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Prevention of Flexor Tendon Pulley Injuries Among Climbers

AN INFORMATIONAL PACKAGE
TO PROMOTE PRIMARY PREVENTION THROUGH EDUCATION

DEGREE PROGRAMME IN PHYSIOTHERAPY
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Abstract

The objective of this work was to develop a product that would have helped to promote primary prevention of pulley injuries among climbers. The goal has been achieved by working in steps. The fist phase has been referencing theoretical knowledge to describe the phenomenon. The second part has been gathering evidence on the injury incidence and risk factors. Following that there has been the prioritization of the educational content based on the injury evidence and data. Lastly, it ahs been all put together with the creation of a product that holds the knowledge gained through this process.

The product leveraged curiosity, modern technologies that facilitate the access to data such as QR codes and the power of web-based resources to extend the availability of its content to the furthest possible extent. This approach is innovative and presents flaws but has major key points that can be implemented to improve the final product similar works. Especially from a usability standpoint, the thesis product tries to lower as much as possible the barrier to entrance that most of the knowledge regarding the injury lies over.

Key words

Climbing, pulley injuries, primary prevention, informational package, injury prevention

CONTENTS

1 INTRODUCTION

The evidence is clear—physical activity can reduce the risk of various chronic diseases, and can make people feel better, function better, and sleep better (Website of the CDC 2019). Unfortunately, physical activity also exposes to the risk of injuries. Developed in the 60's and became popular in the 80's, climbing has grown progressively faster during the last 20 years. (Vilella 2019; Crowley 2012, 25-29.) Today, rock climbing is popular worldwide, as recreational activity and competitive sport (Woollings, McKay & Emery 2015).

With its rising popularity, the number of climbing related injuries has started to grow (Crowley 2012). There is still a gap not filled by science when the subject is climbing. As the sport is continuing to grow, we still have no validated preventive tests or strategies. (Vilella 2019.) Of climbing injuries, hand injures are the most common. Specifically, forty percent of all climbing injuries are to the fingers, with fifty percent of these being injuries affecting the pulleys and flexor tendons. (Crowley 2012.)

There is an increasing need for evidence-based prevention, for both professionals and amateurs. With the intent of being as relevant as possible, this thesis will focus on the most common injuries among climbers: flexor tendon pulley injuries.

