can be seen.

Table 1. The research material

Research question	Number of articles found
How should rehabilitation of syndesmotic ankle sprain be progressed from one phase of repair and remodelling to another?	5
Which methods can be used to prevent the loss of cardiovascular fitness during the rehabilitation of syndesmotic ankle sprain?	6
What kinds of exercises are found to be most efficient in each rehabilitation phase of syndesmotic ankle sprain?	7

4. ICE HOCKEY

4.1 History and description of the game

The Society for International Hockey Research (SIHR) has the following definition for ice hockey: “Hockey is a game played on an ice rink in which two opposing teams of skaters, using curved sticks, trying to drive a small disc into or through the opposing goals” (Website of International Ice Hockey Federation 2012).

Hockey game consists of three 20 minute periods. There is also a 15 minute intermission period between each period. The typical player performs approximately 15 to 20 minutes, but more skilled players have 30 to 35 minutes of ice time. (Garret & KirKendall 2000, 815).

The sport of ice hockey is physiologically demanding, especially in professional level. It is assumed, that in recent years higher physiological demands have been placed on athletes (Quinney et al 2008, 753-754). To prevent overstrain injuries, musculoskeletal system must be prepared for the raise of demands.

4.2 Physiology of ice hockey

In his theoretical review of physiological demands of ice hockey MacLean states that ice hockey is a high-impact sport, that requires repeated acceleration and slow down. Explosive dynamic movement patterns and the technical skills of skating, shooting, passing, and body checking characterize practice and competitive play (MacLean n.d.). High-intensity bouts of skating require rapid acceleration and changes of direction. For example elite skaters are able to exceed a velocity of 8 m/s after only four strides. Although skating is the most important skill and task during a hockey game, each ice hockey player must also know the background of

the game, philosophy of the game and psychological concepts. In addition to that players should have specific physiologic training and psychomotor skills. (Garrett & KirKendall 2000, 818).

Physiological training is dependent of the intensity of the game. The average in ice intensity is estimated at 70 % of maximal aerobic uptake (VO₂ max). A physically well trained ice hockey player should therefore have high anaerobic power and capacity for good sprint performance, a high aerobic endurance capacity for fast recovery coupled with high muscle strength, power and endurance (Gilenstam 2009, 22).

5. ANKLE ANATOMY

5.1 Bones, articulations and articular surfaces of the ankle joint.

Due to anatomical position which is lateral from centre of gravity ankle joint can be easily injured. Ankle is solely responsible for transmission of the all weight-bearing forces between the body and the foot. (Gross et al. 2011, 11).

To fully understand ankle sprain injury and pathoanatomy, it is essential to deeply understand the basic anatomy of ankle joint. Ankle (talocrural) joint is a load-bearing joint (Golano et al 2010), modified uniaxial hinge joint, a synovial joint (Nyska & Mann 2002, 6-13) which is formed between the talus, the medial malleolus of the tibia and lateral malleolus of the fibula (Norkus & Floyd 2001).

Distal tibia and fibula, 7 tarsals, 5 metatarsals and 14 phalanges make up the bones of the foot and ankle. The leg is made up by tibia and fibula. The foot is divided into 3 segments: hindfoot (talus, calcaneus), midfoot (navicular, cuboid, 3 cuneiforms), forefoot (5 metatarsals, 14 phalanges). (Kisner & Colby 2007, 760).

Articulations between talocrural and subtalar joint and distal tibiofibular syndesmosis create the ankle complex.

Tibiotalar or talocrural joint consists of the dome of the talus, the medial malleolus, the tibial plafond, and the lateral malleolus. Articulations between the talus and calcaneus forms the subtalar joint. Distal articulation between tibia and fibula is a syndesmosis, the third joint of the ankle complex. (Hertel 2002, 367).

The articular surfaces of the ankle joint are placed on superior, lateral and medial aspect of the talus. The superior articular surface of the talus is broader anteriorly than posteriorly. The articulation occurs between medial and lateral malleoli and the lower end of tibia. “The fully dorsiflexed position is stable compared with fully plantar flexed position. In plantar flexion when the tibia and fibula articulate with the narrowed posterior part of the superior articular surface of the talus, some side-to-side movement of the joint is allowed, accounting for the instability of the joint in this position”. At the lateral side of the talus articulation with lateral malleolus takes place in triangular articular area and within the medial side of the talus articulation with medial malleolus occurs in comma shaped articular area (Agur & Dalley 2008, 455).

5.2 Ligaments of the ankle joint

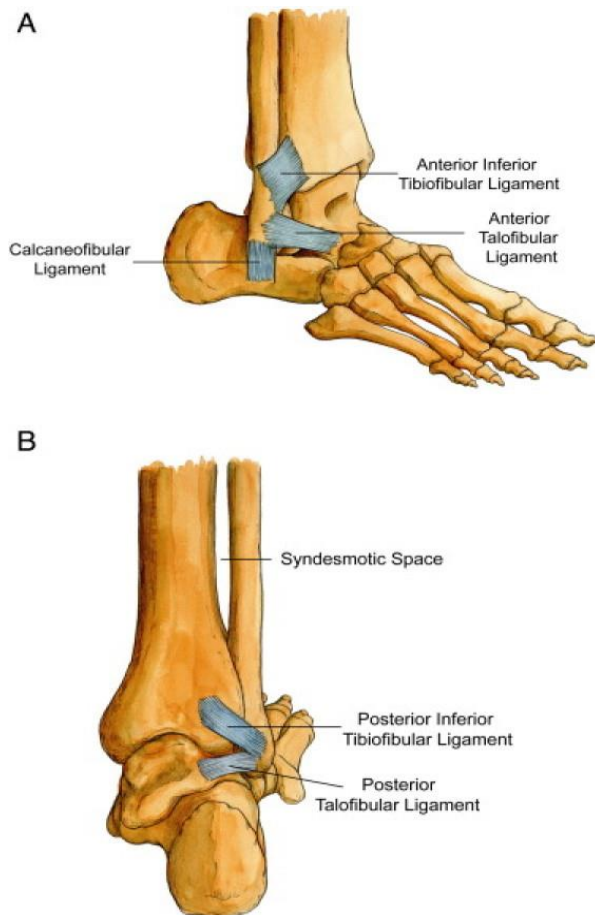
Ligaments are band-like tissues that help connect bones together. The stability of the ankle joint depends on its ligamentous structure, which must be intact. The reason for this is the anteriorly and posteriorly fairly thin and weak capsule of talocrural joint. The articular capsule of the ankle surrounds the joints, and is attached, above, to the borders of the articular surfaces of the tibia and malleoli; and below, to the talus around its upper articular surface. The anterior part of the capsule which is also called anterior ligament is a broad, thin, membranous layer is attached, above, to the anterior margin of the lower end of the tibia; below, to the talus, in front of its superior articular surface. It is in relation, in front, with the Extensor tendons of the toes, the tendons of the Tibialis anterior and Peroneus tertius, and the anterior tibial vessels and deep peroneal nerve. The posterior part

