Satakunnan ammattikorkeakoulu
Satakunta University of Applied Sciences

Zürcher Hochschule
für Angewandte Wissenschaften

LEA HEINRICH & THEA MARIE LOHMANN

Fascial Techniques for Lower Limb Injury Prevention in Triathlon

A Systematized Literature Review & Workshop

DEGREE PROGRAMME IN PHYSIOTHERAPY
2020

Author(s) Heinrich, Lea Lohmann, Thea Marie	Type of Publication Bachelor’s thesis	Date 16th Month October Year 2020
	Number of Pages 68	Language of publication: English

Title of publication
Fascial Techniques for Lower Limb Injury Prevention in Triathlon: A Systematized Literature Review & Workshop

Degree program in Physiotherapy

Abstract

Background

Triathletes compete in swimming, running and cycling. Long training hours and competitions generate strain on the body and increase the risk of injuries. Especially overuse injuries are common amongst triathletes and can be traced back to fascia. As fascia techniques can improve the range of motion (ROM) of the lower extremity, incorporating those into the training regimen can have a positive impact on injury prevention.

Research Question for the Systematized Literature Review

What are the effects of fascia techniques on the lower extremity of the human musculoskeletal system concerning injury prevention for triathletes?

Objectives of the Workshop

The workshop synthesizes information in an attainable format. The results of the systematized literature review are linked with information about the role fascia training plays in preventing injuries in triathlon.

Method

A systematized literature review was conducted with two main studies, which were selected according to in- and exclusion criteria. On the basis of the systematized literature review, a workshop with fascia techniques for injury prevention, was implemented.

Results

The results of the systematized literature review suggest that fascia techniques can reduce the prevalence of injuries in triathlon, by increasing the ROM in the lower extremity. Foam rolling (FR) and Fascial Abrasion technique (FAT) lead to acute increases of the hip and knee ROM, while FR, static stretching (SS) and the combination of SS and FR acutely improve the passive ankle dorsiflexion ROM. The FAT technique and the combination of FR and SS are superior to the other techniques.

Conclusion

Using the fascia techniques FR, SS and FAT may be used for injury prevention, as they lead to an acute increase of the ROM in the lower extremity. Using FAT and the combination of FR with SS, is especially recommended.

Key words:
Triathletes, Triathlon, fascia technique, foam rolling, myofascial release technique, static stretching, workshop, injury prevention

CONTENTS

1 INTRODUCTION 5
2 AIM AND OBJECTIVES OF THE THESIS 6
2.1 Research Question approached in the Systematized Literature Review 6
2.2 Objectives approached in the Workshop 7
2.3 The Joint Thesis Collaboration 7
3 TRIATHLON 8
3.1 Demands of the Sport 8
3.2 Risk Factors and Common Injuries 9
4 FASCIA AND INJURY PREVENTION 12
5 FASCIA 13
5.1 Functions of Fascia 13
5.2 Histology 16
5.3 Effects of Exercise on Fascia 18
5.4 Significance for Physical Exercise, specifically Triathlon 19
6 FASCIA TECHNIQUES 20
7 SYSTEMATIZED LITERATURE REVIEW 21
7.1 Search Strategy 23
7.2 Study Selection 25
7.3 Methodological Quality Assessment 26
8 RESULTS OF THE SYSTEMATIZED LITERATURE REVIEW 27
9 THE EFFECTS OF FASCIA TECHNIQUES ON THE LOWER EXTREMITY CONCERNING INJURY PREVENTION 32
10 DISCUSSION 33
10.1 How are the Results of the Systematized Literature Review relevant to Injury Prevention in Triathlon? 33
10.2 Duration of the Fascia Techniques' Application 35
10.3 Time Frame between Intervention and Measurements 36
10.4 The Instruments and their Application 36
10.5 Stretching Styles 37
10.6 Participants 37
10.7 Additional Limitations of the Literature Review 39
10.8 Further Research Suggestions 39
11 CONCLUSION 40
12 WORKSHOP 41

12.1 Information Synthesis 41
12.2 Teaching & Learning 41
12.3 Practical Arrangements 45
12.4 Realization of the Workshop.. 46
12.5 Reflection, Self-Evaluation and Feedback 46
12.5.1 Reflection of Marie’s Workshop Implementation with Triathletes 47
12.5.2 Reflection of Lea’s Workshop Implementation with Physiotherapy Students 48
12.5.3 Evaluation using the Feedback Questionnaire 50
12.5.4 Interpretation of the Results 51
12.6 Conclusion of the workshop.. 55
13 REFLECTION ON THE JOINT THESIS PROCESS 56
14 FORMALITIES 59
14.1 List of Abbreviations 59
14.2 List of Tables.. 59
14.3 List of Figures 60
14.4 Declaration of Originality 60
REFERENCES
APPENDICES

1 INTRODUCTION

Triathlon is a popular free-time activity, practiced by men and women of almost all ages, with many practicing on a professional or competitive level. The sport incorporates three disciplines – swimming, cycling and running – which together create a diverse composition of physical demands on the human body's structures. (Puterbaugh 2011, 37.)

Physical activity is considered essential for overall mental and physical well-being (Website of the World Health Organisation 2018). Nevertheless, triathletes are considered as having a high risk of sustaining injuries from or during the exercise, due to the extremely long training sessions, the wide range of specific techniques, required in the performance of each single triathlon-component, plus the transitions from one triathlon discipline to the next (Spiker, Dixit & Cosgarea 2012, 206). Hence, it is not surprising that many athletes make use of counterbalancing exercise programs to aid injury prevention (Mugele, Plummer, Steffen, Stoll, Mayer & Müller 2018, 1-2). Incorporating exercises that increase the joints' ROM, is suggested to decrease the risk of experiencing overuse injuries (Spiker, Dixit & Cosgarea 2012, 206-213). The loss of flexibility in the structures can be traced back to stiffness in the muscles and fascial adhesions (Schroeder & Best 2015, 200; Van Mechelen, Hlobil, Zijstra, de Ridder & Kemper 1992, 605).

The fascial network is an anatomically and functionally essential, continuous structure that interconnects and spreads throughout the whole body (Pilat 2003, 55). The understanding of and perspective on the structure is under continuous development, as current research is being published with new findings. (bioconectiva · Anatomía Viva 2018). The latter make fascia, its treatment and the resulting effects sound promising – not only for health professionals but also for athletes (Rosa 2016, 182). Many treatment measures are used in daily practice of physiotherapists to release tension in the fascial system and facilitate the patient's body to take advantage of its many properties (Pilat 2003, 314). Next to those, effecting on the fascial network through active exercises or self-help-methods by the athletes themselves is suggested, not only in the current research literature but also in popular sports-magazines (Rohé 2018; Schleip & Müller 2013, 108-113).

In this thesis the topics of triathlon and related common lower limb injuries are connected with the prophylactic use of fascia techniques. The theoretical background gives information about the matter, and the systematized literature review investigates on the currently available research, where these topics have been linked. The practical part features a workshop as a tool to make all the information attainable for implementation and presentation to target groups, such as athletes, coaches or other health professionals.

2 AIM AND OBJECTIVES OF THE THESIS

The general aim of the thesis is to create an evidence-based workshop for triathletes concerning injury prevention by using fascial techniques. A systematized literature review is conducted to identify a current status of research and knowledge on the effect of fascial techniques on the human musculoskeletal system concerning injury prevention.

2.1 Research Question approached in the Systematized Literature Review

What are the effects of fascia techniques on the lower extremity of the human musculoskeletal system concerning injury prevention for triathletes?

2.2 Objectives approached in the Workshop

The workshop synthesizes information in an attainable format. The results of the systematized literature review are linked with information about the role fascia training plays in preventing injuries in triathlon. The following questions are dealt with:

1. What is fascia and how does it function in the human body?
2. What techniques can be used to address fascia and why do these decrease the risk of injury?
3. How can these methods be implemented in the training process of triathlon?

Feedback of the participants, that will be collected verbally and through a questionnaire, will be used to evaluate and reflect on the workshop.

2.3 The Joint Thesis Collaboration

Thea Marie Lohmann and Lea Heinrich are students in universities that are members of the European Network of Physiotherapy in Higher Education, which is where the collaboration between the Zürich University of Applied Sciences (ZHAW) and Satakunta University of Applied Sciences (SAMK) was founded. Both students shared the wish to, through their thesis, make theory attainable and convert it into a practical and implementable format that could be useful for athletes, as well as other physiotherapists and practitioners in that area.

Throughout the whole process, the two authors of the thesis worked closely together on all parts of the thesis. The following arrangement was agreed on: Thea Marie Lohmann from the ZHAW would take the main responsibility in conducting a systematized literature review, and Lea Heinrich from SAMK would be responsible for the creation of a workshop.

The thesis was supervised by a teacher from each university. For the international collaboration, different communication channels were utilised; Skype and webex HILL meetings, emails, shared documents plus face to face working weekends. The thesis document template used, as well as the citing and reference guidelines followed, were provided by SAMK.

3 TRIATHLON

The sport of triathlon was commenced in France in the 1920’s. It incorporates the three disciplines of swimming, cycling and running in one event. While the order is fixed – swimming, cycling, running, there are many variations concerning the length: sprint distance competitions include 750m swimming, 20km cycling and 5km running, in the Olympic distance the exact double of each is accomplished and a full Ironman incorporates a 3.8km swim, a 180km cycle and a 42.195km run. (Website of Totaltriathlon 2015.) The popularity of triathlon has increased immensely during the last years. For example, USA Triathlon, the American national rules committee, reported an increase of 114000 members between 2000 and 2010. (Puterbaugh 2011, 37.)

3.1 Demands of the Sport

Triathlon athletes seem to be at higher risk of injury compared to a single-sport athlete. As triathlon includes three disciplines, their training and competition sessions are strenuous and have a long duration. Especially during competitions, many athletes experience injuries, as they push their limits even more during these events (McHardy, Pollard & Fernandez 2006, 132). Each of the disciplines is very demanding and carries with it the risk of injury. A high amount of injuries seems to occur during running as the last discipline of triathlon. The accumulation of tiredness, dehydration and stress from the previous disciplines makes the triathlete more prone to injuries. (Puterbaugh 2011, 37-38; Spiker, Dixit & Cosgarea 2012, 206-213.) Especially the transition phase from cycling to running is very delicate. The muscle activation must adapt to the change of load during running as the weight of the body that the bike was carrying, is now taken over by the body itself. Hence, the mostly concentric muscle contractions during cycling change to rather eccentric ones during running. (Migliorini 2011, 311; Puterbaugh 2011, 38; Spiker, Dixit & Cosgarea 2012, 206.)

Performing different types of sports can, on the other hand, be beneficial and healthy. Different muscle activation and movement patterns are combined, as the physical activity incorporates more variety. (Puterbaugh 2011, 37-38.)

3.2 Risk Factors and Common Injuries

The high demands of the sport result in an increased injury risk, especially for triathletes who suffer from old, not- sufficiently rehabilitated injuries (Spiker, Dixit, & Cosgarea 2012, 206). In general, every athlete is exposed to the risk of obtaining an acute injury during triathlon practice or events. These include muscle strains, fractures, wounds or bruises and occur due to falls, road accidents or competitive rivalry. The latter especially causes injuries during swimming. (Migliorini 2011, 310.)

In later life, it is likely for the athletes to develop osteoarthritis relatively early due to overuse and high loading of the joints. Nevertheless, an athlete’s developed musculature may help in preventing limitations and pain. (Piotrowska, Majchrzycki, Rogala & Golebiewski 2015, 19-23.)

Further, maladjustment of the triathlon equipment, for example the bike, as well as not, or incorrectly, implementing specific techniques in each discipline increase the probability of injury occurrence (Migliorini 2011, 310-311). A vast amount of injuries in triathlon are due to over- or misuse of the musculoskeletal system. Generally, overuse injuries can be traced back to a high number of repetitive forces exerted on a specific structure over an extended period of time which, in sum, exceed the structure’s threshold of tolerance. (Hreljac, Marschall & Hume 1999, 1635). According to Pilat (2003, 198), especially chronic or intermittent malpractice of the fascial system leads to this type of harm. An overuse injury results from the excessive accumulation of microtrauma. In the repair process, adhesions form which cause a decrease in flexibility and elasticity. Movements are executed less effectively and less precisely, more energy is expended, and hence effusive stress is put on various parts of the musculoskeletal system. (Pilat 2003, 198-202.)

The following overuse injuries and their risk factors are related to lesions in the fascial network and are explained more in depth in this chapter. Common in the lower limb are stress fractures, plantar fasciitis, Achilles tendinitis, medial tibial stress syndrome, chondromalacia patellae, anterior knee pain, and hip bursitis (Hreljac, Marschall & Hume 1999, 1635; Spiker, Dixit & Cosgarea 2012, 208).

Stress fractures are mostly atraumatic (Spiker, Dixit & Cosgarea 2012, 210). Hreljac, Marschall & Hume (1999, 1635) suggest that runners with less ankle flexibility are more prone to suffer a stress fracture. Amongst triathletes, this may evolve during the swimming part: the ankle maintains a plantar flexed position almost the whole time, which can cause shortening in the calf muscles and the Achilles tendon (McHardy, Pollard & Fernandez 2006, 134). Stress fractures commonly occur in the lower body in the metatarsal, also referred to as “march fractures”, the tibia or the femoral neck (Spiker, Dixit & Cosgarea 2012, 206-213).

Spiker, Dixit & Cosgarea (2012, 212) estimate that 76% of the athletes suffering from plantar fasciitis are runners. The plantar fascia is stretched excessively when the training is overly demanding, which consequently leads to microtrauma and inflammation. Pain mostly arises on the inferior aspect of the calcaneus, where the insertion of the plantar fascia is located. Acute plantar fasciitis left unattended may further develop into a chronic condition with plantar fascia degeneration, fragmentation and fibrosis. (Ribeiro, João, Dinato, Tessutti & Sacco 2015, 2; Spiker, Dixit & Cosgarea 2012, 206-212.) A tight Achilles tendon, excessive pronation, dorsiflexion restricted to less than 10 degrees and an abnormal foot structure – as a flat or cavus type – increase the risk of plantar fasciitis (Spiker, Dixit, & Cosgarea 2012, 212).

Overload and irregular stress on the Achilles tendon cause microtrauma as well as maldistribution of forces in the calf, leading to friction and damage in the fibres (Luscombe, Sharma & Maffulli 2003, 215). In consequence, this can lead to painful

Achilles tendinopathy, an atraumatic degenerative pathology, that may include calcification in the tendon and posterior heel spurring (Spiker, Dixit & Cosgarea 2012, 206-213).