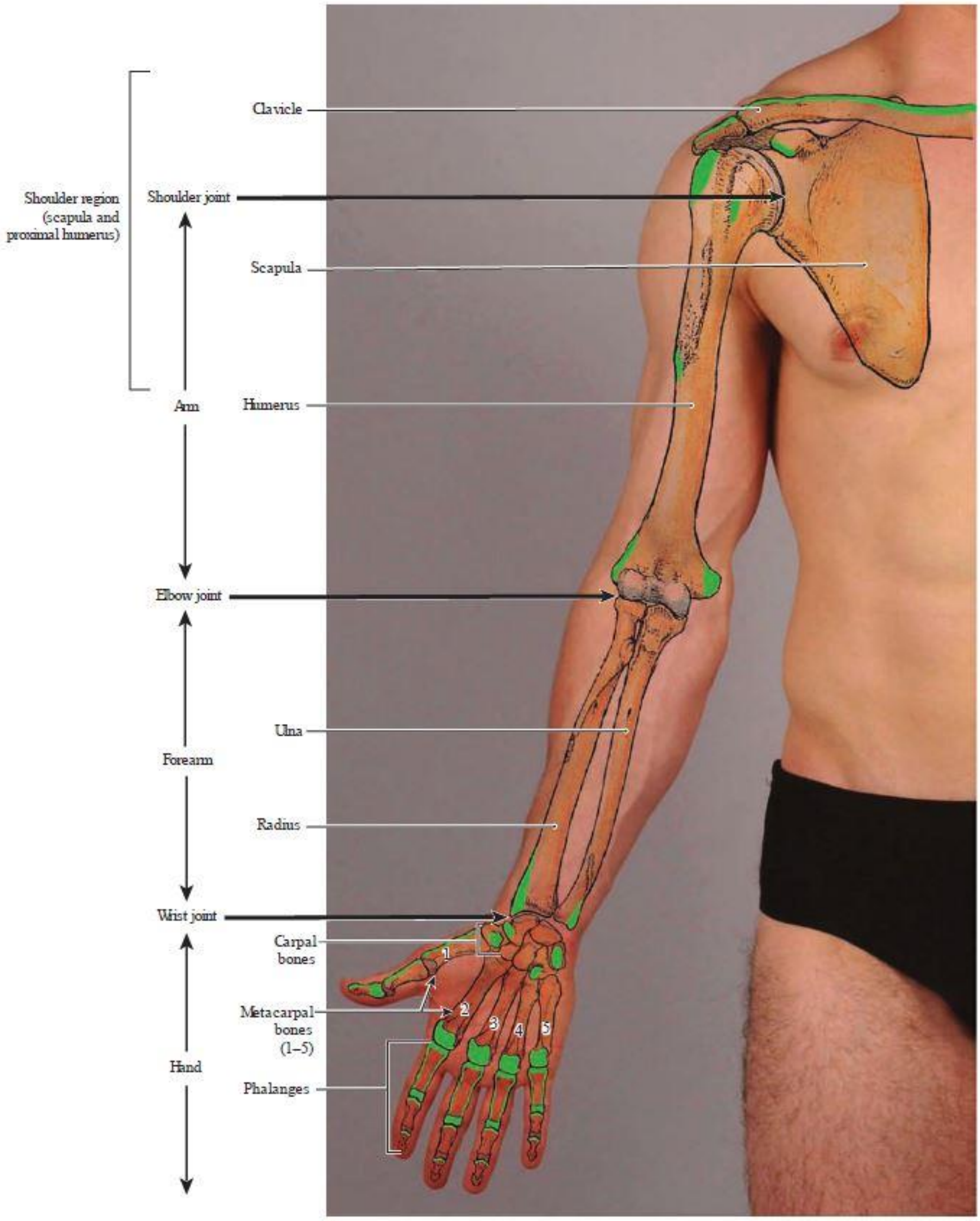
2 AIM AND OBJECTIVES

This thesis aims to create a simple and practical way to deliver updated and evidence-based knowledge on prevention of flexor tendon pulley injuries during climbing. The product is composed by an infographic and a website. It is meant to be used as a resource by the climbers to minimize the risk of injury. The objectives of this resource are multiple. To provide an overview of hand anatomy functional to understand how the flexor-pulley system works. To present information based on literature about the incidence and causes of flexor tendon pulley injuries among climbers. Lastly, to offer evidence-based interventions aimed to prevent pulley injuries in non-agonistic climbers.