of the capsule (posterior ligament) is very thin, and consists principally of transverse fibres. It is attached above to the margin of the articular surfaces of the tibia, blending with the transverse ligament; below to the talus behind is superior articular facet. Laterally, it is somewhat thickened, and is attached to the hollow on the medial surface of the medial surface of the lateral malleolus. (Agur & Dalley 2008).

The two major ligaments that create stability of the joint are the medial collateral ligament and the lateral collateral ligament. Medial collateral ligament is also commonly referred as deltoid ligament. The lateral collateral ligament consists of anterior talofibular ligament, posterior talofibular ligament and calcaneofibular ligament. Depending on the position of the foot, each of these ligaments have a role of stabilizing the ankle joint. (Nyska & Mann 2002, 8; Voight et al 2007, 677).

All three ligaments of the lateral collateral ligament complex have different strength. The anterior talofibular ligament is the weakest of the three ligaments of the complex. The main responsibility of lateral collateral ligaments is to control joint stability laterally and limit extremes in range of motion. (Hall & Brody 2005, 525). In other words ankle ligaments on both side of the ankle joint provide stability against movements inwards and outwards the joint line.

Ligaments of the ankle can be divided into three regions- lateral, medial and posterior. Ligaments of the ankle region and syndesmotoc space can be seen on picture 1.



Picture 1. Ligaments of the ankle complex: A. Lateral view, B. Posterior view (Dubin et al.2011)

The outer (lateral) aspect of the ankle joint is comprised by lateral collateral ligaments and a syndesmosis. The lateral complex is formed by anterior talofibular ligament, a flat weak band (ATFL), calcaneofibular ligament, a round cord directed postero-inferiorly (CFL), posterior talofibular ligament, a strong medially-directed horizontal ligament (PTFL). (Agur & Dalley 2008, 454). The inner (medial) aspect of the ankle joint is supported by collateral ligament or deltoid ligament. Deltoid ligament is strong ligament, which consists of a superficial and deep portion. It consists of four parts: the tibionavicular part, the tibiocalcaneal part, the anterior tibiotalar part and posterior tibiotalar part. Medial ligament reinforce ankle joint during eversion of the foot and help to prevent subluxation (partial dislocation) of the ankle joint. (Agur & Dalley 2008, 452). The posterior aspect of the ankle joint is reinforced by tibiofibular ligament and posterior talofibular ligament. The posterior talofibular, the posterior tibiotalar,

the tibiocalcaneal and the calcaneofibular ligament are the strongest parts of the ligaments of the ankle. These ligaments prevent anterior subluxation of the leg bones. (Agur & Dalley 2008, 451).

5.3 Syndesmosis

Distal tibiofibular syndesmosis is a fibrous joint that consists of two bones and four ligaments that make a connection between them. (Hermans et al 2010). “The primary role of the syndesmosis is to maintain the relationship of the talus to the tibia under physiological loads.” To accomplish this goal, the distal tibiofibular joint must maintain its stability, which is provided by both osseous congruity between the distal tibia and fibula and the integrity of the syndesmotic ligaments. (DeFranco et al 2008, 564).

6. ANKLE KINESIOLOGY, FUNCTIONAL ANATOMY AND BIOMECHANICS

Stability and mobility of the structures of lower extremity is provided by the joints, ligaments, and muscles of the ankle and foot. During standing, the foot must bear the body weight with a minimum of muscle energy expenditure. In addition, the foot must be capable of being either pliable or relatively rigid depending on various functional demands of everyday activities. Foot must be able to absorb forces and accommodate to uneven surfaces, or become a structural lever to propel the body forward during walking and running. (Kisner & Colby 2002, 759).

Ankle joint stability depends statically on articular surfaces and ligaments and dynamically on musculotendinous units (Hertel 2002, 367).

The ankle is classified as a hinge joint (Hertel 2002, 367). Sagittal plane motion around a frontal coronal axis is dorsiflexion and plantarflexion. These two movements are most common for the ankle joint. Frontal plane motion around sagittal axis consists of inversion and eversion. Abduction and adduction occur around a vertical axis in transverse plane. (Kisner & Colby 2002, 762). Plantar flexion and dorsiflexion take place in talocrural joint and pronation and supination take place in subtalar joint. Pronation is a combination of dorsiflexion, eversion and abduction. (Hertel 2002, 366). Supination consists of plantarflexion, inversion and adduction (Kisner & Colby 2002, 761). Distal tibiofibular joint allows limited movement between tibia and fibula and to provide normal mechanics of the ankle joint accessory gliding motion is needed (Hertel 2002, 367).

As articulating surfaces are maximally contacted in dorsiflexion it is the most stable position of ankle joint. This position of the joint creates the boniest contact and is called closed packed position of ankle joint. (Norkus & Floyd 2001).

Normal active dorsiflexion (approximation of anterior aspect of tibia and top of the ankle and foot) is about 15° to 20°. Normal active plantarflexion (foot moves away from tibia) is about 45° to 55°. (Thompson & Floyd 1998, 129-132).

The least packed position of the ankle joint is plantarflexion, because in this position the narrow portion of the talus lies between the two malleoli, permitting some side to side movement. To provide the stability of the ankle joint anterior capsule, the anterior fibres of the deltoid and the anterior talofibular ligaments are under maximal tension. (Nyska & Mann 2002, 12)

According to Chung et al (2005) the extension of the foot upon the tibia and fibula is produced by the Gastrocnemius, Soleus, Plantaris, Tibialis posterior, Peroneus longus and brevis, Flexor digitorum longus, and Flexor hallucis longus. Muscles that create dorsiflexion are Tibialis anterior, Peroneus tertius, Extensor digitorum longus, and Extensor hallucis proprius (Chung, K & Chung, and M 2005).