Medial Tibial Stress Syndrome, also referred to as shin splint, is a type of periostitis and presents itself as a pain on the distal posteromedial portion of the tibia, oftentimes bilaterally. It develops due to excessive stress on the medial border of the tibia. Differential diagnosis should consider tibial stress fractures and chronic exertional compartment syndrome. (Spiker, Dixit & Cosgarea 2012, 206-213.)

Anterior knee pain may be caused by chondromalacia patellae, which evolves through the softening of the joint’s articular cartilage. A patellofemoral pain syndrome is often the cause of anterior knee pain and is well-known as the “runner’s knee”. Its cause is multifactorial, but, inter alia, may origin from a lack of flexibility in the hamstrings, quadriceps and gastrocnemius muscles or in the iliotibial band. (Spiker, Dixit & Cosgarea 2012, 209.) The poor flexibility can lead to increased stress on adjacent joints, hence, explaining the generation of knee pain (Hreljac, Marschall & Hume, 1999, 1639).

Iliotibial Band Syndrome (ITBS) is another kind of overuse injury, characterized by pain in the lateral knee, hip or both. It evolves through repetitive friction on the greater trochanter and/or the lateral epicondyle of the femur in 30° knee flexion. The origin of the ITBS is associated with increased ankle pronation, which develops due to tightness in the gastrocnemius and soleus muscles. (Spiker, Dixit & Cosgarea 2012, 206-209.)

Hip bursitis, also called Greater Trochanter Pain Syndrome, occurs due to the irritation of one or more of the bursae that are located around the hip and trochanter area. Just like its name suggests, the Snapping Hip Syndrome is characterized by a snapping sound or sensation noted during hip movements. Especially when “the hip is extended from a flexed, externally rotated, and abducted position”. It occurs when soft tissues, such as the iliotibial tract, gluteus maximus or iliopsoas muscles, slide over bony parts of the hip joints, as, for example, the trochanter major or the femoral head. (Spiker, Dixit & Cosgarea 2012, 207-208.)

4 FASCIA AND INJURY PREVENTION

Injury prevention is seen as the performance of specific exercises or actions, which help to decrease, treat, prevent and ameliorate injuries (Hemenway, Aglipay, Helsing & Raskob 2006, 349). Specific exercise programs that target the prevention of injuries can be used to decrease the athletes' risk. These may be sport-specific or relating to certain types of injury. (Mugele, Plummer, Steffen, Stoll, Mayer & Müller 2018, 1-2.)

The following types of maladaptation in the fascial system can be linked to the previously mentioned lower-limb overuse injuries and are common amongst triathletes. Their causes are considered as risk factors, which in turn should be converted into injury prevention measures. (Offord & Kraemer 2000, 70-71.)

Through delayed-onset muscle soreness (DOMS) fascial adhesions form, negatively impacting joint ROM, muscle length and hence the overall flexibility (Schroeder & Best 2015, 200). Van Mechelen, Hlobil, Zijlstra, de Ridder and Kemper (1992, 605) state that also generally stiff muscles reduce joint ROM. These factors thus increase the risk of related overuse injuries. (McHardy, Pollard & Fernandez 2006, 134; Spiker, Dixit & Cosgarea 2012, 209). Therefore, decreasing DOMS, while increasing joint ROM and thus muscle flexibility is suggested to aid injury prevention. This may be achieved through the implementation of fascia techniques, such as different stretching approaches and myofascial release (MFR). (Ajimsha 2011, 432; Schleip & Müller 2013, 106-108.)

Exercises targeting the proprioceptive and neuromuscular control are also hypothesized to decrease the chance of injuries (Hübscher, Zech, Pfeifer, Hänsel, Vogt & Banzer 2009, 419). Both can be improved through fascial techniques such as, inter alia, proprioceptive refinement exercises (Schleip & Müller 2013, 108-110).

The next chapter provides background knowledge on fascia, aiming to establish a deeper insight of the network and of how fascia techniques can have a positive impact on the above-mentioned factors.

5 FASCIA

Fascia comprises of sheets of connective tissue, which permeate the human body (Adstrum, Hedley, Schleip, Stecco & Yucesoy 2017, 174; Stecco & Schleip 2016, 1). It creates continuity amongst all tissues by enclosing, attaching and separating muscles and other internal organs (Kumka & Bonar 2012, 182; Stecco & Schleip 2016, 139). Fascia is thus also referred to as being a supportive framework, that extends in a three-dimensional matrix from head to toe and enhances the body's functioning (Kumka & Bonar 2012, 179). It consists of fibrous connective tissue, including aponeuroses, ligaments, tendons, periostea, epineurium, peripheral nerves, blood and lymph vessels as well as endomysial and intermuscular fibres of the myofasciae (Adstrum, Hedley, Schleip, Stecco & Yucesoy 2017, 174; Kwong & Findley 2014, 876).

The fascial network encloses muscles and varies in its function and structure depending on its location in the body (Kwong & Findley 2014, 876; Schleip & Müller 2013, 104). One distinguishes between superficial and deep fascia: Superficial fascia is in the subcutaneous tissue, between the superficial and deep adipose tissue and is defined by a loose density and mostly multidirectional fibre alignment. Deep fascia on the other hand can be found beneath the superficial layers and consists of a dense and irregular fibrous membrane. (Kwong & Findley 2014, 876.)

While these differentiations are made, the fascial system creates, anatomically and functionally, one sole structure which extends without interruptions throughout the whole body (Pilat 2003, 55).

5.1 Functions of Fascia

Fascia surrounds all structures of the body, it is a "network of interacting, interrelated, interdependent tissues forming a complex whole, all collaborating to perform a movement." (Stecco & Schleip 2016, 140).

Fascia plays an important role as a sensory organ, containing six times as many sensory receptors as muscles (Rosa 2016, 296; Stecco & Schleip 2016, 139). Through its sensory neural fibres, it senses proprioceptive and nociceptive information. It responds to manual pressure, temperature and vibration. In addition, receptors within the fascial system influence autonomic responses, for example blood pressure alterations. Fascia contains two types of sensory receptors: free nerve endings, which are the terminal branches of axons, and encapsulated endings, enclosed by non-neuronal cells at the terminal parts of axons. Both receptors operate as mechanoreceptors and nociceptors in muscles, ligaments and bones. Furthermore, the encapsulated endings contain Golgi receptors, Pacini- and Ruffini's corpuscles and thus react to mechanical pressure and deformation. (Kumka & Bonar 2012, 184.)

Even though the fascia network is one sole structure, Kumka and Bonar (2012, 184-189) sub-divided fascia, according to its function in the body, into four different categories linking-, fascicular-, compression- and separating fascia. An overview is given in table 1.

Table 1. Categories of fascia (Kumka & Bonar 2012, 184-189)

	Compression Fascia	**Separating Fascia**	**Fascicular Fascia**	**Linking Fascia**
Keywords to the specific function	Locomotion, venous return, enables local sliding	Supports and compartmentalizes	Organizes the structure of muscles, nerves, tendons, locomotion qualities, transports, strengthens	Enables movement and joint stability
Sensory Organ Components	Proprioception	Responds to pressure and forces	Golgi tendon organs	Detects vibration and rapid pressure

Compression Fascia encases whole limbs, creating a "stocking effect". Due to its impact on compartmental pressure, muscle contraction and force distribution, it displays a vital role in locomotion and venous return. It is also characterized by the spatial orientation of collagen fibres, which changes from layer to layer. In between each layer lies more loose connective tissue, enabling local sliding. In contrast to the linking and fascicular fascia, the compression fascia does not have sensory receptors, but is innervated with proprioceptors. (Kumka & Bonar 2012, 188.)

Separating fascia separates, supports and compartmentalizes the entire body through a continuous matrix. It divides different kinds of fibres into visible sheets and layers. Through this, on the one hand, proper structure and functional relationships within the body are preserved and at the same time the ability to withstand multidirectional forces, friction and stretch is created. Pancini and Ruffini corpuscles are present in separating fascia and respond to pressure and forces. (Kumka & Bonar 2012, 188.)

Another category is the fascicular fascia. It is important for transport, organization, strength and locomotion. It bundles vessels and fascicles in muscle tendons, bones and nerves, providing them with additional support. Added to that, fascicular fascia is responsible for the muscle's architecture by dividing it into three layers: the epimysium, which covers the whole muscle, the perimysium, which separates fascicles or bundles of muscle fibre and the endomysium, which surrounds individual muscle fibre. The distinction into layers also applies to tendons: endotendon, peritendon and epitendon in tendons and nerves: perineurium and epineurium. These layers receive a special meaning at the myotendinous junction where the fascicular fascia of the muscle transitions into the fascicular fascia of the tendon. This specific region contains Golgi tendon organs which are stimulated by muscle contraction. As soon as the tendon is put under tension, it in turn decreases the tension in neighbouring muscle fibres. (Kumka & Bonar 2012, 185.) In addition, fascicular fascia plays an essential role in the myofascial force transmission. Through myofascial junctions and connections, forces exerted by and on one muscle are not only transmitted within the muscle, but also epi-muscularly between muscle fibres and fascial connective tissue. Hence, a force created in one muscle also applies to neighbouring synergist-muscles and even to antagonistic muscles. (Kwong & Findley 2014, 877.)

Linking fascia can be further divided into dynamic and passive divisions. The dynamic one is associated with movement and joint stability as it contains a high amount of contractile and proprioceptive fibres. It can create tension in the musculoskeletal system by contracting, however it does not create the primary force when performing a movement. Linking fascia is, compared to other fascia categories, densely innervated and hence contributes in nociception and proprioception. In addition, free nerve endings and Paciniform corpuscles, allow the detection of vibration and rapid pressure stimuli. The passive divisions on the other hand operate as muscular insertion points, joint linkages and tendinous arches. By building tunnels and sheaths, it maintains the continuity of fascia throughout the body. It can thus only transmit force and provide proprioceptive information when a certain level of tension is apparent. (Kumka & Bonar 2012, 185.)

The fascial system is in a state of pre-tension, which is present even before any kind of external force is applied to the structure. This ability is established through the basic concepts of the fascial network: tensegrity and viscoelasticity principles which apply to fascia globally, hence also to every single sub-group. Tensegrity describes the self-stabilizing property of fascia: rigid parts which respond to compressional stimuli cooperate with flexible parts that respond to traction forces. In this way, the fascial network is ready to respond in various ways to the stimuli and provides fundamentally important functional integrity. Healthy fascia is prepared to respond efficiently to dynamic demands at any time; to move, protect, control, mobilize, stabilize – it gives life. As mentioned before, all bodily elements are interconnected. When any type of stimuli is applied locally, the response is global. This guaranties the absorption and distribution of forces, impacts and information throughout the whole body, seeking to maintain the body’s holistic state of self-balance – its homeostasis. (Adstrum, Hedley, Schleip, Stecco & Yucesoy 2017, 174; Pilat 2003, 143-158.)

5.2 Histology

Fascia’s functional properties are defined by the specific characteristics of its cellular components. It consists of specific cells, fibres and ground substance. The cells are fibrocytes, which include fibroblasts and myofibroblasts, adipocytes and white blood cells. (Kumka & Bonar 2012, 182-183.) Fibres contain collagen and elastin, whilst ground substance contains proteoglycan and glycoproteins (Kumka & Bonar 2012, 182; van den Berg 2003, 4).

The specific composition of fascia provides it with viscoelastic properties. Through the latter, fascia is elastic and can adapt in a multifaced way to forces; it deforms in response to different stimuli temporarily as well as permanently, without tissue damage. (Pilat 2003, 113-119.) The structure and molecular composition of the fascial network vary, depending on local mechanical forces and strains as well as their effects to the whole system (Kumka & Bonar 2012, 183). In the following the properties of fascia's components are explained in more detail.

Connective tissue and hence fascia, contains a variety of collagen fibre types. Their main function is to resist tension and stretch, by orienting parallel towards a predicted outward force vector. (Kumka & Bonar 2012, 182-183). Their specific composition, density and fibre arrangement depend on the local and global strains on the tissue (Kwong & Findley 2014, 876). For example, high compression forces lead to the replacement of fibroblasts with chondrocytes, forming a more solid mineral deposition in the cartilage (Kumka & Bonar 2012, 182-183).

Fibroblast are responsible for the arrangement of collagen. They are a subgroup of fibrocytes and are known for their high capability of adapting to their environment. They reconstruct, depending on the direction of mechanical stimuli. (Kumka & Bonar 2012, 183; Schleip & Müller 2013, 104.) Fibrocytes also include myofibroblasts, which incorporate actin-myosin filaments, that enable fascia to contract. They are found to an increased degree in pathological fascia, explaining the formation of tissue contractures. (Kumka & Bonar 2012, 183.) The composition and architecture of the fascial network is not fixed: through stretch and biochemical signalling fibroblasts can transform into myofibroblasts (Kwong & Findley 2014, 878).

Proteoglycans, which are contained in the ground substance, contribute to the sliding property of fascial layers: they are highly negatively charged, and thus attract water molecules, creating a gel-like substance. The so-called ground substance absorbs shear stress and adds lubrication, enabling frictionless musculotendinous movement. (Kwong & Findley 2014, 878.)

5.3 Effects of Exercise on Fascia

Fascia changes in response to regular every day or specific training: fibroblasts remodel the local collagen fibre network according to the local strain and the direction of repetitive mechanical stimuli. As a result, fascia becomes more youthful, displaying a wavier fibre arrangement and possessing a higher elastic storage capacity of collagen. (Schleip & Müller 2013, 104-105.) To achieve this, Schleip and Müller (2013, 108-110) propose, inter alia, the implementation of techniques that utilize the facial spring- and recoil effects.

This transformation however only takes place if the exercises exceed the habitual strain. The fascia techniques should be performed on a regular basis over years, as fascia changes slowly. After implementing fascia techniques, the tissue needs 72 hours to regenerate, build and align its new elastic collagen architecture. Hence, it is recommended to train fascia techniques continuously once or twice a week. (Schleip & Müller 2013, 113; Rosa 2016, 182).

When a force is applied, may it be a compression or stretch stimulus, it can be distinguished between three stages of fascia's response. In the pre-elastic phase, the tissue transitions from a resting state into that of pre-tension, which was described earlier. How much force and time this phase requires depends on the type of tissue as well as the fibres' state of undulation. As further force is applied, the elastic phase begins. The tissue changes almost lineally, not just according to the amount of force, but rather to the duration of that force being applied for. The final maximum of the tissue change will not be met immediately – the tissue must experience the force regularly and will then reach every time a greater momentous maximum. When considering a stretch-stimuli, this will be visual through changes in ROM. These phenomena can be traced back to the large component of collagen in the tissue. The latter is responsible for resisting tension and stretch, hence does not allow an immediate maximal increase of the tissue's length. When the force is released, the tissue aims to return to its initial state, which happens relatively slower, nonlinearly and never completely. This can be explained by the previously mentioned viscoelasticity of the tissue: during the application of a force, energy in form of heat is released and the interior liquids of the cell – especially the fascia's ground substance – are squeezed out. With the release, liquid re-enters, providing the tissue with nourishing fluid from the surrounding tissue and the local vascular system. (Pilat 2003, 111-114.) This process is also known as the "sponge effect" and de- and rehydrates fascia. It is essential for fascial health, as it prevents inflammation, oedema, accumulation of free radicals and waste products. (Schleip & Müller 2013, 108.)