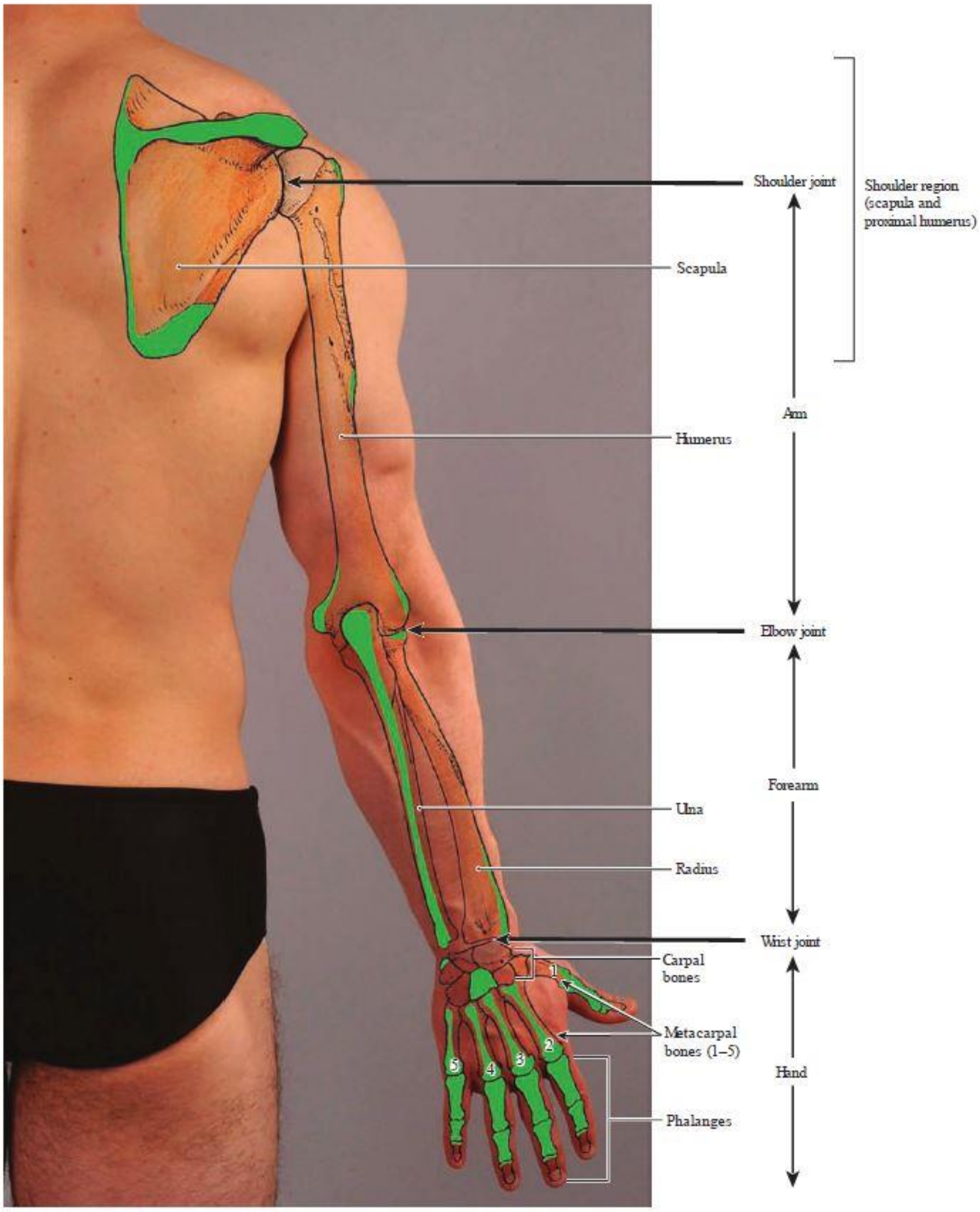
3 ANATOMY AND THE FLEXOR-PULLEY SYSTEM

For conscious prevention, it is important to understand how and why the flexor tendon pulley injuries happen. To fully comprehend this mechanism, it is crucial to have a sufficient background knowledge of anatomy regarding the involved structures. This section aims to provide the needed notions of anatomy, functional to understand the injury mechanics. (Woollings, McKay & Emery, 2015.)

Before proceeding to unfold the hand and forearm anatomy, it is important to define what is a joint in order to understand the distinctions that we will soon make. A joint or articulation is the point of contact between two bones, between bone and cartilage or bone and teeth. Two bones that articulate each other form a joint between them. Joints allow the degree of movement that we are used to observe in humans. (Tortora & Derrikson 2014, 258.) The biggest joints of the upper limb are shoulder joint, elbow joint, and wrist joint. Which divide the limb into 4 regions (picture 1 and 2): shoulder, arm, forearm, and hand. (Agur & Dalley 2016, 64.)