7. MECHANISM OF ANKLE INJURY

7.1 Lateral ankle sprains

Ankle sprains can be classified into three groups: inversion sprains, eversion sprains and syndesmotic sprains. Inversion sprains are the most common. Because lateral ankle ligament are affected, inversion sprain is also called lateral ankle sprain. Injury mechanism is usually forceful inversion of the plantar flexed ankle joint. In this position the bony structure allows only minimal stability, the leverage is maximal, and the weakest component of the lateral ligament of the ankle, anterior talofibular ligament, is taut and exposed to injury.(Nyska & Mann 2002, 160). The calcaneofibular and posterior talofibular ligaments are also likely to be injured in inversion sprains. Deltoid ligament may also be contused due to impingement between the fibular malleolus and calcaneous. (Kisner & Colby 2007, 777). The mechanism of injury makes lateral ankle sprains the most common ankle injuries.

7.2 Medial ankle sprains

Thick and strong deltoid ligament stabilizes ankle joint medially and prevents excessive ankle eversion. If a plantar flexed ankle is forcefully everted avulsion fracture of the tibia is more common than the deltoid ligament tear. Because of the strength of the stabilizing structures medial ankle sprains are less common than lateral. (Voight et al 2007, 683).

7.3 Syndesmotic ankle sprains

Syndesmotic ankle sprains are also known as “high ankle sprains”. These injuries involve the stabilizing ligaments of the ankle mortise, in other words tibiofibular joint. They are less common, but at the same time they are more severe than

lateral ankle sprains, and thus require longer recovery. Mechanism of syndesmotic ankle sprain injury is usually ankle external rotation and extreme dorsiflexion. The second possible mechanism of injury is reported to be severe ankle inversion and eversion on high or repetitive mechanical loading. Usually tibiofibular ligament is ruptured above the ankle mortise joint and in case of more serious trauma in addition to that the interosseus ligament gets torn. (Voight et al 2007, 684). According to literature syndesmosis sprains often occur in combination with other injuries. Failure to recognize and treat a significant syndesmosis sprain can produce secondary complications like widening of the mortise and severe degenerative joint disease. (Hall et al 2005, 547)

Syndesmotic ankle sprains often take months to heal due to the limited blood supply. If ankle is immobilized, there is a much better environment for the injured ligament to heal. Although lack of swelling is common in patients with syndesmotic sprains, it does not indicate the depth of the injury. High sensitivity over the anterior aspect of tibiofibular joint is characteristic to high ankle sprain. These two signs are helpful in diagnosis of the injury. (Chinn & Hertel 2010, 4).

Hermans et al. describe that distal tibiofibular syndesmosis injury occurs in 1-11 % all ankle sprains and about 40 % of those people who had ankle sprain, still make complains about ankle instability during 6 month after injury. This might be related to widening of the ankle mortise due to traumatically lengthened syndesmotic ligaments. If syndesmosis widens 1 mm, contact area of tibiotalar joint decreases 42%- that may lead to early osteoarthritis and instability. 50% of Weber A type and all Weber C type cause syndesmotic injury. (Hermans et al.2010, 633-634).

8. ANKLE INJURY IN SPORTS

Ankle is a weight bearing joint, which absorbs tremendous stress during athletic competition. During vigorous activity, different forces that affect the ankle joint and foot can reach up to six times the athletes' body weight. These forces can lead both to fracture and ligament disruption. (Jelinek et al 2009, 1).

According to Jelinek et al. (2009) between 15% and 25% of all athletic injuries involve the ankle. Thormeyer et al (2012) state that ankle sprain makes up to 10 to 30 % of injuries in sport. Ankle sprain and fracture are the most common ankle injuries (Lin et al 2010, 1). It is also stated that according to literature syndesmotic ankle sprains make up to 1-18% of ankle sprains and even 17-74 % in young athletes. He also makes a connection between the raise of the frequency of syndesmotic injury and better awareness of its clinical diagnosis and biomechanical causes of it. At the same study, it is emphasized, that health care providers caring for professional athletes consider syndesmotic injuries to be the most difficult foot and ankle injury to treat. Compared to lateral ankle sprains syndesmotic injuries are more often the cause of delayed return to play and long-term disability. (Thormeyer, Leonard & Hutchinson 2012). These injuries are also more expensive to treat. The annual cost associated with ankle sprains in the Netherlands alone is estimated at around 84 million euros (Bleakley et al, 2010).

In systematic review made by Fong and colleagues in 2007, which includes a total of 227 studies reporting injury pattern in 70 sports from 38 countries was found that, the ankle is most common site of the injury in 24 of the 70 sports studied. Ankle sprain was the major ankle injury in 33 of 43 sports, especially in Australian football, field hockey, handball, orienteering, scooter and squash. (Fong et al, 2007).

9. ANKLE INJURY IN ICE HOCKEY

9.1 Statistics of ankle injury in ice hockey

Since season 1998-1999 the IIHF Injury Reporting System (IRS) is used by International Ice Hockey Federation (Website of International Ice Hockey Federation 2013). The IRS reports on the various types of injuries that occur in IIHF championships and the causal factors (mechanism of injury, area of ice, etc.) identified with these injuries. Based on this data, lower body injuries are more common in ice- hockey than upper body injuries. 32 % of injuries are lower-body and 19 % are upper-body injuries. The most injured lower body part was knee, with 35.7 % and ankle injuries accounted for 19.6 % of lower body injuries.

In a study from 2007 Agel and colleagues have reviewed four years of National Collegiate Athletic Association (NCAA) injury surveillance data for women's ice hockey. The goal of the study was data collection about the different injuries to make it possible to prevent them. According to this study 31.8 % of injuries in game and 31.1 % of injuries in practice were lower extremity injuries. Among the injuries that occurred during the game 4.2 % were ankle injuries. It has not been explained in the study how many of these injuries were lateral and how many were syndesmotric ankle sprains. (Agel et al 2007 b)

Based on data collected during years 1988-1989 through 2003-2004 descriptive epidemiology of collegiate men's ice hockey injuries has been analyzed in a study from year 2007. More than one third of all game (34.3%) and practice (35.9%) injuries were found to be to the lower extremity. During games knee injuries were the biggest area of concern and ankle sprains made up 4 % of overall injuries. In practice ankle sprain injury rate was higher with 5.5 % of injuries. It has been pointed out in the same study that ankle ligament sprains were among the injuries that required more than ten days of time loss from practice and game. (Agel et al 2007a). The study analyzing injuries in Japanese elite team during three years has

also stated that ankle injuries are more common during game than practice. In game the injury rate was 3,5 % and in practice 0.8 % . (Kuzuhara et al 2009).