When a force, which exceeds the deformation capacity of the tissue, is applied, traumas occurs in the collagen fibres. In this so-called plastic stage, the tissue loses its tensile capacity. The changes in the tissue are irreversible, meaning that they will recover solely by passing through an inflammatory process. Hence, after unduly overloading stress on the fascial system, the tissue goes through a process of reparation and because of that presents an increased collagen proportion. This is due to the inflammatory reaction of micro-scarring, which increases rigidity and resistance in the tissue. (Pilat 2003, 111-114.)

Without exercise however – immobilised, fascia suffers; it sticks together and builds adhesions (Rosa 2016, 182). Especially the above-mentioned separating fascia forms adhesions as a consequence of incorrect movement patterns or injury (Kumka & Bonar 2012, 188). Without mechanical stimuli cross links build up in all directions. As a result, the structure loses its elasticity and sliding capacity, and subsequently becomes more prone to injury. (Rosa 2016, 182.)

5.4 Significance for Physical Exercise, specifically Triathlon

Until recently, conventional sport training mainly focused "on the classic triad of muscular strength, cardiovascular fitness and neuromuscular coordination" (Journal of the Australian... 2014, 296). Only physical activities such as Pilates or yoga incorporated fascia training (Schleip & Müller 2013, 104). Literature suggests that many injuries can be traced back to the fascial system rather than only to the muscles or the skeleton (Journal of the Australian... 2014, 296; McHardy, Pollard & Fernandez 2006, 134; Schroeder & Best 2015, 200; Spiker, Dixit & Cosgarea 2012, 209). This leads to the consideration, if regularly performing fascia techniques could have a positive impact on injury prevention (Schleip & Müller 2013, 104).

6 FASCIA TECHNIQUES

Fascia creates a continuous network throughout the body and is linked to all structures in it. Hence, fascia techniques not only affect the fascial tissue itself, but also other organs. This especially applies to fascia and muscles, as they merge. Hence, a diverse training is required to address fascia globally. (Rosa 2016, 182.)

Fascial stretching includes SS and dynamic stretching techniques. Both have positive long-term effects on force, jump height, speed and help preventing limited ROM. A comprehensive stimulation of fascial tissue is achieved through dynamic muscular loading, where the muscle is lengthened and shortly contracts in that position. To increase the production of collagen in the tissue and enhance its arrangement implementing fascia training, tendons are recurrently loaded with few repetitions of soft, elastic bounces at the end ROM. To prevent limitations in ROM and promote shear-ability between the fascial layers a variety of different stretching styles is recommended. Stretching in a slow and static manner is recommended to decrease inflammatory processes and to achieve an analgesic effect. (Schleip & Müller 2013, 105-108.)

The previously mentioned effect of dehydration and rehydration of fascia, also known as the sponge effect, is achieved when a force is put on the tissue and then released. It provides fascia with nourishing fluids from the surrounding tissue and the local vascular system. (Schleip & Müller 2013, 108.)

This effect can be achieved through a wide variety of MFR techniques. According to Ajimsha (2011, 432), MFR techniques consist of long, low load stretch of the myofascial complex and should be performed with a slow, consistent pressure for 120 to 300 seconds. Using external forces, MFR can be applied manually or instrumentally by a therapist (Shah & Bhalara 2012, 73). MFR applied with a tool is also referred to instrument-assisted soft-tissue mobilization (IASTM). It includes a variety of techniques such as the Graston technique or FAT (Markovic 2015, 641.) Self-myofascial release (SMR) on the other side mimics a manual MFR of a therapist through the utilization of a foam roller (Chaudhry, Schleip, Zhiming, Bukiet, Maney & Findley 2008, 389). An individual applies pressure on his fascial tissue with his own body mass by rolling over a dense foam roller (Grieve, Goodwin, Alfaki, Bourton, Jefferies & Scott 2014, 545). There are a variety of foam rollers, which differ in their length, diameter and the type of foam (Markovic 2015, 692). According to Schleip and Müller (2013, 112) the firmness of the foam roller and the application of body weight should be adapted individually and be supervised.

Research hypothesizes that externally applied mechanical forces may not reach the necessary large forces to address deep and dense fascial layers. Nevertheless, these stimuli in the superficial layers effect fascial mechanoreceptors, achieving a change in muscle tonus which then will release the tension and pressure in the tissue, consequently leading to the effect that was initially aimed for. (Chaudhry, Schleip, Zhiming, Bukiet, Maney & Findley 2008, 389.)

As Fascia is a proprioceptive sensory organ, it needs to be trained in this area as well. Proprioceptive refinement is a recommended practice. It involves variations in the movement range, quality and velocity. Other principles incorporate the fascial spring and elastic recoil effects. These include moving with a focus on fluidity, using “sinusoidal movements”, as well as loading the tissue with bouncy stimuli. (Schleip & Müller 2013, 108-110.)

7 SYSTEMATIZED LITERATURE REVIEW

Literature reviews summarise publications of a specific area. A review is perceived as systematic when it is based on a clearly defined research question, identifies relevant studies, critically appraises the quality of the studies and synthesizes them. (Khan, Kunz, Kleijnen & Antes 2003, 118-121.) Systematic literature reviews aim to reduce bias and give a high-quality evidence on a specific topic through a comprehensive plan and search strategy (Uman 2011, 57). A literature review is perceived as a systematized review, when it aims to fulfil the criteria of a systematic review. The latter investigates all relevant sources, including the bibliographies of all studies and their included articles, which would exceed the scope of a bachelor thesis. Hence, this thesis' literature review can be categorized as systematized, as it follows the structure of a systematic one but in a limited depth. (Grant & Booth 2009, 95; Wright, Brand, Dunn & Spindler 2007, 25-27.)

The first step when conducting a systematic review is to construct a clear research question. In medical research the PICO strategy is commonly used: PICO is the acronym for: Population, Intervention, Comparison and Outcome. Applied on this thesis an example is:
P: Triathletes.
I: fascial techniques, applied to the lower extremity.
C: (Not applied in this case.)
O: injury prevention. (Sayers 2008, 136.)
Consequently, resulting from the formulation of the research question, the inclusion and exclusion criteria are determined (Uman 2011, 57).

In the next step a search strategy is defined, which aims towards finding relevant studies. The search should include keywords, which are linked to one of the categories of the PICO-based research question. These keywords can be connected in a broad variety. For example: Triathlon AND fascia technique. (Uman 2011, 57.)

After the conduction of the search, relevant studies should be identified with the aid of the inclusion and exclusion criteria, which were determined in advance. In the next step a methodological quality assessment of the included studies is conducted. (Uman 2011, 58.) For this purpose, PEDro (Physiotherapy Evidence Database) displays are a commonly utilized tool (Sherrington, Herbert, Maher & Moseley 2000, 224).

Subsequently, the relevant studies are summarized and compared. Strengths and weaknesses of the included studies are discussed. The interpretation and conclusion of the studies allow the researcher to suggest an answer to the research question. If at the end of the systematic review only a limited answer can be given, it does not necessarily mean that the systematic review is incomplete. It simply illustrates that there is little evidence due to a lack of literature. Consequently, a recommendation for further research in this research field can be given. (Wright, Brand, Dunn, & Spindler 2007, 27.)

7.1 Search Strategy

The implementation of fascia techniques as a measure for injury prevention is an emerging topic and hence lacks evidence. Thus, a broad research was conducted. To enhance the number of findings, adjustments were made during the research, resulting in several database searches.

The first database search was conducted on the 16.05.2019 and 17.05.2019. The aim of this search was to find studies concerning injury prevention through fascia techniques in triathlon, respectively one of the components of triathlon: running, swimming or cycling. The keywords were the combination of “Triathlon”, OR “swim”, OR “run”, OR “cycle” as the main heading along with one of the following terms: AND “fascia”, AND “fascial training”, AND “fascia technique”, AND „fascial release“, AND „myofascial release therapy“, AND “foam rolling”. The utilised databases were PubMed and EBSCO. In the first database search 413 hits could be found. Results of the combination for each database are illustrated in table 2.

Table 2. Results of the first database search

Search terms		**PubMed**	**EBSCO**
triathlon	AND fascia	1	3
	AND “fascial training”	0	0
	AND “fascia technique”	0	0
	AND „fascial release “	1	0
	AND „myofascial release therapy “	1	0
	AND “foam rolling”	0	0

swim*	AND fascia	12	2
	AND “fascial training”	0	0
	AND “fascia technique”	4	0
	AND „fascial release “	0	1
	AND „myofascial release therapy “	0	0
	AND “foam rolling”	0	0
run*	AND fascia	98	96
	AND “fascial training”	2	1
	AND “fascia technique”	0	0
	AND „fascial release “	0	2
	AND „myofascial release therapy “	0	1
cycle*	AND fascia	142	34
	AND “fascial training”	8	0
	AND “fascia technique”	0	0
	AND „fascial release “	1	0
	AND „myofascial release therapy “	1	1
	AND “foam rolling”	1	0
Total hits		272	141

After implementing the first database search, no hits matched the research question. To increase the number of suitable results in a new database search the research field was broadened: the second database search aimed to find studies with athletes who performed a sport which includes at least one component of triathlon: swimming, running or cycling.

Two database searches were performed on the 24.05.2019: one on PubMed with only MeSH terms and another one on EBSCO. On PubMed, the search was conducted with the combination of the following MeSH terms: “physical therapy modalities”, AND “fascia”, AND “sport”, AND “performance”, AND “myofascial system”, AND "self-myofascial release", AND “endurance”, AND “fascial tissue”, AND “exercise”, AND “Therapy, soft tissue”, AND “myofascial”, AND “pliability”. The results are illustrated in table 3. On EBSCO the utilized search terms were the combination of: “athletes”, OR “sport”, OR “athletics”, AND “fascia”, AND “athlet*”, AND “fascia therapy”, AND “self-myofascial release”, AND “foam rolling”, AND “stretching”, AND “fascia”, AND “fascial tissue”, AND “sport”, AND “endurance”. The results of the database search on EBSCO are displayed in table 4.

Table 3. Database search with MeSH Terms on PubMED

Search terms	**PubMED**
Physical therapy modalities AND fascia AND Sport:	19
Dynamic stretching AND passive stiffness AND Sport	85
Physical therapy modalities AND fascia AND performance	3
Myofascial system AND fascia	51
("self-myofascial release") AND sport AND endurance	13
("self-myofascial release") AND endurance	1
("self-myofascial release") AND sport	49
Myofascial release AND fascia AND pliability	1
physical therapy modalities AND fascial tissue AND exercise	47
Therapy, soft tissue AND endurance	50
Therapy, soft tissue AND endurance AND myofascial	6
Total hits	227

Table 4. Database search on EBSCO

Search terms	**EBSCO**
athletes OR sports OR athletics AND fascia therapy	0
athlet* AND fascia therapy	0
athlet* AND “self-myofascial release” OR foam rolling	36
athlete* AND “self-myofascial release”	11
athlet* AND stretching AND fascia	1
athlete* AND fascial tissue	3
sport AND “self-myofascial release”	9
endurance AND “self-myofascial release”	1
Total hits	61

7.2 Study Selection

In total 701 hits were found. These were then screened entirely to determine if they met the in- and exclusion criteria, which are defined in table 5. Figure 1 displays the flow diagram of the study selection process, as well as the reasons for exclusion. As a result, only two studies were identified as meeting the inclusion criteria. Methodological quality assessment and data extraction for the two articles was conducted.

Table 5. In- and exclusion criteria:

Inclusion criteria	Exclusion criteria
Present in English.	Published before the 1st of 2010.
Studies that solely focus on the lower extremity.	Studies that examine the full body or the upper extremity.
Participants are either triathletes or athletes from a sport which incorporates a component of triathlon: swimming, running or cycling.	Participants are non-athletes or recreationally trained individuals.
Studies focusing on injury prevention. As described in chapter 4 parameters concerning injury prevention are: flexibility, stiffness, ROM, DOMS.	Studies examining performance.
Studies examine fascia techniques	
Available in full text.	
Age 14 and above.	

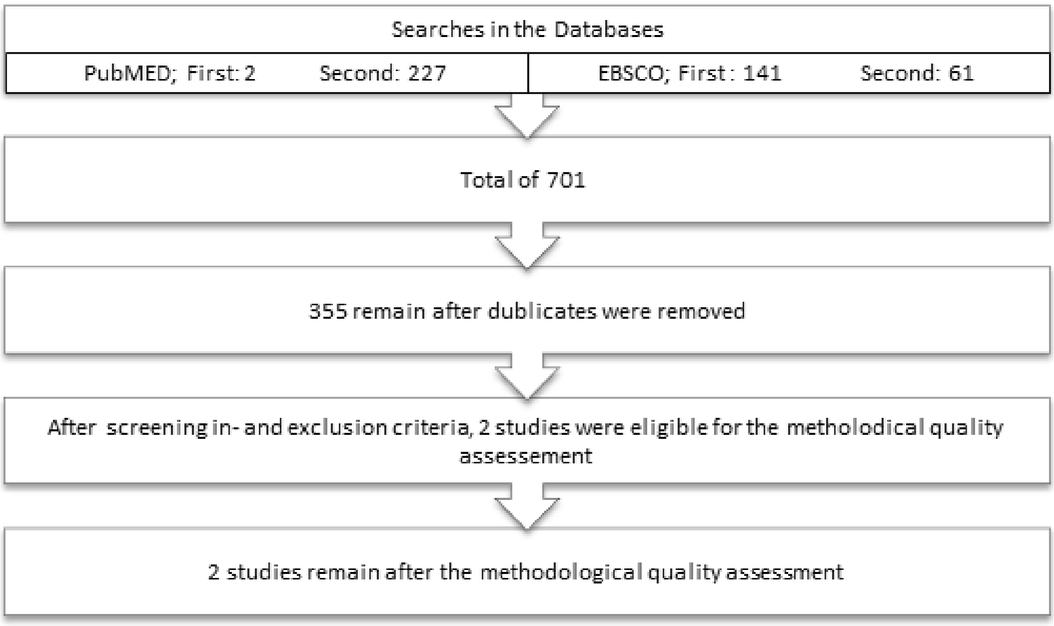

Figure 1. Flow chart of study selection

7.3 Methodological Quality Assessment

To determine the methodological quality of the remaining studies the PEDro scale was used, which is attached in appendix 1. PEDro is the abbreviation for Physiotherapy Evidence Database. It is a free online database containing over 44,000 randomised controlled trails, systematic reviews and evidence-based clinical practice guidelines, which all have been assessed via the PEDro scale. The PEDro scale contains 11 criteria to assess the quality of a study. Of these 11 criteria, 10 are used for the final score. (Website of Physiotherapy Evidence Database 1999.)