Picture 1: Frontal view of the bony structures of the arm (Agur, Dalley, 2017, 64)



Picture 2: Posterior view of the bony structures of the arm (Agur, Dalley, 2017, 65)

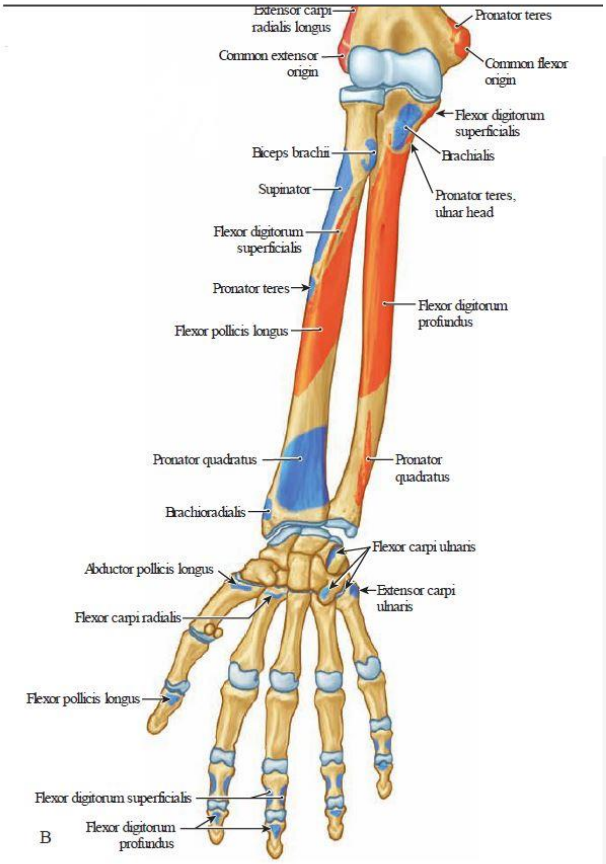
The bone connecting the shoulder joint to the elbow joint is called humerus and it is the largest bone in the upper limb. The bones connecting the elbow joint to the wrist are ulna and radius. (Agur & Dalley 2016, 65.) The structure of this section allows supination and pronation of the hand (Agur & Dalley 2016, 135). The hand is a complex structure, involving many different joints (picture 3). The most important and functional to our purposes are: the radiocarpal joint, the carpometacarpal joints

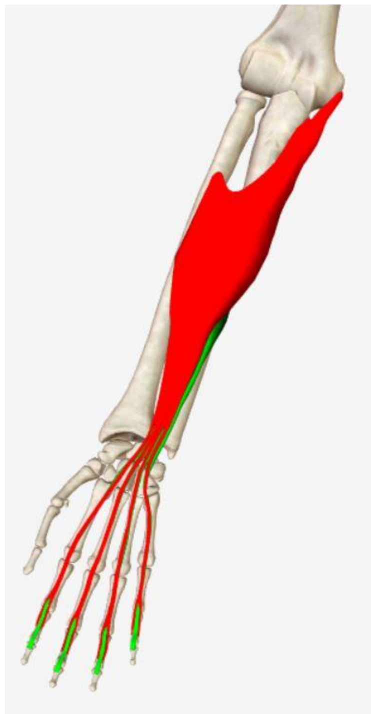
(CMC), the metacarpophalangeal joints (MCP), the proximal interphalangeal joints (PIP), and distal interphalangeal joints (DIP). (Agur & Dalley 2016, 150.)

The bones forming the digit are four: respectively (from proximal to distal) metacarpal bone, first or proximal phalange, second or middle phalange and third or distal phalange. This scheme is repeated for 4 of the 5 fingers. The thumb has only one metacarpal bone and two phalanges, one distal and one proximal. Lastly, metacarpal bones are numerated from one to five, starting from the metacarpal bone of the thumb as number 1. (Agur & Dalley 2016, 164.)