In year 2010 Deits and colleagues have described patients with ice hockey injuries presenting to a representative sample of US emergency departments from years 1990 through 2006. According the data collected in this study the most commonly injured body sites were the face with 19.1 %, wrist/hand/finger with 14.1 % and shoulder/upper arm with 13.8 % . Lower leg/ankle/foot injuries made up 11.1 % of the hockey- related injuries in US emergency departments. (Deits et al 2010).

9.2 Etiology of high ankle sprain in ice hockey

Wright and colleagues analyzed the medical records of the St Louis Blues (1994–2001) and Dallas Stars (1991–2001) National Hockey League teams to reveal ankle problems in National Hockey League (NHL). Study showed that syndesmotic ankle sprain is a serious injury in ice hockey players. Return to play in games was 45 days (range, 6–137 days) for syndesmosis sprains versus 1.4 days (range, 0–6 days) for lateral sprains. (Wright et al 2004).

Combination of plantar flexion, inversion and internal rotation that might lead to lateral ankle sprain occurs relatively rarely in ice hockey. Modern and stiff skating boots support feet firmly and in ice hockey, there is relatively little jumping and landing, that is the main reason of inversion injuries in other sports. Dorsiflexion-eversion-external rotation ankle sprain, that is more serious is also more common in ice hockey. (Caselli et al 2002).

Caselli and colleagues (Caselli et al 2002) described in their study two principal etiological ways for high ankle sprain. Most common injury pattern is forceful rotation and eversion of ankle when support blade gets caught in ice rut. Second possible injury mechanism is fall of the player in front of the skates. Usually foot gets injured in externally rotated and dorsiflexed position under the body, deltoid ligament, tibiofibular ligament and inerosseus ligament get strained. Agel and

Harvey (2010) stated that the raise of foot injuries might be related to modern skate design and it should be examined if there does exists such a relation.

10. EVALUATION OF SYNDESMOTIC ANKLE INJURY

A missed unstable syndesmosis injury that is under treated can lead to a poor result and, potentially, career-ending disability. Evaluation of this injury must be full and all information gained from the assessment should be used for proper diagnostics. Previous history, intrinsic and extrinsic abnormalities must be considered in case of ankle injury (Voight et al 2007, 684). Jelinek and Porter (2009, 279) have also emphasised on their study about the management of ankle fractures and syndesmosis injuries in athletes, that through examination of the entire lower extremity is needed in there is a suspicion of ankle injury. The skin integrity, neurovascular status, soft tissue structures should be assessed, soft tissue edema and ecchymosis have to be noticed. To differentiate between third grade lateral ankle sprain and syndesmosis injury, the mechanism of injury, including location of injury, type of sport, position of the limb, direction of deforming forces, and magnitude and speed of injury should be known. Pre-injury status of the extremity is also important in the initial evaluation. (Jelinek & Porter 2009, 279).

Pain in syndesmotic ankle sprain is felt in deltoid ligament, in the medial aspect of ankle and anterior inferior tibiofibular and distal interosseus ligament in the anterolateral aspect of the ankle. The pain is increased with combination of eversion, external rotation and dorsiflexion. (Caselli et al 2002).

Injury to the tibiofibular syndesmosis is suggested by a positive squeeze test or external rotation test. On plain radiographs, widening of the medial clear space strongly suggests syndesmosis disruption; however, non-weight-bearing views are often negative. Other suggestive radiographic findings include: lateral clear space

greater than 6 mm on anteroposterior or mortise views; tibiofibular overlap less than 6 mm on anteroposterior view or less than 1-2 mm on mortise view (Thornmeyer et al. 2012, 436)

It is suggested to make stress X- rays in case of eversion ankle sprains to exclude or confirm possible diastasis (enlarged gap) of syndesmosis. For more proper diagnostic and for purpose not to miss proximal fibular fractures, Caselli et al (2012) recommend including the entire tibia and fibula on the film.

The ligament sprains are classified into three grades: grade I is minor tearing with no functional loss of ankle stability, grade II is partial tearing of the ligament with moderate instability and grade III is complete rupture with significant functional instability (Kisner & Colby 2002, 777-779).

In relation to evaluation and diagnostics it should be noted, that syndesmosis injuries also involve grades I through III. A grade I injury presents with normal alignment throughout the ankle, and the stability is maintained on stress views. A grade III injury shows widening of the medial clear space and, in most instances, widening of the tibia-fibula interval. A grade II injury is more deceptive, it is stable on non – stressed views like a grade I injury, but demonstrates widening and instability on stress views like a grade III injury (Jelinek & Porter 2009, 283).

The athlete's ability to bear weight is another important diagnostic tool in differentiation of the ankle injury. Usually third grade ankle sprain leaves an athlete an ability to walk, but severe syndesmotic sprains cause severe pain that makes ambulation impossible (Jelinek & Porter 2009, 279).

Less than one week of avoidance of physical activity is needed in grade I sprain, but grade II sprains with moderate to severe pain and swelling might need several days of immobilization which is followed by restricted physical activity. The most severe grade III sprain causes debilitating pain that can make weight bearing impossible for several days. With grade II sprains there is only moderate instability of the joint, because usually there is only some tearing of ligamentous

fibres. Gross instability of the joint caused by total rupture of the ligaments occurs with grade III sprain. (Chinn & Hertel 2010, 156).

In acute injury to the syndesmosis, for example injury mostly to the anterior tibiofibular ligament, the syndesmotic recess can tear. In the acute setting, arthrography of the tibiotalar joint would demonstrate leakage of contrast fluid into the incisura tibialis or, on the extent of injury, into the interosseous ligament between the tibia and fibula, or even outside the borders of the anterior tibiofibular ligament and posterior tibiofibular ligament. (Polzer et al 2012).

11. ANKLE INJURY REHABILITATION

11.1 Main principles of ankle injury rehabilitation

Like other musculoskeletal injuries healing of ankle sprain involves process of inflammation, phase of repair and phase of remodelling. These phases follow each other sequentially, but at the same time they overlap each other. To provide environment for optimal healing of the tissues, exercises and functional activity must be appropriate for each phase. (Voight et al 2007, 684).