The assessment was made by two independent reviewers, who assessed the quality of the two articles. An agreement was made on the following score: Markovic (2015, 690-696) achieved a score of 4/10, whilst Škarabot, Beardsley and Štirn (2015, 203-212) achieved 7/10. It was determined that both studies would be included in the systematized literature review. Table 6 provides information regarding the fulfilment of methodological quality criteria of the two studies.

Table 6. Methodological quality assessment using PEDro Scale

Study by	PEDro Scale Criterion											Score*
	1	2	3	4	5	6	7	8	9	10	11	
Markovic, 2015	0	1	0	1	0	0	0	0	0	1	1	4
Škarabot, Beardsley & Štirn, 2015	1	1	1	1	1	0	0	0	0	1	1	7

*Score: Total score of the article following the PEDro scale criteria.

8 RESULTS OF THE SYSTEMATIZED LITERATURE REVIEW

This chapter provides an overview of the studies. In total, the study selection process concluded with two quantitative studies, which are both randomized controlled trials. These are listed with author, name, year, and study design in table 7.

Table 7. Studies included in the systematized literature review

Authors	Name	Year	Study design
Markovic	Acute effects of instrument assisted soft tissue mobilization vs. foam rolling on knee and hip range of motion in soccer players	2015	Randomized controlled trial

Škarabot, Beardsley & Štirn	Comparing the effects of self-myofascial release with static stretching on ankle range of motion in adolescent athletes	2015	Randomized controlled trial

As mentioned previously in chapter 7.1, the inclusion criteria were adjusted in the literature search process: the population was broadened to the field of athletes performing a sport that incorporates a triathlon component. Table 8 displays, in what way the two selected studies can be linked to triathlon and are therefore considered relevant in providing an answer to the research question.

Table 8. Relevance of the selected studies to the research question

Study by	Relevance relating to the study's population
Markovic, 2015	Participants are soccer players → there is a lot of running incorporated in the sport → fits to the running discipline of triathlon
Škarabot, Beardsley & Štirn, 2015	Adolescent swimmers → swimming is a component of triathlon

The selected studies can be used to generate an answer to the research question. Table 9 summarizes the study "Acute effects of instrument assisted soft tissue mobilization vs. foam rolling on knee and hip range of motion in soccer players" by Markovic (2015, 690-696) and table 10 summarizes the study "Comparing the effects of self-myofascial release with static stretching on ankle range of motion in adolescent athletes" by Škarabot, Beardsley and Štirn (2015, 203-212).

Table 9. Study by Markovic (2015, 690-696)

Aim	The study aims to examine the effects of FR and the IASTM technique called FAT on the hip and knee ROM in soccer players.
Participants	20 regional-level male soccer players, aged 19 ± 2 years, participated. The subjects were included if they did not have thigh muscle injuries in the last two years. All subjects were requested to follow a normal diet and avoid alcohol, nicotine, caffeine and any vigorous physical activity 48h before and during the test sessions. During the period of the study they should not take pain killers and analgesics.

Measurements	Knee and hip ROM were measured on the dominant leg before, immediately after and 24h after the intervention: first the supine passive knee flexion test was conducted, followed by the passive straight leg raise test. The Pro 3600 digital inclinometer was utilized to read the angles. Both tests were conducted twice in the above-mentioned order, with the highest result being used for analysis.
Intervention	The study comprised of two parts, with were conducted with a 24h gap in-between. The participants were randomly separated into 2 groups with 10 subjects in each. One group performed FR and the other group received FAT. The two testing sessions each involved a warm up with: 5-min cycling on a cycle ergometer at 75 W and 70-80 rev/min, walking lunges (2x5 each leg), walking knee to chest (2x5 each leg), side squats (2x5 each leg), deep squats (2x5), standing toe-touches (2x8) and SS of the quadriceps and hamstrings muscles (2x30s each). The first session included the warm-up, a pre-test hip and knee ROM measurement, a short intervention of either FR or FAT and a post-test measurement of knee and hip ROM. The FR group applied 2x 1min of FR on the quadriceps and the hamstrings on the dominant leg with the opposite leg crossed over the dominant one. During each minute the muscle was rolled out 4-5 times, with a break of 30s in between sets. They were instructed to utilize short, kneading like movements in one direction and only one quick motion in the other direction. A grid foam roller was utilized with a length of 33cm, diameter of 14 cm and with a hard-hollow core, wrapped in ethylene vinyl acetate foam. The FAT group received a 2min application on the quadriceps and hamstring muscles with a FAT-tool Pro Large model, which consists of a handle and 20cm treatment surface. The muscles were treated in a pre-stretched position, meaning a knee flexion in a supine position for the quadriceps muscle and a hip flexion and knee extension in a side-lying position for the hamstring muscles. Before the treatment, a small amount of friction balm was applied with the edge of the tool. The areas of tension were first identified with feathering (using the edge of tool) and sweeping (using the bevelled surface of the tool) motions and then treated with constant, light pressure realizing sweeping and burst strokes. The second session included a warm-up and a measurement of the hip and knee ROM (24h post-test). Both testing sessions were conducted at the same time of the day.
Results	Knee and hip ROM improved immediately after FR and FAT with a higher effect in the FAT group: knee ROM increased by 13.1° or 10% in the FAT

	group, while it increased only by 6.6° or 5% in the FR group. Hip ROM gained 15,2° or 19% in the FAT group and only 7.0° or 9% in the FR group. 24 hours after the intervention only the FAT group displayed pre- to post-intervention gains: in knee ROM 9° or 7% and in hip ROM 10.1° or 13%. The results of the FR group illustrated after 24h identical outcomes as before the intervention.
Limitations	The author mentions several limitations. Firstly, only a small sample size group of young, healthy and only male soccer players was examined. Secondly, treatment variables such as the amount of pressure or the optimal duration time of FR and FAT are unknown. The author is aware that additional literature suggests that Fascial Manipulation techniques should be applied for more than 2 minutes, hence longer than in their study. Modifying the treatment variables might have led to a higher effect on the ROM.

Table 10. Škarabot, Beardsley & Štirn (2015, 203-212).

Aim	The primary aim of the study was to compare the acute effects of SS, FR and a combination of FR and SS on the passive ankle dorsiflexion ROM in adolescent resistance-trained athletes, who have been performing FR for at least 6 months. The secondary aim of the study was to compare the duration of the possible acute changes in flexibility in each condition at four different times post-intervention.
Participants	11 adolescent, trained swimmers, aged 15.3 ± 1 year, were involved in the study. Five were women and six were men. Each of them trained for 6 months 16 hours of swimming, 3 hours of resistance-training and at least 30min of FR per week. The latter, additionally to being swimmers, allows to classify the subjects as intermediate resistance trained, according to the definition by the American College of Sports Medicine. To be included in the study the participants had to ensure that they were not suffering from ankle-related or lower-limb injuries.
Measurement	Passive ankle dorsiflexion ROM was measured in a weight-bearing lunge position pre-intervention and immediately after, plus 10-, 15- and 20-minutes post-intervention. In the above-mentioned position, the subjects aimed to touch the wall with their knee. With the aid of a measurement tape the linear distance between the big toe and the wall was measured. In order to prevent heel lifting, an elastic resistance band was positioned underneath the heel of the subject and brought under tension by an experimenter. If the heel would accidently lift, the band would twitch away, and the trial would be declared as invalid. The participants had an unlimited number of tries during the measurement.

Intervention	In this study a randomized with-in subject design was used, meaning that every subject performed SS, FR and a combination of SS and FR on a different occasion between 4pm and 5pm with at least 24h in between each intervention. The order of the interventions was randomized. Each session included a baseline measurement, followed by an intervention and then by an immediate, 10-, 15- and 20- minutes post intervention measurement. The interventions were all conducted for 3x 30s with 15s breaks in between and only on the dominant leg. SS of the plantar flexors was performed on a bench, with one foot on the edge of the bench, allowing the foot to be dorsiflexed and the knee extended. The heel was directed towards the floor. For FR a grid foam roller, consisting of a uniform cylinder with a hard-inner core, wrapped with a layer of ethylene vinyl acetate foam, was used. The researchers chose this type of foam roller as it exerts more pressure on the tissue than foam rollers made of polystyrene foam. FR of the plantar flexors was carried out in a sitting position on the floor, with an extended knee and relaxed feet. The calf was positioned on the foam roller and the other leg was placed above so that more pressure could be exerted on the plantar flexors. The subjects were instructed to utilize their arms to move their body back and forth and roll out the muscle with as much pressure as possible. For the combination intervention, first FR and then SS was performed.
Results	Passive ankle dorsiflexion ROM improved through the combination of FR and SS by 1.3 ± 0.65 cm directly after the intervention. It was followed by a continuous decrease: by 0.7 ± 0.67cm after 10min, by 0.6 ± 0.66cm after 15min and 20min afterwards by 0.4 ± 0.65cm. This phenomenon could also be observed in the other interventions: through SS by 0.9 ± 0.6cm directly post-intervention, 0.4 ± 0.69cm 10min post-intervention, 0.3 ± 0.69cm 15min post-intervention and 0.2 ± 0.68cm 20min post-intervention, and through FR by 0.4 ± 0.67cm immediately after the intervention, 0.2 ± 0.67cm after 10min, 0.3 ± 0.66cm after 15min and 0.4 ± 0.65cm after 20min. Post-hoc testing revealed that FR+SS is more effective than SS alone, with an improvement of 9.1% for FR+SS and only 6.2% for SS alone. The effect of all three interventions did not last more than 10 Minutes.
Limitations	The authors list several limitations. First, an unlimited number of ROM measurements was allowed. This may have led to a mobilizing effect which might have indirectly also increased the ROM of the ankle. Secondly, SS was performed with an extended knee, resulting in a greater impact on the biarticular gastrocnemius muscle than on the monoarticular

	soleus muscle. For the measurement however, the weight-bearing lunge test was utilized, in which participants have a flexed knee. Hence, in this position, it is possible that the ROM was restricted by the less addressed soleus and not by the treated gastrocnemius. Thirdly, even though the subjects had an experience of 6 months with FR, they were not specifically familiar with the utilized grid foam roller. Further, no warmup was performed prior to the first baseline measurement. Additionally, the outcomes could have been influenced by the subjects knowing their results and by the experimenters being aware of the beforehand applied treatment modality. Also, the activities of the subjects before and during the period of the study were not controlled. As the measurements were conducted on different days, the possible presence of DOMS from training might have impacted the ROM. The authors also state that the sample size was not based on a power analysis.

9 THE EFFECTS OF FASCIA TECHNIQUES ON THE LOWER EXTREMITY CONCERNING INJURY PREVENTION

The purpose of this review was to research the current evidence and summarise the effects fascia techniques have on the lower extremity of the human musculoskeletal system concerning injury prevention for triathletes.

Literature suggests that minimizing fascial adhesions and maintaining or regaining a normal ROM results in a reduced risk of injury (Schroeder & Best 2015, 200; Markovic 2015, 690). Both included studies suggest that the application of specific fascia techniques leads to an acute increase of ROM in the lower extremity. Markovic (2015, 691) explored the effects of FR and an IASTM technique named FAT on the hip and knee ROM in soccer players. He concludes that both techniques result in an acute increase of knee and hip ROM. Škarabot, Beardsley and Štirn (2015, 211) investigated SS, FR and the combination of both (FR+SS) on passive ankle dorsiflexion in adolescent swimmers. The latter study’s results display an increase in ROM through all three interventions.

10 DISCUSSION

The following chapter critically discusses the results of the studies and establishes a link to the theoretical background. While elaborating further on the answer to the research question, it is explored whether the results of the studies may be of use for injury prevention amongst triathletes. The chapter shows limitations of the systematized literature review and provides recommendations for further research.

10.1 How are the Results of the Systematized Literature Review relevant to Injury Prevention in Triathlon?

The results of the two studies included in the systematized literature review only demonstrated short-term results, however in both studies the effect of one of the techniques lasted longer than that of the other technique: Škarabot, Beardsley and Štirn (2015, 207-211) post-hoc testing showed that the impact on ROM through FR, SS and the combination of the two did not last longer than 10 minutes and that FR combined with SS is superior when compared to FR alone. According to Markovic (2015, 693) the FAT technique's effect was twice as high than in the FR group immediately after the intervention, and it was still present 24h later, even though slightly decreased. These findings suggest that in triathlon practice, if the techniques were applied identically as in the studies, to increase hip and knee ROM the FAT technique might be preferable, while for the improvement of passive ankle dorsiflexion ROM might be the better choice.

In the following, a link is established between the results of the two studies and specific injuries that are common amongst triathletes. These injuries were elaborated on previously in the theoretical background in chapter 3.2.

Research indicates that a reduced ankle flexibility may increase the risk of experiencing stress fractures in runners (Hreljac, Marschall & Hume 1999, 1635). Thus, increasing the ROM in the ankle joint by implementing the suggested combination of FR and SS may decrease the chances of suffering from such injury.

Škarabot, Beardsley and Štirn’s (2015, 207) results could be used in the prevention of the ITBS. Amongst other factors, this syndrome develops through an increased ankle pronation, which in turn may be due to tight gastrocnemius and soleus muscles. (Spiker, Dixit & Cosgarea 2012, 209) As the latter function as plantar flexors, and their tightness limits the ankle joint flexibility, using FR with SS may result in an increased passive ankle dorsiflexion ROM. In addition, one can hypothesize that their tightness could decrease as well.

Further, limited ankle ROM is a risk factor for sustaining plantar fasciitis. Hence, increasing passive ankle dorsiflexion ROM through the same interventions may be beneficial in preventing this overuse injury as well. (Spiker, Dixit & Cosgarea 2012, 212.)

The patellofemoral pain syndrome, which results in anterior knee pain, can be traced back to a lack of flexibility in the hamstrings, quadriceps and gastrocnemius muscles as well as in the iliotibial band. One could assume that the FAT and FR technique used in Markovic’s (2015, 691) study, may have a positive short-term influence on the flexibility of the quadriceps and hamstring muscles, while FR, SS or their combination, as suggested by Škarabot, Beardsley and Štirn (2015, 207), may increase the flexibility of the gastrocnemius muscle.