3.1 Flexor muscles

To fully understand the mechanism of the flexor pulley system, it is crucial to know which muscles are involved and how they function. The muscles interested in the pulley system of the 2^{nd} ,3^{rd} ,4^{th}, and 5^{th} digits are the flexor digitorum profundus and the flexor digitorum superficialis (picture 4 and 5). The flexor digitorum profundus originates form the upper ¾ anterior and medial side of ulna, and it inserts at the palmar base of the distal phalanges 2 to 5. The flexor digitorum superficialis originates from the medial epicondyle of the humerus and from part of radius and ulna. It inserts in the anterior part of the second or middle phalanges of the 4 fingers (excluding the thumb) (picture 4). The main function of these two muscles is to flex the wrist, the metacarpophalangeal and the interphalangeal joints of the four fingers. (Agur & Dalley 2016, 142.)



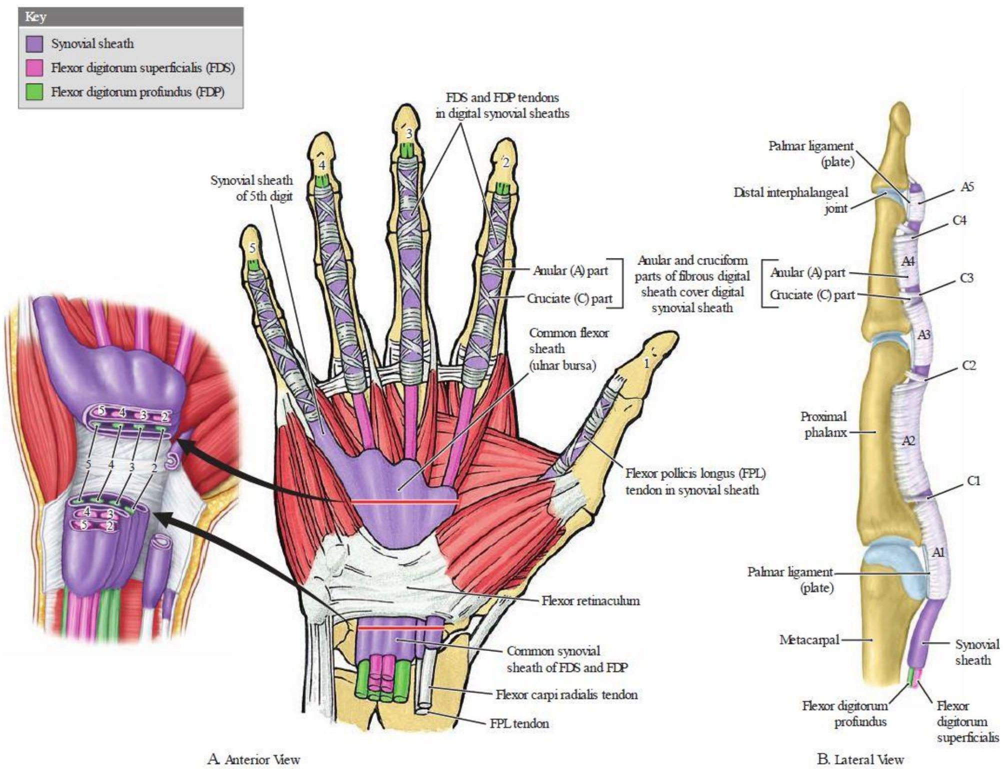


Picture 4 and 5: Attachments and anatomy of flexor muscles (Agur, Dalley, 2017, 150) (website of biodigital, 2020)

The digital flexor sheath keeps the tendons of flexor digitorum profundus and superficialis close to the phalanges, therefore allowing an effective transfer of force to the the digits (picture 6). The flexor sheath is structured by two components: a synovial element and the pulley. (Crowley 2012.)

The membranous structure is a synovium lined tube in which the tendons of the 2 flexor muscles run. The tube is attached to the ventral portion of the metacarpal bone and to all the phalanges up to the distal interphalangeal joint. In the gap between the joints, the tube is attached to the ventral volar plate or palmar ligament. The synovial nature of the tube gives it elasticity, allowing it to follow the movements of the hand without being damaged. (Crowley 2012.) Synovial membranes usually fill the cavities between movable joints. The most important characteristics of these membranes are their ability to bend and follow the joint movements, as well as the secretion of synovial fluid. Synovial fluid functions as a lubricant inside the synovial membrane, facilitating the movement and preventing grinding between other tissues. Lastly, synovial fluid contains macrophages that remove microbes from the area. (Tortora & Derrikson 2014, 134.)