During the initial phase of ankle rehabilitation, the major goals are reduction of post-injury swelling, bleeding, and pain, and protection of healing ligament. For this purpose compression, ice, elevation, rest and protection are used. Controlling swelling is considered to be the single most important treatment measure during the entire rehabilitation process, because it can significantly reduce the time required for rehabilitation. (Voight et al 2007, 684).

Jelinek et al. (2009, 283) have stated that in the first phase of ankle rehabilitation the priority is adequate blood flow, provisional reduction of marked deformity or dislocation if present and care of open wound or soft tissue injury, precise

reduction of skeletal deformity through surgery if indicated and also repair of associated injuries.

Williams & Allen (2010) describe the three rehabilitation phases and criteria for progression on table 2 Rehabilitation phases and progression

Table 2 Rehabilitation phases and progression (Williams & Allen 2010, 465).

Rehabilitation phase	Goals and criteria for progression
Acute	Goal: Joint protection, minimize pain, inflammation, weakness, and loss of motion. Progressed when: Able to ambulate in full weight bearing on various surfaces and travel stairs with minimal discomfort.
Subacute	Goal: Normalize joint mobility, strength, neuromuscular control, and return to basic function in activities of daily living. Progressed when: Can jog and hop with minimal discomfort.
Advanced training	Goal: Prepare for return to sports participation. Return to sports when: Performs sport tasks at game speed with minimal discomfort and quality movement.

11.2 Operative treatment of ankle sprain

First- and second-degree ankle sprains are usually treated conservatively. After an acute third-degree inversion injury conservative treatment is successful for most of the patients, but sometimes the operative treatment is needed for full recovery (Kisner & Colby 2007, 777).

According to Kisner & Colby (2007, 779), indications for surgical treatment are chronic mechanical and functional instability of the ankle during activity, which remains unsolved after conservative management and/or acute, third-degree lateral ankle sprain resulting in a complete tear of anterior talofibular and/or calcaneofibular ligaments.

11.3 Functional rehabilitation

Full rehabilitation of the foot is essential to avoid secondary injuries, because it is the base of lower kinetic chain (Chinn & Hertel 2010, 157). In creation of the

rehabilitation program the main goal should be the return of the athlete to the pre injury level. As athletes need to return to their exercise and competition as soon as possible, the rehabilitation should be as fast as possible. The athlete must be fully and functionally recovered before return to sport to make it safe. The intent of early ROM, weight bearing, and modified exercise are considered to be factors, which help to accelerate natural healing process of the ankle injury. (Jelinek and Porter 2009, 1).

It is not likely that the inherent stability of the joint provided by the ligament before injury will be regained. Complete tear of one or more lateral ligaments causes mechanical instability and functional instability during weight-bearing activities. Thus, to restore stability to the joint, the other structures, that surround that joint, primarily muscles and their tendons, must be strengthened. (Voight et al 2007, 684).

Mechanical instability is defined as ankle mobility beyond the physiological ROM, increased talar tilt, and an anterior drawer sign. Functional instability is characterized by the sensation of ankle “giving way” experienced by the patient. (Kisner & Colby 2007, 776).

According to Norkus et al. (2001, 73) syndesmotic ankle sprains have prolonged recovery time and the injury is difficult to evaluate, and often normal joint function may be disrupted by long recovery period.

12. THERAPEUTIC EXERCISE FOR ANKLE INJURIES AND RE-INJURY PREVENTION FOR ICE HOCKEY PLAYERS

The chosen search strategy found no randomized clinical trials or case studies for rehabilitation of syndesmotic ankle injury. According to literature exercise may be beneficial for both: prevention of recurrent ankle sprains and management of

chronic ankle instability. The increased muscle tension provided by resistance training can improve stability of the injured joint. (Voight et al 2007, 687). Clinicians agree that wobble board or disk training is beneficial in ankle rehabilitation to prevent recurrent ankle sprains and chronic ankle instability (Lin et al 2010, 25). If other therapeutic modalities are added to exercise program the recovery is not faster or more complete and for this reason the focus of the treatment should be on exercise (Chinn & Hertel 2010, 161)

Treatment principles for syndesmotic and lateral ankle sprain are similar to each other. Therapeutic intervention program is accommodated to unique anatomy, physiology and pathomechanics associated with ankle syndesmosis injuries (Williams & Allen 2010, 464). For the best treatment outcome early functional treatment of an ankle sprain should consist of using a semi-rigid ankle brace and supervised rehabilitation (Polzer et al 2012, 27).

Exercise progression has been described in literature for syndesmotic ankle injuries. For the first grade injury, operative treatment is not necessary. The first physiotherapeutic modality used is cryotherapy. The boot immobilization is also used until three to six weeks after trauma. When immobilization boot is removed, therapeutic exercise is started. At first range of motion exercises are initiated. The second phase consists of gentle stretching exercises, which are gradually progressed into bike program and balancing exercises. According to this study, average time to return to sports after first grade syndesmotic injury is between four and eight weeks (Porter et al 2008).

Second and third grade syndesmosis injuries often need operative treatment. Rehabilitation after surgery is similar to that used in non surgical management. Slower progression, reduced weight bearing and immobilization with weight bearing cast or walking boot are characteristic to post operative rehabilitation. (Williams & Allen 2010, 464). Progression of the treatment plan depends on the severity of injury, the patient's response to therapy, and the achievement of goals during each treatment phase (Dubin et al 2011).

After the surgery rehabilitation process begins with early protected weight bearing exercises, stretching and proprioception. Weight bearing exercises are added on the rehabilitation program on the later stages. The last part of the functional rehabilitation is running and sport specific exercises. To protect the healing tissues, an ankle-foot orthosis is recommended (Porter et al 2008). The post operative rehabilitation progression is described in table 3 Postoperative rehabilitation protocol.