In summary, the above made connections indicate the benefits of improving simultaneously the ROM in the hip, knee and ankle, in order to reduce the risk of injuries amongst triathletes. Hence, fascia techniques should be applied to the hamstrings, quadriceps and the plantar flexors regularly. This should, as described above, preferably be done with FAT for the hip and knee ROM and FR technique for the passive ankle dorsiflexion ROM.

The next subchapters discuss, the implementation of techniques applied in the included studies, concerning the duration of application, the instruments utilized and the time period between intervention and measurement. Further, possible variations in the stretching techniques are considered, as well as the comparability between the sports exercised by the athletes in the studies and triathlon. Following every chapter recommendation for further research are provided. At the end of the review, limitations of the systematized literature review are discussed, and further recommendations are given.

10.2 Duration of the Fascia Techniques' Application

SS is performed for 30 seconds and repeated 3 times in the study by Škarabot, Beardsley and Štirn (2015, 205-207). Schleip and Müller (2013, 104) suggest that only few repetitions are necessary to promote the collagen synthesis. Collagen plays a vital role in resisting tension and stress; it differs in its architecture depending on the local strain and force distribution (Kwong & Findley 2014, 876). Hence, triggering the collagen synthesis and its adaptability to strain are desired outcomes of fascia techniques. One could assume that in the study of Škarabot, Beardsley and Štirn (2015, 203-211), the impact on fascia could have been increased through a different amount of repetitions, presumably less, as one must note that Schleip and Müller (2013, 108) do not define few repetitions further.

In Markovic's (2015, 692) study, FR is conducted 2 times for 1 minute each set. In Škarabot, Beardsley and Štirn (2015, 206) study participants perform FR 3 times for 30 seconds. Then again, according to Ajimsha (2011, 432) MFR-techniques should consist of 120 to 300 second sets. SMR mimics the effects of MFR. As FR classifies as an SMR technique, the recommendation may also apply here. (Chaudhry, Schleip, Zhiming, Bukiet, Maney & Findley 2008, 389.)

The variation concerning the length and repetition of FR application among the above-mentioned sources illustrates the controversy of the topic: a universal recommendation concerning these aspects of SMR cannot be given based on the current state of available research. Hence, this may be an objective of further research.

10.3 Time Frame between Intervention and Measurements

Both studies aimed to find out the duration of the acute improvements in flexibility after fascia techniques. Markovic (2015, 691-692) conducted the passive knee-flexion- and passive straight-leg-raise-tests immediately and 24 hours after the FR or FAT intervention. Škarabot, Beardsley and Štirn (2015, 205-207) on the other hand, measured passive ankle dorsiflexion ROM immediately, 10-, 15-, and 20- minutes after FR, SS and FR combined with SS. They both revealed that the effects of MFR, or respectively SMR, on ROM decreased over time: in Škarabot, Beardsley and Štirn (2015, 207) study already after a maximum of 20 minutes and in Markovic (2015, 693) after 24 hours. Previous research, however, suggests that fascia, compared to other parts of the body, such as muscles, adapts rather slowly. This means that a stronger, elastic fascia-network evolves only after years of regular, weekly training. Schleip and Müller (2013, 113) suggest that lasting effects can only be expected after 6 months to 2 years of consistent practice. Hence a long-term study could explore the effects of fascia techniques on ROM over a longer period of time.

10.4 The Instruments and their Application

In Markovic's (2015, 692) and Škarabot, Beardsley and Štirns' (2015, 206) study, the same commercially available grid foam roller was utilized. It consists of a hard-inner core, wrapped in EVA foam. They reason their choice with the high pressure this type of foam roller exerts on the tissue. However, according to Schleip and Müller (2013, 112) the foam roller and accordingly its firmness should be picked out individually in order to maximise the effectiveness.

In Markovic's (2015, 692) study the participants performed short, "kneading like motions" in one direction and used only one quick motion in the other. Škarabot, Beardsley and Štirn (2015, 205-207) only mention that participants were instructed to exert as much pressure as possible and perform "fluid motions". Schleip and Müller (2013, 112) suggest that FR should be conducted with slow and unidirectional movements. This leads to the assumption that different – perhaps better – results in the improvement of ROM could have been achieved according to the selected type of foam roller and the specific application technique. So far, literature does not provide a general recommendation regarding this matter. Future research could compare different FR application techniques and their effects on different areas of the lower body.

Participants in the study by Markovic (2015, 692) were not accustomed to FR, while those in the study by Škarabot, Beardsley and Štirn (2015, 205) had a minimum of half a year experience with FR. The FAT intervention was conducted by a certified physical therapist and an IASTM practitioner, who was specially trained in FAT: hence, also they had presumably a high level of experience with the FAT technique. As the FAT technique achieved noticeably higher results in the acute increase of the hip and knee ROM, one might consider if the expertise of the practitioners had a positive impact. Further research should investigate if the level of experience in FR and SS has an impact on the techniques' effects.

10.5 Stretching Styles

While Škarabot, Beardsley and Štirn (2015, 203-211) examine the effects of FR, SS and the combination of the two: FR + SS, Schleip and Müller (2013, 108) emphasise the benefits for fascia when a variation of stretching styles are incorporated in the training routine. Such combination prevents limited ROM and increases the sliding ability of the fascial layers. Also, the ability of fascia to withstand friction, stress and stretch is enhanced (Kumka & Bonar 2012, 188). All of these effects that can be achieved with the application of fascial techniques are desired in injury prevention for triathletes. Therefore, further studies could investigate the combination of FR with a variety of stretching styles, such as dynamic muscular loading techniques, as these comprehensively stimulate fascial tissue. (Schleip & Müller 2013, 108.)

10.6 Participants

At the beginning of the thesis process, an inclusion criterion was that the participants in the studies would solely be triathletes. However, as described in chapter 7.1, due to the currently limited availability of research in this field, the perspective of the systematized literature review was broadened to encompass athletes of sports which incorporate a component of triathlon. Two studies matched those criteria, as either swimming or running are incorporated. Škarabot, Beardsley and Štirn (2015, 205) study includes adolescent swimmers, who were classified as intermediate resistance trained athletes and had six months of experience with FR experience. Markovic (2015, 691) conducted his study with soccer players, whose sport also includes running. Nevertheless, during a soccer match, players vary their running speed from walking to sprinting, incorporate abrupt direction changes frequently, and interact with one another, whereas triathletes mostly run at a constant speed and direction (Bradley, Sheldon, Wooster, Olsen, Boanas & Krustrup 2009, 162; McHardy, Pollard & Fernandez 2006, 136; Website of Totaltriathlon 2015).

The sample size of the included studies was relatively small, and the mean age of the participants rather low. Markovic (2015, 691) conducted his study with 20 soccer-players. Even though the participants classified as adults, they were still rather young with 19 ± 2 years. Škarabot, Beardsley and Štirn's (2015, 205) study included 11 adolescent athletes aged 15.3 ± 1 year. It should additionally be noted that none of the authors made use of a sample size calculation. These factors weaken the studies' validity. Still, both studies strengthen their validity by randomly allocating the participants to the intervention groups (Markovic 2015, 691; Škarabot, Beardsley & Štirn 2015, 205).

Škarabot, Beardsley and Štirn's (2015, 205) study presents an equal gender distribution with 5 males and 6 females, who could all be considered as rather professional athletes. Markovic (2015, 691) however, neither included female players, nor professional soccer athletes, therefore making the results possibly less valid as it would have been if professional football players and women would have been included.

The above-mentioned factors partly limit the generalizability of the systematized literature review to triathletes. Hence, a suggestion for further research is to examine fascia techniques solely amongst triathletes of both genders. Using a blinding procedure will increase the reliability.

10.7 Additional Limitations of the Literature Review

When making conclusions from this systematized literature review it should additionally be noted that it is based on solely two studies. This may be due to the precise in- and exclusion criteria. Still, it illustrates the lack of research in the field of fascia techniques on athletes. Both studies achieved a moderate to low scoring in the methodological quality assessment tool PEDro, failing thus to provide valid and reliable evidence. Škarabot, Beardsley and Štirn’s study (2015, 203-212) achieved a PEDro score of 7/10, whilst Markovic’s (2015, 690-695) achieved a 4/10 score. The plot with error bar, shows the validity and reliability of Markovic´s (2015, 694) study, as it clearly emphasises which of the results were statistically significant ($P > 0.5$). Also, Škarabot, Beardsley and Štirn’s study (2015, 207) mentions which results were statistically significant ($P > 0.5$) and interprets them accordingly. Taking everything into consideration, the results of the systematized literature review should be interpreted cautiously when transferring these findings into practical implementation.

This thesis includes two systematic literature searches, however, it is referred to as a systematized literature review and not a systematic literature review itself, as the depth of research is not as thorough as it would have needed to be in order to classify as a systematic review.

10.8 Further Research Suggestions

Suggestions for further research were described above, recommending that further research should investigate more extensively the effects of the combination of several treatment variables and the optimal duration of their application in triathletes. In addition, it might be of interest if the location of FR or FAT application within the muscle may influence the ROM outcome. It is possible that performing the latter specifically on tension points within the muscle results in an even higher increase of ROM compared to applying the techniques universally on a muscle.

Further, research could also examine if SS and the combination of the FR and SS, as applied in Škarabot, Beardsley and Štirn's (2015, 205-207) study, not only increases passive, but also active ankle dorsiflexion ROM and, considering the globality of the fascial network, reduce tightness in adjacent joints as well.

In the theoretical background chapter 4 and 6, it is mentioned that fascia is very important for proprioception and neuromuscular control. Additionally, researching on the latter topics would have exceeded the scope of this bachelor thesis. Hence this matter could be the objective of further research.

11 CONCLUSION

In conclusion, the results of the systematized literature review suggest that FR, SS and the combination of the two, applied to the plantar flexors increase the passive dorsiflexion ROM, while FR and FAT increase the ROM of the hip and knee joints. Notably FAT and FR combined with SS, had higher effects. Increasing the ROM may have a positive impact on decreasing the risk of common triathlon injuries. (Markovic 2015, 691; Škarabot, Beardsley & Štirn 2015, 205.)

The above-mentioned limitations and suggestions for further research already point out that the answer to the research question could only be answered restrictively. Hence, when applying and transferring the results of this systematized literature review to practice, this should be done cautiously, in awareness of the limitations.

12 WORKSHOP

The workshop creation and implementation form the practical part of the thesis. Its aim is to provide a tool for other health professionals, coaches and athletes, wanting to inform themselves or further pass on the information about fascia, fascia techniques and their relation to the prevention of lower-limb injuries in triathlon.

12.1 Information Synthesis

The information used in the workshop is based on the previous chapters of the thesis; the systematized literature review, the theoretical background as well as the related literature and findings. The content is chosen with the intention to reach the following learning outcomes:

1. The participants understand the basic concepts of fascia, including its function and properties.
2. Their awareness of risk factors of common injuries is raised, with the focus on the fascial network.
3. They are able to apply fascial techniques that can aid the prevention of injuries.

12.2 Teaching & Learning

Implementing the workshop requires the implementor to take over the role of a teacher. It is aimed to create a sense of partnership, rather than a hierarchic relation between the participants and the implementor. This will “stimulate discussion” and establish a casual learning atmosphere. (Mercerer-Mapstone & Marie 2019, 8.) The aim is to create an active learning environment, where the participants are motivated to “engage in the process” by, for example, asking questions and actively experiencing the gained knowledge (Hudson, Buckles & McMillen 2001, 194).

Further, essential skill sets of the implementor are those of communication and interpersonal competences. The content needs to be brought across in an understandable and relatable way. Active listening is used to hear questions and comments of the participants, which then are answered to the presenter's best knowledge. (Moynihan, Paakkari, Välimaa, Jourdan & Mannix-McNamara 2015, 11.) Moreover, the implementor should be aware that both, verbal and non-verbal communication have great impact on the atmosphere, on how the participants receive the content and feel engaged. For example, making eye-contact, showing confidence and authentic enthusiasm through the body language and speech are considered as important. (Takase, Niitani, Imai & Okada 2019, 415; Bengtsson & Ohlsson 2010, 153.)

The implementor should face the topic as well as the workshop content and later the group with devotedness and passion, eager to share the knowledge and skills with others. In this way, the learning will be more effective, the participants will feel motivated and their curiosity will be raised. (Moynihan, Paakkari, Välimaa, Jourdan & Mannix-McNamara 2015, 11.)

Increasing the curiosity and motivation of the participants is a main goal of the workshop, as these are considered under the most important factors for learning (Bengtsson & Ohlsson 2010, 154). Heick (2019) even hypothesizes that the absence of curiosity results in "teaching and learning [to] fail completely". He suggests a four-stage model of curiosity which gives an understanding of the phases a learner, hence, the workshop participants, go through (Heick 2019). It can be expected that the participants already have some previous knowledge or ideas about the concepts dealt with in the workshop; fascia, injury prevention and triathlon, but chances are, not in that combination. Throughout the workshop the implementor guides the group through those four stages as displayed in figure 2 and aims towards satisfying the demands of each stage. However, it should be kept in mind, that such models are generalizations, and that individual factors of every learner, facilitator as well as external factors have influence on the process (Takase, Niitani, Imai & Okada 2019, 415).

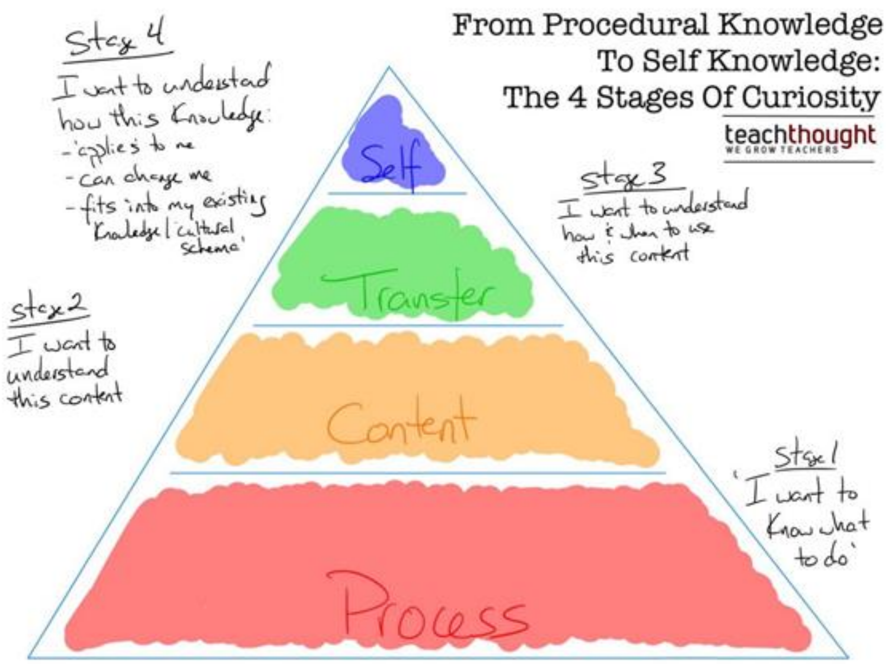

Figure 2. The Pyramid of Curiosity. (Heick 2019)

The workshop is created to make attainable further knowledge and further deepening the existing basis about the concepts dealt with. The participants are guided through the first, and into the second stage of the pyramid. The aim is to facilitate the “interaction between the learner and content to be […] authentic and direct”, which is established by using relatable and easy-to-understand examples (Heick 2019).