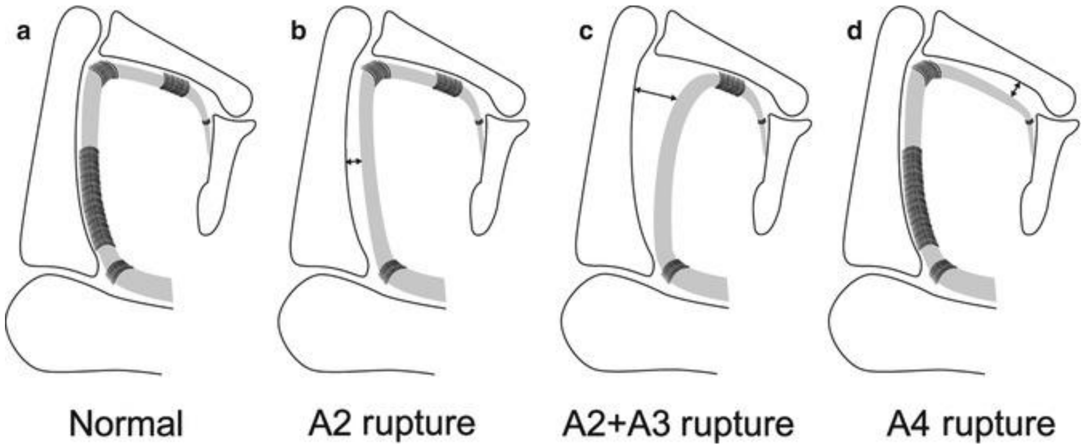
The retinacular part of the sheath is made by fibrous tissue that wraps the tendons. These ligaments pulleys and lie against the flexor tendons. There are five annular pulleys per digit and three cruciform pulleys. The ligaments are numbered from proximal to distal (picture 6). Of all the annular pulleys, A2 and A4 are true fibro-osseous pulleys, making them the strongest. The other ones (A1, A3 and A5) are more flexible to make compression during flexion of the digit possible without impairing the tendon. (Crowley 2012.) Ligaments are bands of dense connective tissue. Their main purpose is usually to limit movement and give support to the joints. (website of WebMD 2020) In the case of the pulley system, the ligaments limit the movement of the tendons to improve the efficacy of the movement. (Crowley 2012.)



Picture 6: Structure of the pulleys (Agur, Dalley, 2017, 159)

3.2 Role of the flexor-pulley system

The synovium sheath and the pulley ligaments act together to maintain the flexor tendons close to the bone. The closer the tendons are to the bone, the more efficient the transfer of force (from the muscles in the forearm to the movement of the digits) will be. In doing this, the pulley system also prevents bowstring (picture 7), which would severely impact the ability to produce force during flexion of the finger. (Crowley T. P. 2012.)



Picture 7: Pulley raptures (Guermazi, Roemer & Crema, 2016, 345)

4 CLIMBING AS A SPORT

Rock climbing is a sport in which athletes move vertically or traverse natural or artificial rock formations. The objective is to arrive at the peak of the segment or to reach the last spot of an artificial track without falling. Climbing is physically and mentally straining, involving strength, endurance, agility, balance and mental control. (website of River Rock Climbing 2020.) Climbing is a biomechanically unique activity: it defies the anatomical fact that human beings are designed to function supporting their body’s weight through lower limbs (Crowley 2012).

The first record of climbing activities dates 400 BCE: paintings have been discovered on the roofs of caves in China that would have been otherwise impossible to reach.