Table 3: Postoperative rehabilitation protocol (Porter et al 2008, 580)

Postoperative	Crutches, no weight bearing, elevate leg. Walking boot and cold therapy. Start home exercise program for stretching
1 week	Home exercises(stretches and range of motion exercises) Protected weight bearing as tolerated Wean to one crutch
2 week	Assess range of motion Start home exercises with resistance bands Start weaning out of boot over next two weeks to stirrup brace
3 weeks	Normal gait in walking boot
1 month	Increase in weight bearing exercises Proprioception(for example biomechanical ankle platform system-BAPS board) and gait training with brace and athletic shoe are initiated. Resistance band exercises Stationary bike
6 weeks	Start progression from bike to elliptical trainer to stair climbing
8-10 weeks	Running
2 months	Strengthen entire lower extremity Work on sport-specific agility drills
3 months	Remove screws
4 to 6 months	Return to sport

Williams and Allen (2010) emphasize, that treatment must be tailored to individual patients' goals, presentation and circumstances. Regular assessment and observation is needed throughout the rehabilitation.

During the immobilization period gentle open chain dorsiflexion and plantar flexion exercises exercises should be started. Eversion and inversion should be held to minimum. When weight bearing is tolerated, the rehabilitation progression is similar as used in lateral ankle sprain. Exercise protocol consists of range of motion exercises, strength exercises, balance exercises, neuromuscular control exercises, and functional exercises. (Chinn & Hertel 2010, 161).

After an injury athlete must be fully rehabilitated to return to practice without the risk of re-injury. Criteria to return to full activity are similar for both syndesmotoc and lateral ankle sprain. Complete range of motion and 80 to 90% of pre-injury strength with ability to run and change direction without difficulty are compulsory and it should be possible to complete full practice without pain or swelling. (Chinn & Hertel 2010, 162)

13. RESULTS AND CONCLUSIONS

13.1 Syndesmotic ankle sprain rehabilitation progression from one phase of repair and remodelling to another

According to literature functional rehabilitation is an essential part of recovery from syndesmotic ankle sprain. During the whole process it is highly important to provide maximally safe environment and appropriate load to the healing tissues to prevent further damage (Jelinek & Porter 2009; Voight et al 2007; Williams & Allen 2010). In exercise prescription the stage of the recovery should be considered. Progression to the next stage of rehabilitation depends on the results of physiotherapeutic assessment (Dubin et al 2011; Williams & Allen 2010). It is emphasized that before full return to sports and competition an athlete must be able to fully complete all the sport specific tasks (Chinn & Hertel 2010; Williams & Allen 2010). For an ice hockey player it means that aerobic capacity must be maintained, the player must be able to skate, stop, cut and change directions without any difficulty (MacLean n.d).

According to Chinn & Hertel (2010); Dubin et al (2011); Williams & Allen (2010), it can be stated, that to prevent the re-injury the player must be fully recovered from the current injury. Supervised neuromuscular exercises are effective in preventing the re-injury. For the ice hockey players they should be included in the physical conditioning program. In Appendix 2 principles of rehabilitation progression according to five authors can be seen. During the rehabilitation process it is found to be necessary by several authors (Polzer et al 2012; Porter et al 2008; Williams & Allen 2010) to use appropriate ankle brace or custom orthosis for the protection of the tissues

13.2 Methods to prevent the loss of cardiovascular fitness during the rehabilitation of syndesmotic ankle sprain

Aerobic conditioning should be maintained through the healing process, for this purpose stationary cycling, elliptical trainer and stair climbing is recommended. In the later stages running can be used. The selection of the method depends on the stage of healing and ability to bear weight (Porter et al 2008; Williams & Allen 2010). The suggested activities to maintain cardiovascular fitness are presented in figure 1.

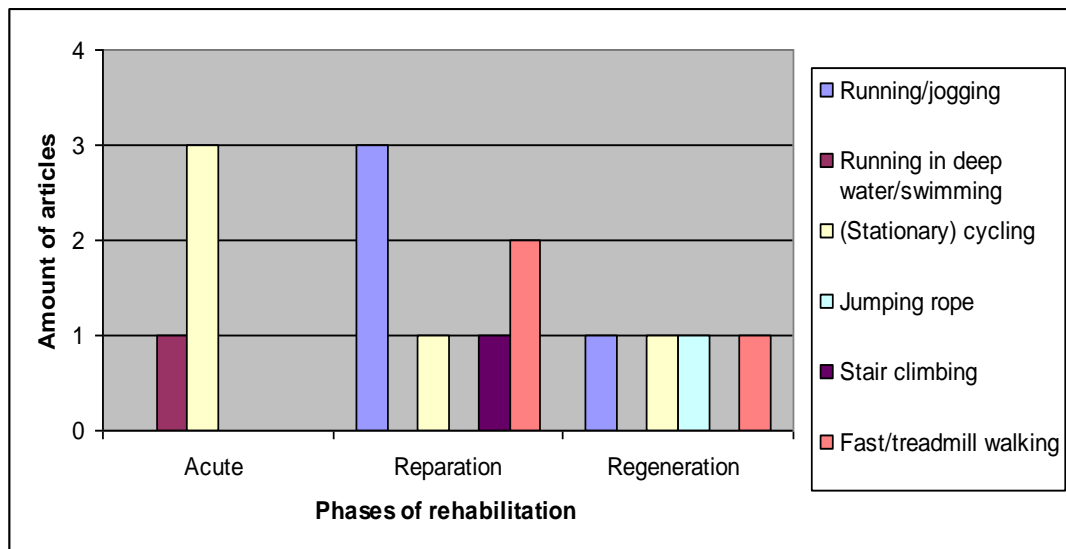


Figure 1 Suggested activities to maintain cardiovascular fitness during rehabilitation (Brosky et al 1995; Chinn and Hertel 2010; Dubin et al 2011; Jelinek and Porter 2009; Lin et al 2006 and Williams and Allen 2010.)

13.3 Most effective exercises in each rehabilitation phase of syndesmotic ankle sprain

PICO summary of articles with the suggested exercises for each rehabilitation phase is presented in Appendix 1.

In the first stage of rehabilitation gentle range of motion exercises and stretching are recommended. Strengthening, balance and neuromuscular exercises are added

to the program to progressively increase the load and prepare the tissues for high demanding activity (Chinn & Hertel 2010; Porter et al 2008; Williams & Allen 2010).

For balance and proprioceptive and neuromuscular training balance boards, cushions and BAPS (Biomechanical Ankle Platform System) board are recommended (Lin et al 2010; Porter et al 2008; Williams & Allen 2010).