Also, the “active involvement” of the participants is a major tool used in the workshop implementation, which will stimulate the above-mentioned points and the further learning process (Takase, Niitani, Imai & Okada 2019, 415). This will be enabled through offering and encouraging the participants to ask questions at any time of the workshop, as well as asking questions to the audience or their participation in explanatory examples.

Transitioning from content-stage into the third stage, “transfer”, the focus lies upon connecting the learned theoretical concepts with the practical application. This requires guidance, yet the freedom to experience and experiment on themselves and with each other. (Heick 2019.) For instance, during the workshop the participants are guided through example-exercises in the first repetitions and then given freedom to experiment freely.

Moreover, the group is asked to form pairs mirroring the other. In this activity they are moving “together collaboratively rather than individually”, which is suggested to increase levels of motivation and “perceptions of successful cooperation” (Davis, Taylor & Cohen 2015, 9).

The last stage is essential, which is where the newly obtained knowledge and skills are integrated into the individual’s lifestyle and situation. The participants should understand the significance of the content and how it can be “useful in the future” for them. (Bengtsson & Ohlsson 2010, 153.) It is an objective of the workshop to encourage every individual towards feeling motivated and confident to apply the gained knowledge and skills into their everyday training and/or professional scope. Possibly, a “sense of changes and possible opportunities” are identified by each participant. (Heick 2019.) A motivated athlete feels empowered and is likely to direct his or her efforts towards implementing measures of injury prevention into their training routines. Equally, a health professional will consider the new information about the fascial network in his or her future practice. (Moynihan, Paakkari, Välimaa, Jourdan & Mannix-McNamara 2015, 11; Takase, Niitani, Imai & Okada 2019, 415.)

Not only the sources used, but the invitation to contact the implementor for further support or collaboration requests is offered to the participants. Their learning process will continue after the workshop and questions may arise, or understanding be achieved when facing the actual training situation or even when discussing with other participants afterwards (Bengtsson & Ohlsson 2010, 154).

It is equally important to increase motivational factors as it is to avoid demotivational ones. Especially in relation to factors of injury prevention: for example, to beware triggering a bad conscience amongst the athletes about factors they might have not been considering previously. Another form of frustration might arise, should a participant feel unable to follow the content. Therefore, as already mentioned, questions are welcomed throughout the implementation. The participants should feel involved, viewing the topics as relevant, relatable and useful. (Takase, Niitani, Imai & Okada 2019, 415.)

The workshop is created with a participant-centred perspective. Hence, to engage the participants and facilitate the building of connections to the content, elements that allude to an athlete’s “competitive edge”, which “coaches and athletes continually seek”, are included (Etxebarria, Mujika & Pyne 2019, 8). Further, interactive activities are realized, based on the “emerging new concepts in endurance training and triathlon to minimise fatigue, illness, and injury” that suggest, inter alia, to increase “team responsibility” (Etxebarria, Mujika & Pyne 2019, 8).

12.3 Practical Arrangements

To arrange the workshop a close communication with the participant group is desired; it is agreed on the time, place and duration of the workshop. A well-done organisation allows for a smooth implementation.

The contact to the TV Oerlikon triathlon team’s coach was taken over by Marie. She guided the workshop with the group of triathletes which was planned to take place during the team’s training session on the 3rd of March at 6:45 pm, for 1 hour and 15 minutes. Lea implemented the workshop the following day, 4th of March, in the Satakunta University of Applied Sciences, for professionally and/or personally interested physiotherapy students at 1:30pm. In the latter case, an email was sent to all the physiotherapy student groups of the university, inviting them to the workshop.

Moreover, careful preparation of the implementation ought to be realized. Enough printed versions of the feedback questionnaire, which is attached in appendix 2, and pens, as well as additional foam rollers and exercise mats should be at hand, plus other tools the presenter considers using in their workshop implementation. The participants are encouraged to bring their tools for fascia techniques to the workshop and come in comfortable clothing. To ensure the uncomplicated realization of the workshop, the available technological equipment and tools for the implementation should be checked in advance.

12.4 Realization of the Workshop

Any implementor is urged to get acquainted with the whole thesis content, when planning to implement the workshop. This ensures a clear understanding of the topics and concepts. Moreover, questions of the participants can then be solved more easily. To guide the workshop, a PowerPoint presentation was created. In this way, the implementors can use visual support for their explanations and demonstrations.

When starting the workshop, at first, the implementor will present himself and give an overview what the participants can expect from the next 1-2 hours. The participants are offered to raise their hand to ask questions at any time during the workshop, to ensure their understanding of the content. Additionally, their active participation in the workshop is encouraged. The workshop is then implemented.

12.5 Reflection, Self-Evaluation and Feedback

Before the implementation, the design of the workshop slides was piloted with another 3^{rd} year physiotherapy student on the 18^{th} of February. The aim was to check the clarity and structure; not only concerning the design and colour-composition of the slides, but also the order of the topics dealt with, to ensure a clear build-up of the content. The suggestions were considered, leading to a possibly better overview for the participants and making it easier to focus, follow and eventually reach enhanced global understanding.

After the realization of the workshop, both implementors reflected on their performance and perception of how the process went before, during and after the workshop, including factors of timing, available equipment and space. Positive points are considered, as well as aspects that could be improved for a next time. The impression of the group concerning their curiosity and interest is reflected on, as well as the perceived vibes and atmosphere.

12.5.1 Reflection of Marie’s Workshop Implementation with Triathletes

“I arrived 15 minutes before the workshop began, to prepare and build up everything. This included the beamer, questionnaire, pencils, my presentation cards and a sponge, that would be used to demonstrate the viscoelasticity of fascia. The triathletes were very kind and helped me in installing the beamer. For the SS of the plantar flexors a stepper would have been necessary. As I did not realize that the gym had steppers, all participants performed the exercise on a regular step, which was present in the gym. In hindsight I should have informed myself in advance about the exact available equipment in the gym.

Presenting in front of a triathlon team was a new and unique experience for me. In advance, I asked the trainer if the participants could bring a foam roller with them, in case they had one at home. I was happy to see that every single one of them brought a foam roller or even several ones with them, showing that they were already familiar with the concept of fascia techniques. In general, I had the impression that the participants were very motivated and interested. In contrast to many patients, I have encountered in my internships, the triathletes were more than eager to perform new exercises and get to know new concepts. They paid good attention throughout the workshop, participating in every exercise and asking questions, concerning the exact implementation of the technique, during the practical part and after the workshop. One of the questions was if one should roll out one or both legs at the same time, or if there are contraindications for FR on the iliotibial tract. I recommended the athletes not to roll out the iliotibial track, as I had read several times about the negative effect it has on running and I explained that according to the exercises from the systematized literature review, one should apply FR only to one leg at the time. Even though the thesis and hence the workshop only focused on the lower extremity, the trainer additionally asked for exercises for the upper extremity of the body. He asked for a PDF document summarizing the exercises and our contact details, which I emailed him a few a days later. One participant also came towards me after the workshop and asked about exercises for his specific back injury.

The workshop started at 6:50 pm and the presentation went till 8:10 pm. After that, the completion of the questionnaire and a few questions followed, so that at around 8:25 the triathlon team could start their official running training. As the goal was originally to end the workshop around 8 pm, I skipped the fascial spring and elastic recoil effect explanations and exercises, as well as the explanation of the hysteresis concept.

Around 7:45 pm a basketball team that apparently had reserved the gym, arrived. They kindly waited a few minutes but then started their exercises in the background, which resulted in an increased noise level. I had to raise my voice slightly, but I did not have the impression that this interfered with the listening ability of the triathletes."

12.5.2 Reflection of Lea's Workshop Implementation with Physiotherapy Students

"Shortly before the workshop would start, I prepared the PowerPoint presentation with the projector and checked the sound functioning, as I planned to integrate music with some of the activities. I collected the equipment I would need, including jump ropes, a TheraBand, foam rollers, two benches and the feedback questionnaire. The location was changed shortly before commencing the workshop, to the next and slightly bigger room in the university. Thanks to the help of fellow students, this was not a problem and we could still start on time.

My impression was that from the beginning on, the group was very interested in the workshop. Fascia is not dealt with extensively in our curriculum, and many of the students are sport-interested – not only as becoming physiotherapists but even more so in relation to their free-time sportive activities. Throughout the workshop they asked questions and were very interactive, eager for the practical parts and curious about the theoretical concepts.

There was a casual but professional atmosphere in the workshop. I was sharing my gained knowledge and skills with the group on an even level. We had a lot of interaction, not only the planned examples for interactive explanations but also through comments, questions, or anecdotes. To create such environment was one of my personal goals for the workshop implementation, as in my opinion, it makes learning more fun and easier. Without difficulty, I could answer to the questions that came up. Further, the practical parts were enjoyed a lot by all participants, and I felt like everyone could follow the demonstrations and explanations well.

When explaining the theoretical concepts, I was able to use relatable examples and visual aids through my body language, gestures and use of tools. However, I am aware of my personal nervousness and shyness, that showed especially during the start of the workshop. I was standing behind the teachers' desk, which was then hiding me partly. In future presentations I want to avoid this and be more confident from the beginning on.

Impressions of the implementation can be seen in picture 1. Even though we changed to a bigger room, the physiotherapy plinths, that we could not remove easily, occupied a lot of space. This made the practical parts a little bit more difficult to implement. In future implementations I hope to have a more spacious location.

Picture 1. Collage with pictures of the workshop implementation with the physiotherapy student group at SAMK.

I was content that the timing went as planned, as a lot of students mentioned, they have other meetings or lectures to get to. Unfortunately, this also meant that there was no time for a discussion after the workshop.

All in all, I am very happy with the realization of the workshop and think I was successful with accomplishing the previously set objectives. It was a very valuable experience, for me personally and professionally."

12.5.3 Evaluation using the Feedback Questionnaire

The feedback questionnaire was filled out by the participants after the implementation and can be viewed in appendix 2. The participants are asked to indicate whether they agree or disagree with the nine given statements. In table 11 and 12 the feedback given through the questionnaire is summarized separately for the 25 triathletes in Marie's implementation, and the 25 physiotherapy students in Lea's implementation. In the tables, some questions are marked with an asterisk. In those cases, a participant did not mark any response to the statement. A correlated percentage was calculated, demonstrating to what extend the group agrees to that statement. Beneath each table, the responses that were given in the open comment section of the questionnaire, are summarized. The original comments can be found in the appendix 3.

Table 11. Summary of the filled feedback questionnaires from the workshop that was implemented with the group of triathletes by Marie.

	5	**4**	**3**	**2**	**1**	**%**
Q1	10	15	0	0	0	88
Q2	4	12	4	4	1	68
Q3	17	7	1	0	0	92,8
Q4	9	11	3	2	0	81,6
Q5	12	8	5	0	0	85,6
Q6	21	1	3	0	0	98,4
Q7	17	8	0	0	0	93,6
Q8	12	9	4	0	0	86,4
Q9*	12	10	2	0	0	88,3

Concerning the open comment, eight of the 25 athletes wrote an answer. The participants applaud the presentation style and how the topic was dealt with. One person mentioned that it was even almost too much of an "motivational talk". The practical examples are viewed as useful, as is the topic itself, – one triathlete notes that he has used fascia techniques for 7 years now and has been injury-free since. Others comment that they had wished for a more extensive focus on the practical part and the reasoning about the specific performance of the techniques, as well as further discussion about more body parts.

Table 12. Summary of the filled feedback questionnaire from the workshop that was implemented with the group of physiotherapy students by Lea.

	5	4	3	2	1	%
Q1	20	3	2	0	0	94,4
Q2	4	9	5	5	2	66,4
Q3	14	9	2	0	0	89,6
Q4	9	8	6	2	0	79,2
Q5	15	5	4	1	0	87,2
Q6	20	4	1	0	0	95,2
Q7*	20	2	2	0	0	95
Q8	12	11	2	0	0	88
Q9*	19	4	1	0	0	95

Fifteen of the 25 physiotherapy students added a comment in the last question. As positive they noted the presentation style, that a calm voice and good spirit supported the understanding, even if there was no background knowledge. The examples that were used to explain the topics were considered as helpful and relatable, as well as the practical and interactive activities as being fun and useful for the understanding and learning. As suggestions for future improvements, students expressed the wish for a deeper focus on the anatomy and function of fascia and the collagen structure. One participant mentions that some content, as SS, felt unnecessary to deal with as being a physiotherapy student. Another one found it uneasy to follow the demonstrations.

12.5.4 Interpretation of the Results

When interpreting the results of the feedback questionnaire, especially when comparing the two groups the workshop was implemented with, there are some factors that must be kept in mind. The two implementations used the same workshop slides as a tool, which are the basis of the realization. However, not all slides were covered in the workshop with the triathletes. This makes the comparison and analysis more difficult. The workshop basis is not the same anymore for the two groups: this concerns all the topics that were covered, the comprehensive understanding and view on the concepts that was transmitted, as well as the ability to globally address the facial system through what is dealt with in the practical part.

Additionally, the ways of explaining, making inter-connections between the topics and bringing across the matter, are individual to the implementor and the teaching situation. This covers personal factors of the implementor and teaching skills.

Equally, the group's dynamic and motivation, individual factors of the participants as for example preferred learning methods influence the learning situation. Surely, a certain diversity in both groups was apparent, concerning the previous background knowledge and experience, effecting on how the content was perceived as new to them.

In the following, each paragraph will be dedicated to analysing a statement of the questionnaire, taking into account the percentage of agreement resulting from the questionnaire, the comments given, and the self-evaluation report of the implementors.

In general, the information of the workshop was considered helpful by the participants. The triathletes agreed with 88% to the statement, while the physiotherapy students agreed to 94,4%. This is a great feedback, as it supports the objective of creating a tool, that would be useful for both groups; health professionals and athletes wanting to know more about the topics of fascia, fascia techniques and injury prevention in triathlon.