Climbing has been a part of human life in different ways, until its official recognition as a sport in 1880. The sport has then started to develop faster and faster. The first Climbing World Cup was held in 1989, and now for the first-time climbing will be part of the Olympics for Tokyo 2020 (with bouldering, speed and lead climbing). (website of Preceden 2020; Website of Rock Climbing Central 2020; website of Mountaineering Methodology 2020.)

The growth of climbing as a sport has been all but linear. Most of its success was developed in the recent 20 years in an exponential way. This eruption of popularity generated a sudden need for scientific literature about injury treatments and prevention. The scientific community has simply not been able to output papers at the same rate of the popularity growth. The discrepancy between available tools and needed intervention is especially present in prevention of climbing-specific injuries. (Crowley 2012.)

5 INJURIES AMONG CLIMBERS

The first reliable report on climbing injuries is dated 1982. The study was based on data collected from the Gran Teton National Park about climber (Schussman & Lutz 1982). Since then studies started to become more frequent and specific with the rise in popularity of the activity. In recent years, scientific literature has uncovered a clear pattern in injuries' incidence and distribution. The most injured areas have been showed to be in order hand, wrist and shoulder in both common population and competitive athletes. (Backe et al., 2009.)

5.1 Injury incidence and distribution

Injury incidence has been investigated by many researchers, with different results. A prospective study from 2013 on 515.337 visits to an indoor climbing indicated an overall injury rate of 0.02/1000 hours of climbing activities. (Schöffl, Volker R., Hoffmann & Küpper, Thomas, 2013.) Another study from 2009 based on a random sample of Swedish Climbing Association members (606 participants) reported an injury incidence of 4.2/1000 hours of climbing. However, higher climbing frequency and climbing difficulty have been showed to be major risk factors. Since members of the Swedish Climbing Association are more likely to push their limits in climbing, this might explain the considerable discrepancy in injury rates. (Backe et al., 2009.) A literature review from Woolings et al. that included all the most reliable articles on the topic defined the injury rates difficult to compare due to methodological differences, suggesting as the most reliable estimation the one by Backe et al. (4.24/1000h). (Woollings, McKay & Emery, 2015.) Finally, a more recent literature review of injury incidence in sport climbing and bouldering from 2018 suggested a injury rate of 2.71 ± 4.49/1000 hours of climbing (Jones, Gareth, Schöffl & Johnson, 2018).

Furthermore, low experience in climbing seems to be associated with higher a perceived activity-related risk. On the other hand, higher experience seems to be associated with lower perceived risk. The influence of physical activity on risk perception has been showed to be high in less experienced individuals and low in more experienced climbers. The consequence of this is that inexperienced climbers overestimate the risk of climbing, especially if they are not physically fit. Experienced climbers, on the other side, have a much lower sense of risk regardless of their physical condition, potentially leading to overconfidence. (Raue et al., 2018.)

While the injury incidence rates are not yet well defined, injury distribution follows the same pattern across all the major studies regarding climbing injuries. The most injured area among recreational and professional climbers is always upper limb, taking up between 37% and 91% of all the injuries. Of all upper limb injuries finger injuries are the most common, followed by shoulder and arm/elbow injuries. Lastly, the most common finger injuries are flexor tendon pulley injuries. (Wegner et al., 2015; Lum, Park, 2019; Schöffl, Volker et al., 2015; Schöffl, Volker R., Hoffmann & Küpper, Thomas, 2013; Mei-Dan, Carmont, 2013; Jones, G., Asghar & Llewellyn, 2008.)

5.2 Risk factors

Sport-specific risk factors, as the injury incidence, are difficult to define due to multiple aspects: scarcity of literature (even more significant about risk factors than about injury incidence), incoherence of the study populations and methodological quality discrepancies among the different studies. However, multiple risk factors, both modifiable and non-modifiable, have been identified. Particularly, non-modifiable (intrinsic) risk factors include the following. (Woollings, McKay & Emery, 2015).