In advanced rehabilitation phase when ROM, strength and basic proprioception have been achieved, more challenging exercises are added to rehabilitation protocol. For example balance exercises are combined with other activities like ball catching and throwing (Brosky et al 1995). In ice hockey balance activities could be combined with disk handling skills. As it is necessary to regain pre-injury strength of the whole body, overall strengthening exercises are also included (Brosky et al 1995; Dubin et al 2011; Jelinek and Porter 2009).

To make it possible for the player to safely prepare for game situations, multidirectional exercises like figure of eight or zigzag running and cutting are considered to be efficient (Brosky et al 1995; Chinn and Hertel 2010; Jelinek and Porter 2009; Lin et al 2006; Williams and Allen 2010). For ice hockey players this phase of rehabilitation should be on ice to make it more sports-specific. Running and skating have different biomechanical characteristics, that is why instead of running skating should be used. From the physiotherapist point of view it is necessary to continue sports-specific functional and proprioception exercises even when the player has fully recovered and returned to sports, because it helps to prevent re-injury.

14. DISCUSSION

14.1 Topic of the thesis

During the thesis writing process selection of the final topic was one of the most time-consuming parts for me. After the graduation I have a wish to work in sports physiotherapy, so I decided that my thesis should be related to sports to increase my current knowledge in the area. To further specify the topic I set myself a goal to choose one field of sports to write about. Ice hockey was chosen for two main reasons: personal interests and practice placement. I have been interested in ice hockey since early childhood and my interest has grown from just watching the game to analyzing the movement efficiency of the players and searching information about the training methods used to prepare the teams for the competition. I was also hoping for a practice placement in Porin Ässät Ice Hockey club and thought thesis related to that area would help me to reach that goal.

The next step was limiting the area or injury to specify on in my thesis. From earlier studies I had knowledge that groin injuries are an area of concern in ice-hockey. In literature I have seen rehabilitation protocols for this injury. As I wanted to offer some new information I decided not to write about groin and hip injuries and try to find a new aspect on the topic.

Initial literature search about injuries in ice hockey to specify the topic informed me that severe ankle injuries also affect the players. It can be stated that syndesmotic ankle injuries are an area of concern in ice hockey (Website of International Ice Hockey Federation 2013, Agel 2007a; Agel 2007b; Kuzuhara et al 2009); Deits et al 2010). The depth of the injury is difficult to evaluate, although there are several diagnostic methods for that purpose (Caselli et al 2002; Jelinek & Porter 2009, 279 Norkus & Floyd 2001). I also noted that syndesmotic ankle sprains that are also known as high ankle sprains are more common in ice-hockey than less severe lateral and medial sprains. There is very little literature about the management of syndesmotic ankle injury in ice hockey and overall. Mostly the management of lateral ankle sprain is described, but at the same time,

according to literature rehabilitation of the syndesmotoc sprain is much more time consuming process. High ankle sprains take up to three times more time to recover and return to play than lateral or medial ankle sprains. If the injury is not treated right the rehabilitation takes even more time and other complications might occur. In subacute stage of the injury the lateral ankle sprain treatment protocol can be accommodated into individual needs to be used in syndesmotoc sprain rehabilitation (Chinn & Hertel 2010; Lin et al 2010; Williams & Allen 2010).

The need for surgical treatment for grade two and three syndesmotoc injuries has also not been fully proved. There is a consensus that first grade syndesmotoc sprain can be treated conservatively. Surgical intervention is usually needed for elite athletes for full recovery. The fact that early weight bearing is possible after surgical treatment makes this treatment opportunity more effective (Polzer et al 2012; Porter et al 2008; Williams & Allen 2010).

The length of the recovery period makes syndesmotoc sprain injury expensive for both the team and the player. In sports evidence based sport-specific rehabilitation protocols have been used to facilitate recovery and prevent re- injury. One example is anterior cruciate ligament injury rehabilitation and prevention protocol in football.

After analyzing this information I came to a conclusion that there is a need for syndesmotoc ankle sprain rehabilitation protocol in ice- hockey. In my thesis I set myself a goal to gather information about syndesmotoc ankle sprain rehabilitation in ice- hockey in a way that makes it possible to create evidence-based rehabilitation protocols according to my thesis results.

To make the data collection systematic I set up three research questions about the topic including rehabilitation progression, cardiovascular fitness maintenance and specific exercises.

14.2 Research methods and limitations

The method for data collection in my thesis was literature review. At first I had a plan to use mainly randomized controlled trials to assure the reliability of the research. Although I had access to multiple databases during the writing process it was quite difficult to find sufficient information about the topic. Unfortunately most of the articles related to current topic don't have a free access to full text. As I do not have enough financial possibilities to purchase these articles I used only the ones that are accessible for free. This is the main limitation of my study.

14.3 Writing process

Formulation and material selection for the thesis was a great opportunity for me to widen my knowledge and skills in usage of scientific databases. As a result of the writing process using and searching the materials from evidence based databases has become a habit for me that I use almost every day. This skill has already helped me to provide more efficient treatment for the clients and develop myself as a physiotherapist during my practice and I hope to maintain this habit in my further work as well.

The small number of available materials narrowed the information that was needed to write the thesis. Despite that I found answers to the research questions that I set for my self in the beginning of the writing process. As a result of the gathered information it is possible to construct evidence based syndesmotoc ankle sprain rehabilitation protocols for the ice hockey players that help to facilitate the therapy process and provide faster and fuller recovery. The material is the most useful for the physiotherapist who is familiar with the physiological and biomechanical demands of the ice hockey game. Although the main out frame of the rehabilitation process is presented in the work, specific knowledge is needed to provide the best suitable advanced stage rehabilitation exercises for the ice hockey players that only do not help to recover from the injury but also help to prepare the player for the return to the game.

I decided to present some of the results of the literature analysis in the appendixes at the end of the work to make it easier to the reader to get full review quickly. To deeply understand the background of rehabilitation of the syndesmotic ankle sprain it is recommended to read the whole thesis, but for the creation and adjustment of rehabilitation protocols familiarization with the appendixes should be sufficient.

14.4 Further research

The topic can be further developed in many different ways. If it is financially possible, more full text articles should be purchased and analyzed in thesis to make the research material more complete. As the practical outcome of the thesis the rehabilitation protocol with pictures and necessary instructions could be made and taken into usage in ice hockey clubs.