From the results we see that in both groups, there were different perceptions on the depth and extensiveness of the content. The triathlete group agreed to 68% that they would have wished for more detailed information. It should be kept in mind, that in their workshop, not all information that was planned to be dealt with was also discussed. Still, many thought that it was enough information. This diversity is also present in the student-group. They agreed with 66,4% to the statement. In each group the participants had different background knowledge and probably also came to the workshop with different expectations and hopes. Hence, for some, the information was more than enough, giving them a general idea about the concepts. For others, the discussion could have gone even deeper. This is reflected also in the open comments. Some of the students would have liked to go deeper in terms of anatomy and physiology. One mentions that stretching felt unnecessary to deal with as they are clear to a physiotherapy student – but also in relation to the fascia network? The triathletes on the other hand asked for more information in terms of the practical part and exercises to address other regions of the body. Others state that the amount of information was perfectly dosed for them.

Answers to the third statement – on how understandable the explanations were – are not only a general feedback for the workshop content, the slide-creation and -design, but also a personal feedback to the presenters. In both groups, the participants agreed rather strongly to the statement. The triathletes with 92,8% and the students with 89,6%. In the comments, the tools used to support the explanations are mentioned often: the orange analogy, the TheraBand and practical interactions. Marie also mentions the use of a sponge.

In both groups, a similar perception of broadening their understanding about injury prevention was achieved. Triathletes agree with 81,6% and the students with 79,2%. Overall, the participants probably already had some background information from their personal studies, experience or what they have read and heard. Still, it seems there was new information for everyone in the workshop content, they got to see the topic from another view and draw their attention to injury prevention.

In comparison to the previous statement, participants in both groups agreed more to have widened their perspective on the fascial network: Triathletes to 85,6% and students to 87,2%. The fascial network is still being researched and there is not circulating much general knowledge about the topic. The perspective on and understanding of the tissue is evolving continuously. Nevertheless, through the workshop we seemingly were successful in broadening both groups' comprehension of the topic, based on the current status of research.

Whether the demonstrations were clear and easy to follow, is very valuable feedback for the overall success of the workshop, as well as for the implementors' individual development. Both groups agreed strongly with the statement: triathletes with 98,4% and students with 95,2%. Hence, using the combination of visual support, through the workshop slides that contained pictures and short descriptions, plus verbal explanations and on-spot demonstrations worked out well. A clear understanding of the demonstration will limit future mal-execution of the exercises and consecutive adverse effects through compensatory motions or inappropriate loading-lines, angels or levers. This individuality reflects also in the open comments: The majority states that they liked the exercises, however, one student found it uneasy to follow. As it was not specified why, it can only be speculated: was it the language, as hardly anyone of the participants, neither the implementors, are native-English speakers or the room arrangement that might have limited clear vision of the demonstrations? Nevertheless, these positive responses to the statement predominate and compliment the implementors' demonstration skills and indicate the success of the workshop.

To make sure that the participants understand the topics, concepts and exercises, questions are required to be dealt with properly by the workshop leader. Whether those arise, and if they are openly asked, depends on the individual participant but strongly on the established atmosphere. It is an important goal of the implementor to create an environment where any question may be asked. However, this is also highly dependent on how informed the implementor is about the topic and around it. Triathletes agreed to the statement with 93,6%, and students with 95%, demonstrating that in both implementations, questions were dealt with well. Marie seems to have achieved this in an exemplary manner, as she describes in her self-reflection.

All participants mostly agree that they can imagine using the workshop's content in the future: may it be exercise-tools that are incorporated in the regular training sessions, or theoretical knowledge about the comprehensive topic of the fascial network. Triathletes agree to 86,4%, and students with 88% to this. In the comments and the aftermath of the workshop implementation we see that we were successful in addressing the interest about the topic in both groups: the team's coach asked to share the workshop content on their club's website, and physiotherapy students asked about it for their personal reading and learning, as the topic is not dealt with extensively in SAMK's physiotherapy curriculum.

The last statement reflects the overall satisfaction with the workshop and implementation as a whole. We see from the answers that both groups agreed that they think it would be a valuable experience also for others – triathletes with 88,3%, the students with 95%. In the open comments, a lot of positive feedback is given, many express their thanks and enjoyment of the workshop.

12.6 Conclusion of the workshop

The workshop was created by Lea, based on the collaboratively developed theoretical background and systematized literature review, as well as the related literature. It was held by both thesis authors. Hence, the success of the workshop being used as a tool by someone else than the creator was being piloted. Concluding from the results of the reflection and feedback, this was successful to most extent. It may be considered, if Marie skipping some slides was due to not only a timing-issue, but consequential to the fact that the content build-up was not as clear to her as being a 'second-line' user, compared to Lea, the creator.

Still, the creation of a tool that could be implemented with more than one specific group of participants, was successful. The goal was that not only athletes would be able to benefit from it, but also coaches or other health professionals, hence having different background knowledge concerning fascia, injury prevention and triathlon.

The objective was to make attainable the information that derived from the previous chapters of the thesis. Reflecting on the achievement of that, while considering the desired learning outcomes, in both groups they are perceived as reached successfully. Judging from the responses to the statements, the participants could improve their knowledge about the basic concepts of the fascial network, its function and properties in the human body. Further, the attention was led to the topic of injury prevention, focusing on the connection to the fascial network. Risk factors as well as measures to be taken into consideration were effectively discussed. The practical implementation of exercises and fascia techniques offered a first experience, as well as examples for incorporating the content in a training regimen. The workshop content was valued by the participants which demonstrates its success. This can be seen through the aftermath of the workshop: Both authors were contacted by participants – the team's coach, individual athletes and students – and asked to share their knowledge further.

Referring to the implementation itself in regard to the factors mentioned in 12.2, both implementors were quite successful in obtaining the role of a facilitator. The atmosphere was rather casual and interactive learning could be realized, as reflected by the authors. Discussions were welcomed in both groups. To the most extend, the content could be brought across in an understandable and relatable format, which the outcomes of the questionnaire demonstrate. Devotedness and passion of the thesis authors about the topic was apparent to which the groups responded with engagement and motivation. Also, guiding the participants through the stages of the curiosity pyramid by Heick (2019) can be viewed as successful. In conclusion, the workshop was designed appropriately in order to be used as a teaching tool for groups of athletes and health professionals.

13 REFLECTION ON THE JOINT THESIS PROCESS

The reflection of the joint thesis project gives an overview of all parts of the thesis process: challenges that we faced, how these were dealt with as well as other factors. This was the second time the Zürich University of Applied Sciences and Satakunta University of Applied Sciences collaborated in a bachelor thesis project.

While planning and writing the thesis, both of us noticed the importance of having the big picture in mind. It was helpful to fulfil the ZHAW's thesis' disposition-task, as well as clearly formulating the aim and objectives of the thesis before further progressing. We benefited from taking a step back and rethink, to keep the line of thought throughout the thesis, even though this thread would be braided by two different people. Here, a special emphasise can be put on collaboratively constructing the theoretical background. Still, throughout the whole process we worked very closely together.

As for us both, Marie and Lea, it was the first time writing such a scientific paper, we highly value the feedback and perspectives from two educational views, received from our tutors. They offered great flexibility and support, while leaving room for freedom, independence and our own learning experiences. Even more, the input we gave each other helped tremendously: again, keeping the big picture in mind, as well as the clarity of the content for someone else than the creator. In addition, the background we had on the topic was different. In both universities' curricula fascia is not emphasised on deeply. However, through an exchange semester at the University of Sevilla, Lea had a module on that same topic, giving her another perspective and understanding of the matter. At the same time, Marie could offer a deeper insight to the sport of triathlon through her personal experiences. Thus, we could complement each other.

Looking back on the systematized literature review, which was conducted with the main responsibility of Marie, its conduction was an extensive learning experience. At the beginning certain steps were perceived as unclear, for example which university's guidelines to follow. The latter raised on the one hand frustration, as the usual helpful support from peers was now rather vaguely applicable. On the other hand, this triggered her as a keen student to successfully find solutions herself: sometimes using the chance to choose by personal preference which of the guidelines to follow. Finding studies, in the rather new field of fascia research with very specific in- and exclusion criteria, was a time-consuming and partly difficult challenge, however, in hindsight, the process enhanced Marie's knowledge immensely, not only on fascia but also on research strategies in general.

Reflecting on the workshop, two parts must be considered: its creation, which was done by Lea, and its implementations, which were realized by both thesis authors. The creation of the workshop was a process itself, as the content and its presentation developed greatly through new inspiration and perspectives. There were no certain guidelines to follow when composing it. However, that freedom to be creative had to be combined with realistic reasoning about the workshop's content: considering timing, doses of knowledge and how deep to dive into the theoretical concepts, plus the selection of engaging, motivating and viable activities for the practical and interactive parts. Originally, it was planned to implement the workshop together by Marie and Lea with solely the triathlon team in Zürich of TV Oerlikon. However, we soon realized that this was not possible due to practical issues. The idea to implement it separately, with two different groups, the triathletes and physiotherapy students, allowed for piloting the usability of the workshop as a tool, as well as its value for different target groups. For both of us it was the first time implementing such workshop, which turned out as very rewarding experiences. We had to leave our comfort zone and were able to develop our skills in explanations and demonstrations as facilitators of learning in-front of a group, as well as strengthen our self-confidence and competences to empower and motivate.

As already hinted, the collaboration also faced some challenges. Hence, throughout the whole process the ability to compromise, as well as a huge amount of flexibility, were demanded from all sides – us students, the tutors and the universities. The distance might be perceived as a challenge, but it was more the different schedules that slowed down and complicated the process. Arrangements and compromise had to be agreed on, as individual factors, such as internships and exam-schedules hindered focussing on the thesis temporarily for both of us. The communication and collaboration skills on an international level, using mostly online channels, were advanced.

All the challenges gave us the opportunity to get to know and develop ourselves, to grow personally and professionally. We learned to trust in the process and improved our ability to think outside the box, while keeping it in its shelf, as when finding solutions inside the frame of the given guidelines.

14 FORMALITIES

In the thesis, several tables and figures are used to improve the visualization of content and outcomes. This section provides an overview of those and the abbreviations made use of. Lastly, the declaration of originality with the authors' signatures is included.

14.1 List of Abbreviations

DOMS	Delayed onset muscle soreness
FAT	Fascial Abrasion technique
FR	Foam rolling
IASTM	Instrument-assisted soft-tissue mobilization
ITBS	Iliotibial Band Syndrome
PEDro	Physiotherapy Evidence Database
MFR	Myofascial release technique
ROM	Range of Motion
SMR	Self- myofascial release
SS	Static stretching

14.2 List of Tables

Table 1. C*ategories of fascia* 14
Table 2. *Results of the first database search* 23
Table 3. *Database search with MeSH Terms on PubMED* 25
Table 4. *Database search on EBSCO* 25
Table 5. *In- and exclusion criteria* 26
Table 6. *Methodological quality assessment using PEDro Scale* 27
Table 7. *Studies included in the systematized literature review* 27
Table 8. *Relevance of the selected studies to the research question* 28
Table 9. *Study by Markovic (2015, 690-696)* 28
Table 10. *Škarabot, Beardsley & Štirn (2015, 203-212)* 30
Table 11. *Summary of the filled feedback questionnaires from the workshop that was implemented with the group of triathletes by Marie* 50
Table 12. *Summary of the filled feedback questionnaire from the workshop that was implemented with the group of physiotherapy students by Lea* 51

14.3 List of Figures

Figure 1. *Flow chart of study selection* 26
Figure 2. *The Pyramid of Curiosity. (Heick 2019)* 43

14.4 Declaration of Originality

We hereby declare that we have written the present work independently, without the help of third parties and citated the sources used.

Thea Marie Lohmann, April 2020 &

Lea Heinrich, April 2020

REFERENCES

Adstrum, S., Hedley, G., Schleip, R., Stecco, C. & Yucesoy, C. 2017. Defining the fascial system. Journal of Bodywork & Movement Therapies 21, 173-177. Referred 24.04.2019. http://dx.doi.org/10.1016/j.jbmt.2016.11.003

Ajimsha, M.S. 2011. Effectiveness of direct vs indirect technique myofascial release in the management of tension-type headache. Journal of Bodywork and Movement Therapies 4, 431-435. Referred 22.12.2019. https://doi.org/10.1016/j.jbmt.2011.01.021

Bengtsson, M. & Ohlsson, B. 2010. The nursing and medical students motivation to attain knowledge. Nursing Education Today 30, 150-156. Referred 21.02.2020. https://doi.org/10.1016/j.nedt.2009.07.005

bioconectiva · Anatomía Viva. 2018. La fascia - Un mundo misterioso bajo la piel | DW Documental. Referred 17.04.2020. https://www.youtube.com/watch?v=euDVh--UYyU

Bradley, P.S., Sheldon, W., Wooster, B., Olsen, P., Boanas, P. & Krustrup, P. 2009. High-intensity running in English FA Premier League soccer matches. Journal of Sports Sciences 2, 159-168. Referred 10.01.2020. https://doi.org/10.1080/02640410802512775

Chaudhry, H., Schleip, R., Zhiming, J., Bukiet, B., Maney, M. & Findley T. 2008. Three-Dimensional Mathematical Model for Deformation of Human Fasciae in Manual Therapy. The Journal of the American Osteopathic Association 8, 379-390. Referred 16.07.2019. https://jaoa.org/article.aspx?articleid=2093620#72978747

Davis, A., Taylor, J. & Cohen, E. 2015. Social Bonds and Exercise: Evidence for a Reciprocal Relationship. PLoS ONE 8, 1-14. Referred 06.02.2020. http://dx.doi.org/10.1371/journal.pone.0136705

Etxebarria, N., Mujika, I. & Pyne, D.B. 2019. Training and Competition Readiness in Triathlon. Sports 5, 1-15. Referred 09.02.2020. https://doi.org/10.3390/sports7050101

Fascial Fitness - A new approach to train your fascial web. 2014. Journal of the Australian Traditional-Medicine Society 4, 296. Referred 30.04.2019. https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip&db=aph&AN=100861595&site=ehost-live&scope=site

Grant, M.J. & Booth, A. 2009. A typology of reviews: an analysis of 14 review types and associated methodologies. Health Information and Libraries Journal 2, 91-108. Referred 22.04.2020. http://dx.doi.org/10.1111/j.1471-1842.2009.00848.x

Grieve, R., Goodwin, F., Alfaki, M., Bourton, A.J., Jeffries, C. & Scott, H. 2015. The immediate effect of bilateral self myofascial release on the plantar surface of the feet on hamstring and lumbar spine flexibility: A pilot randomised controlled trial. Journal of Bodywork and Movement Therapies 3, 544-552. Referred 22.12.2019. https://doi.org/10.1016/j.jbmt.2014.12.004

Heick, T. 'From Procedural Knowledge To Self Knowledge: The 4 Stages Of Curiosity'. TeachThought We Grow Teachers. 07.10.2019. Referred 22.02.2020. https://www.teachthought.com/learning/4-stages-of-curiosity/?fbclid=IwAR0VX7zPUKla7iN8D6sG_tSeBPu7LY2K-dVROZ1Pba5O4-dOacWPa_Swr4E

Hemenway, D., Aglipay, G., Helsing, K. & Raskob, G. 2006. Injury prevention and control research and training in accredited schools of public health: a CDC/ASPH assessment. From the schools of public health 121, 349-351. Referred 03.11.2019. http://dx.doi.org/10.1177/003335490612100321

Hreljac, A., Marschall, R. & Hume, P. 2000. Evaluation of lower extremity overuse injury potential in runners. Medicine & Science in Sports & Exercise 9, 1635-1641. Referred 23.02.2020. http://dx.doi.org/10.1097/00005768-200009000-00018

Hübscher, M., Zech, A., Pfeifer, K., Hänsel, F., Vogt, L. & Banzer, W. 2009. Neuromuscular Training for Sports Injury Prevention: A Systematic Review. Medicine & science in sports & exercises 3, 413-421. Referred 03.11.2019. http://dx.doi.org/10.1249/MSS.0b013e3181b88d37.

Hudson, J.N., Buckles, P. & McMillen, I.C. 2001. Linking Cardiovascular Theory to Practice in an Undergraduate Medical Curriculum. Advances in Physiological Education 25, 193-201. Referred 21.02.2020. https://journals.physiology.org/doi/pdf/10.1152/advances.2001.25.4.193

Khan, K.S., Kunz, R., Kleijnen, J. & Antes, G. 2003. Five Steps to Conducting a Systematic Review. Journal of the Royal Society of Medicine 96, 118-121. Referred 23.03.2019. https://doi.org/10.1177/014107680309600304

Kumka, M. & Bonar, J. 2012. Fascia: a morphological description and classification system based on a literature review. Journal of the Canadian Chiropractic Association 3, 179-191. Referred 25.04.2019. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3430451/pdf/jcca_v56_3_179_kumka.pdf

Kwong, E.H. & Findley, T.W. 2014. Fascia- Current knowledge and future directions in physiatry: Narrative review. JRRD Journal of Rehabilitation Research & Development 51, 875-884. Referred 25.04.2019. http://dx.doi.org/10.1682/JRRD.2013.10.0220

Luscombe, K.L., Sharma, P. & Maffulli, N. 2003. Achilles tendinopathy. Trauma 4, 215-225. Referred 26.04.2019. https://doi.org/10.1191/1460408603ta285oa

Markovic, G. 2015. Acute effects of instrument assisted soft tissue mobilization vs. foam rolling on knee and hip range of motion in soccer players. Journal of Bodywork and Movement Therapies 4, 690-696. Referred 23.11.2019. https://doi.org/10.1016/j.jbmt.2015.04.010

McHardy, A., Pollard, H. & Fernandez, M. 2006. Triathlon injuries: A review of the literature and discussion of potential injury mechanisms. Clinical Chiropractic 3, 129-138. Referred to 25.04.2019. https://doi.org/10.1016/j.clch.2006.04.001

Mercerer-Mapstone, L. & Marie, J. 2019. Practical Guide: Scaling up student-staff partnership in higher education. The Univeristy of Edinburgh, 1-27. Referred 21.02.2020. http://www.docs.hss.ed.ac.uk/iad/Learning_teaching/Academic_teaching/Resources/Student_Engagement/MercerMapstoneMarie_Practical%20Guide_Scaling_up_student-staff_partnership.pdf

Migliorini, S. 2011. Risk factors and injury mechanism in Triathlon. Journal of Human Sport and Exercise 2, 309-314. Referred 25.04.2019. http://dx.doi.org/10.4100/jhse.2011.62.11

Moynihan, S., Paakkari, L., Välimaa, R., Jourdan, D. & Mannix-McNamara, P. 2015. Teacher Competencies in Health Education: Results of a Delphi Study. PLoS ONE. 12, 1-17. Referred 21.02.2020. http://dx.doi.org/10.1371/journal.pone.0143703

Mugele, H., Plummer, A., Steffen, K., Stoll, J., Mayer, F. & Müller, J. 2018. General versus sports-specific injury prevention programs in athletes: A systematic review on the effect on injury rates. PLoS One 10, 1-16. Referred 01.04.2020. https://doi.org/10.1371/journal.pone.0205635

Offord, D.R. & Kraemer, H.C. 2000. Risk factors and prevention. Evidence Based Mental Health 3, 70-71. Referred 01.04.2020. http://dx.doi.org/10.1136/ebmh.3.3.70

Pilat, A. 2003. Terapias Miofasciales: Inducción Miofascial. Madrid: McGraw-Hill Interamerica. Referred 19.02.2020.

Piotrowska, S., Majchrzycki, M., Rogala, P. & Golbebiewski, P. 2015. Does it pay to be active?. TRENDS in Sport Sciences 22, 19-23. Referred 09.06.2019. http://yadda.icm.edu.pl/yadda/element/bwmeta1.element.agro-2ae3573c-62a6-4efc-a5d4-8631a6269836

Puterbaugh, D.T. 2011. Swim! Bike! Run!. USA Today Magazine 2796, 37-38. Referred 24.04.2019. http://usatodaymag.com/index.php?id=sf&fid=99&sid=5

Ribeiro, A.P., João, S.M.A., Dinato, R.C., Tessutti, V.D. & Sacco, I.C.N. 2015. Dynamic Patterns of Forces and Loading Rate in Runners with Unilateral Plantar Fasciitis: A Cross-Sectional Study. PLoS ONE 9, 1-9. Referred 26.04.2019. http://dx.doi.org/10.1371/journal.pone.0136971

Rohé, K. 2018. ‘Faszientraining: Muskeln und Gewebe trainieren. Klassisches Faszientraining für Rennradfahrer’. Tour 23.08.2018. Referred 20.04.2020. https://www.tour-magazin.de/fitness/training/faszientraining-muskeln-und-gewebe-trainieren/a46467.html

Rosa, T. 2016. Robert Schleip talks about Fascial Fitness. Journal of the Australian Traditional- Medicine Society 3, 182. Referred 25.04.2019. https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip&db=aph&AN=118335133&site=ehost-live&scope=site

Sayers A. 2008. Tips and tricks in performing a systematic review. British Journal of General Practice 538, 136. Referred 23.03.2019. http://dx.doi.org/10.3399/bjgp08X277168

Schleip, R. & Müller, D.G. 2013. Training principles for fascial connective tissues: Scientific foundation and suggested practical applications. Journal of Bodywork and Movement Therapy 1, 103-115. Referred 25.04.2019. https://doi.org/10.1016/j.jbmt.2012.06.007

Schroeder, A.N. & Best, T.M. 2015. Is Self Myofascial Release an Effective Preexercise and Recovery Strategy? A Literature Review. Current Sport Medicine Reports 3, 200-208. Referred 03.11.2019. http://dx.doi.org/10.1249/JSR.0000000000000148

Shah, S. & Bhalara, A. 2012. Myofascial Release. International Journal of Health Sciences and Research 2, 69-77. Referred 22.12.2019. https://www.ijhsr.org/IJHSR_Vol.2_Issue.2_May2012/11.pdf

Sherrington, C., Herbert, R.D., Maher, C.G. & Moseley, A.M. 2000. A database of randomized trials and systematic reviews in physiotherapy. PEDro Manual Therapy 4, 223-226. Referred 23.03.2019. https://doi.org/10.1054/math.2000.0372

Škarabot, J., Beardsley, C. & Štirn, I. 2015. Comparing the effects of self-myofascial release with static stretching on ankle range of motion in adolescent athletes. The International Journal of Sports Physical Therapy 2, 203-212. Referred 23.11.2019. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4387728/

Spiker, A.M., Dixit, S. & Cosgarea, A. J. 2012. Triathlon: Running Injuries. Sports Medicine and Arthroscopy Review 4, 206-213. Referred 24.04.2019. http://dx.doi.org/10.1097/JSA.0b013e31825ca79f

Stecco, C. & Schleip, R. 2016. A fascia and the fascial system. Journal of Bodywork and Movement Therapies 1, 139-140. Referred 27.04.2019, https://doi.org/10.1016/j.jbmt.2015.11.012

Takase, M., Niitani, M., Imai, T. & Okada, M. 2019. Students’ perceptions of teaching factors that demotivate their learning in lectures and laboratory-based skills practice. International Journal of Nursing Science 4, 414-420. Referred 19.02.2020. https://doi.org/10.1016/j.ijnss.2019.08.001

Uman, L.S. 2011. Systematic Reviews and Meta-Analyses. Jornal of the Canadian Academy of Child and Adolescent Psychiatry 1, 57-59. Referred 23.03.2019. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3024725/

Van den Berg, F. 2003. Angewandte Physiologie, Das Bindegewebe des Bewegungsapparates verstehen und beeinflussen 3. Auflage. Stuttgart: Georg Thieme Verlag.

Van Mechelen, W., Hlobil, H., Zijlstra, W.P., de Ridder, M. & Kemper, H.C.G. 1992. Is Range of Motion of the Hip an Ankle Joint Related to Running Injuries?. International Journal of Sport Medicine 8, 605-610. Referred 03.11.2019. http://dx.doi.org/10.1055/s-2007-1024574

Website of Physiotherapy Evidence Database. Referred 25.03.2019. www.pedro.org.au

Website of Totaltriathlon. Referred 24.04.2019. https://totaltriathlon.com/

Website of World Health Organisation. Referred 17.04.2020. https://www.who.int/

Wright, R.W., Brand, R.A., Dunn, W. & Spindler, K.P. 2007. How to Write a Systematic Review. Clinical Orthopaedics and Related Research 455, 23-29. Referred 23.03.2019. https://doi.org/10.1097/BLO.0b013e31802c9098

APPENDIX 1

PEDro scale

1.	eligibility criteria were specified	no ❑ yes ❑ where:
2.	subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	no ❑ yes ❑ where:
3.	allocation was concealed	no ❑ yes ❑ where:
4.	the groups were similar at baseline regarding the most important prognostic indicators	no ❑ yes ❑ where:
5.	there was blinding of all subjects	no ❑ yes ❑ where:
6.	there was blinding of all therapists who administered the therapy	no ❑ yes ❑ where:
7.	there was blinding of all assessors who measured at least one key outcome	no ❑ yes ❑ where:
8.	measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	no ❑ yes ❑ where:
9.	all subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat"	no ❑ yes ❑ where:
10.	the results of between-group statistical comparisons are reported for at least one key outcome	no ❑ yes ❑ where:
11.	the study provides both point measures and measures of variability for at least one key outcome	no ❑ yes ❑ where:

The PEDro scale is based on the Delphi list developed by Verhagen and colleagues at the Department of Epidemiology, University of Maastricht (*Verhagen AP et al (1998). The Delphi list: a criteria list for quality assessment of randomised clinical trials for conducting systematic reviews developed by Delphi consensus. Journal of Clinical Epidemiology, 51(12):1235-41*). The list is based on "expert consensus" not, for the most part, on empirical data. Two additional items not on the Delphi list (PEDro scale items 8 and 10) have been included in the PEDro scale. As more empirical data comes to hand it may become possible to "weight" scale items so that the PEDro score reflects the importance of individual scale items.

The purpose of the PEDro scale is to help the users of the PEDro database rapidly identify which of the known or suspected randomised clinical trials (ie RCTs or CCTs) archived on the PEDro database are likely to be internally valid (criteria 2-9), and could have sufficient statistical information to make their results interpretable (criteria 10-11). An additional criterion (criterion 1) that relates to the external validity (or "generalisability" or "applicability" of the trial) has been retained so that the Delphi list is complete, but this criterion will not be used to calculate the PEDro score reported on the PEDro web site.

The PEDro scale should not be used as a measure of the "validity" of a study's conclusions. In particular, we caution users of the PEDro scale that studies which show significant treatment effects and which score highly on the PEDro scale do not necessarily provide evidence that the treatment is clinically useful. Additional considerations include whether the treatment effect was big enough to be clinically worthwhile, whether the positive effects of the treatment outweigh its negative effects, and the cost-effectiveness of the treatment. The scale should not be used to compare the "quality" of trials performed in different areas of therapy, primarily because it is not possible to satisfy all scale items in some areas of physiotherapy practice.

Last amended June 21st, 1999

APPENDIX 2

Feedback questionnaire

Workshop: Fascial Techniques for Lower Limb Injury Prevention in Triathlon.

		5😊	4	3😐	2	1☹
Q1	**The information was helpful.**					
Q2	**I would have wished for more detailed and deeper information.**					
Q3	**The information was explained in an understandable way.**					
Q4	**I got a new and wider perspective on injury prevention.**					
Q5	**I got a new and wider perspective about the fascial network.**					
Q6	**The demonstrations were clear and easy to follow.**					
Q7	**Questions were dealt with properly.**					
Q8	**I will use the content of today in the future.**					
Q9	**I would recommend others to participate in this workshop.**					
Q10	**Open Comment (What did you like a lot? Suggestions for improvements? Other thoughts?)**					

5 = Yes, I agree; **4** = I agree partly; **3** = Maybe, I don't know; **2** = I rather disagree; **1** = No, I disagree

___

APPENDIX 3

Quoted comments by the triathlete group:

“thank you very much”
“good presentation style”
“I studied human movement sciences: hence the 3's in Q4 and Q5. I like how practical it is & we can use the examples. P.S: I 've been doing FR for 7 years & haven't been injured since.”
“the "how to" not too fast and too often”
“Techniques for more parts of the body”
“more practical part”
“More about exercises → why they are done in a certain way”
“Less motivational talk and more sports details or applicable techniques”

Quoted comments by the group of physiotherapy students:

“Good Example with the orange”
“Very good job! I knew nothing about fascia or foam rolling before this + you explained it well + I could understand everything easily! Thanks for letting us participate!”
“The orange analogy was very good way of explaining fascia. I think a little bit clearer explanation of collagen structure & function could have been a bit more clear”
“More detailed about how fascia works and the debate around it. Maybe no need to go back to stretching for physio students”
“You have performed greatly, and you apply your natural skills with outstanding style. Bravissimo.”
“I liked the example exercises”
“Good and calm way of speaking!”
“The examples with TheraBand were nice & useful”
“Demonstrations would need more work. Was little bit uneasy to follow”
“Thanks”
“Good activities, but put more focus on anatomy”
“Hands on & warm up 😊"
“Your spirit is good!!! 😊"
“Thank you! Sorry I have'd to leave earlier. Would wanted to stay!”
“I really loved your examples”