There is also a possibility to widen the topic and provide the complete material to the team physiotherapists which covers the whole injury management starting from the diagnostics until the return to play. It would consist diagnostics, additional therapies like anti-inflammatory medications, taping, bracing, positioning, usage of assistive devices, specific exercises in each treatment phase, nutritional strategies and psychological management of the player and of course re-injury prevention methods. As the analyze of information needed for this outcome is really time consuming process it could be a topic for doctoral degree in physiotherapy or a research group.

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APPENDIX 1

PICO summary of the articles and suggested exercises for rehabilitation of syndesmotic ankle injury.

Author/Publication year	Patients	Intervention	Control	Outcome measures	Acute phase exercises	Reparative phase exercises	Remodelling phase exercises
Bleakley et al/ 2010	101 patients with an acute grade 1 or 2 ankle sprain.	Accelerated intervention with early therapeutic exercise.	Standard protection group with rest, ice and elevation.	Lower extremity functional scale, pain at rest and on activity, swelling, physical activity, ankle function and rate of re-injury .	ROM, sensorimotor exercises	-	-
Author/Publication year	Patients	Issue	Outcomes	Acute phase exercises	Reparative phase exercises	Remodelling phase exercises	
Brosky et al/1995	Injury to distal tibiofibular syndesmosis.	Review the ligamentous anatomy of the ankle and the incidence of injury to the lateral ligaments of the ankle, with emphasis on DTFS injury.	Early recognition is important. Activity modifications are needed. Restoration of proprioception and stability are key components of rehabilitation.	Toe curls, ankle pumps	Gastrocnemius and soleus stretch; theraband exercises, standing weight shifting exercises, proprioception exercises on BAPS-board	Functional and proprioception exercises, BAPS- board exercises with progressive resistance, Balance exercises with ball catching, Multidirectional walking with resistance band; overall strengthening exercises and zigzag and figure eight running.	
Chinn and Hertel/ 2010	Foot and ankle injuries in athletes.	Discussion of rehabilitation programs of different ankle and foot injuries.	Therapeutic exercise is effective in rehabilitation of athletic lower-leg and foot injuries.	ROM- plantar and dorsiflexion	Strengthening, neuromuscular and balance exercises, functional exercises	Uniplanar exercises; hops, jumps, skips; exercises with change of direction, cutting, shuffling, carioca	
Dubin et al/2011	Lateral and syndesmotic ankle sprains.	Description of anatomy, biomechanics, injury mechanics and diagnostics. Treatment progression	Non-surgical approach is mostly effective treatment method. Accurate diagnostics and treatment can shorten time lost from	ROM exercises	Gastrocnemius and soleus stretching; isometric exercises; ROM with overpressure, theraband multidirectional	Gluteus medius strengthening, calf raises, proprioception exercises on wobble- and balance board, cushions and BAPS board	

		presentation.	competition and prevent re-injury.		ankle strengthening exercises	
Jelinek and Porter/2009	Unstable ankle fracture and syndesmosis injuries in athletes.	Athletes have different demands on their musculoskeletal system and in case of injury might benefit from surgical treatment or accelerated rehabilitation.	Operative treatment helps to return to sports faster. Faster weight-bearing after injury has a positive influence.	Toe curls, leg lifts, knee bends, ankle ROM with and without thera-band, Achilles stretching exercises.	Proprioception exercises with BAPS board, strengthening with thera-band, calf raises, balance exercises on soft surface and balance board.	Entire lower extremity strengthening; ankle flexibility exercises, proprioception exercises and sport specific agility training- sprinting, passing, figure of eight exercises.
Lin et al/2006	Ankle injuries.	Treatment of ankle sprains and ankle fractures based on literature review.	After immobilization period the main emphasis of the treatment should be on exercise.	ROM and toe curls	Thera-band strengthening, ankle stretching exercises, balance exercises on balance pad, jogging, running, cutting, shuttle and jumping exercises.	Single leg heel raises; jog to run progressions; sport specific training.
Williams and Allen/2010	Syndesmotoc ankle sprains.	Discussion of current concepts in rehabilitation of ankle sprains.	A rehabilitation program is described.	ROM with thera-band, heel raises	Achilles stretching, lateral stepping, neuromuscular balance training on cushions, rocker- and wobble board, balance exercises combined with other exercises	Advanced neuromuscular and agility training, sport specific tasks, multidirectional activities: jumping, hopping, running, shuffling, carioca and figure of eight running, plyometrics.

APPENDIX 2

Principles of progression in syndesmotic ankle sprain rehabilitation

Author/Publication year	Principles of rehabilitation progression
Chinn and Hertel/ 2010	<ul style="list-style-type: none"> • Exercises in pain free limits • If no pain in weight bearing, use crutches minimally • Progress to functional activities if ROM and strength are normalized
Dubin et al/2011	<ul style="list-style-type: none"> • Weight bearing as tolerated, if needed use crutches and orthoses • Isometric exercises as soon as possible • Start proprioception exercises if foot can bear bodyweight, progress from sitting to standing • Increase running mileage 10 % weekly if 20 to 30 minutes of running is not painful • Increase running intensity when pre-injury duration has been achieved • If exercises are done with proper technique and there is no swelling- possible to progress to home exercise • Start multidirectional and sport specific exercises when simple drills are not painful and with good technique
Jelinek and Porter/2009	<ul style="list-style-type: none"> • Start strengthening when 95 to 100 % of ROM has been achieved • Stretching is initiated if there is no contraindicating ligament injury • If stability is radiographically confirmed at 1 week, partial weight bearing with axillary crutches is initiated in the boot with progression to full weight bearing at 2 weeks. • If weight bearing in the boot becomes not painful it is removed within 2 week period • Stirrup brace in biking is used until athlete reaches 30-40 minutes pain and symptom free • If stair-climbing or elliptic machine can be used for 30 minutes 4 to 5 days week without difficulty, transition to running is possible
Lin et al/2006	<ul style="list-style-type: none"> • All activities in pain free limits • If simple exercises not painful it is possible to start stretching • Progress balance exercises as weight bearing is tolerated • Restore normal functional ankle strength, achieve pain free running, jumping, and cutting and then move on to functional readiness challenges
Williams and Allen/2010	<ul style="list-style-type: none"> • Initial weight bearing according to individual symptoms • Full weight bearing when ambulation in different surfaces and stairs is not painful • Progress according to presence of pain, post-exercise edema and perception of instability • Start advanced training when jogging or series of hops are not painful • Always monitor quality of movement