Sex might play a role on the incidence of injuries, but the evidence is highly conflicting. Multiple studies found men to be generally at higher risk of injury. (Hasler et al., 2012; Rohrbough, Mudge & Schilling, 2000; Gary Josephsen et al., 2007.) Schoffl et al. found a higher IR in females than males (Schoffl, Burtscher & Coscia, 2013). Nelson et al. found that males were more susceptible to factures and lacerations, while females were more prone to strains and sprains (Nelson, McKenzie, Lara B., MA, PhD, 2009). Lastly, the study with the biggest sample size, found no significant differences between sexes (Neuhof et al., 2011).

5.3 Non-modifiable factors

Age has been mentioned in multiple studies as a possible risk-factor, but there is no coherent evidence about how it may affect the incidence of injury. Many articles report no correlation between injuries and age. (Gerdes, Hafner & Aldag, 2006; Wright, Royle & Marshall, 2001; Neuhof et al., 2011; Jones, G., Asghar & Llewellyn, 2008.) However, Backe et al. which has the highest methodological quality score, reports a higher risk of reinjury in adolescents compared to older participants (Woollings, McKay & Emery, 2015; Backe et al., 2009). Finally, Pieber et al. found significantly more injuries in their older age groups: 29.5±1.7 years and 39.7±5.6 years (Pieber et al., 2012).

Total years of experience has been investigated by different studies. A general pattern of higher injury rates can be observed in more experienced climbers; however, studies do not agree on specific groups. Wrigth et al. and Hasler et al. find higher injury rates in climbers with more than 10 years of experience, while Nouhof et al. shows differences already after 5 years. (Wright, Royle & Marshall, 2001; Hasler et al., 2012; Neuhof et al., 2011.)

The last non modifiable risk factor worth mentioning is the difficulty. Studies differ in population, but they all report a pattern of higher injury rates with the increase of the difficulty level. Difficulty level can be adjusted during training, but for the sake of progressing, climbers must proceed gradually to more and more difficult climbs, even during training. For this reason, Difficult level is mentioned among the non-modifiable risk-factors. (Jones, Asghar & Llewellyn, 2008; Neuhof et al., 2011; Wright, Royle & Marshall, 2001; Hasler et al., 2012.)

5.4 Modifiable factors

Body mass index (BMI) had been examined mainly by 3 studies. The first two studies found no significant correlation between injury rates and BMI. However, the study by Backe et al., which has a methodological score higher than the previous ones (15/32 against 12/32 of the first ones), describes a strong relationship between higher BMI and injuries, as well as reinjury. (Woollings, McKay & Emery, 2015; Gary Josephsen et al., 2007; Neuhof et al., 2011; Backe et al., 2009.)

Climbing volume has an impact on the prevalence of overuse injuries. Yearly climbing volume does not appear to affect the incidence of injuries. However, higher weekly climbing volume seems to be linked to higher risk of overuse injuries. (Neuhof et al., 2011; Jones, Asghar & Llewellyn, 2008.) Carmeli found a correlation between muscular strength, specifically lower grip strength, and higher risk of injury. However, the correlation is mild to moderate. (Carmeli E, Shuruk S, Sheklow SL, et al., 2002.) Lastly, A2 pulley is most likely to be injured when loaded eccentrically (Schöffl, I. et al., 2009). Therefore, performing dynamic moves using a “crimp” grip, especially when landing, represents a significant risk factor for finger pulley injuries (Crowley, 2012).

6 PULLEY INJURY MECHANISM

Pulley injuries happen when the load placed on the annular pulleys exceeds their loading capacity. When the loading is increased rapidly over the limit of the annular ring, this can break or tear. Similarly, working on a level close to the rapture threshold for multiple sessions can cause over strain injuries. When loaded eccentrically, the load at which pulleys would rapture has been showed to be decreased, most likely due to the high friction between the pulley and the flexor tendon. Most of the climbers with partial or complete rapture report a fast onset while performing a difficult dynamic move with “crimp position” or when rapidly loading the fingers as they lost their footing. However, significant bowstring happens only if two or more adjacent pulleys are completely raptured. (Crowley, 2012.)

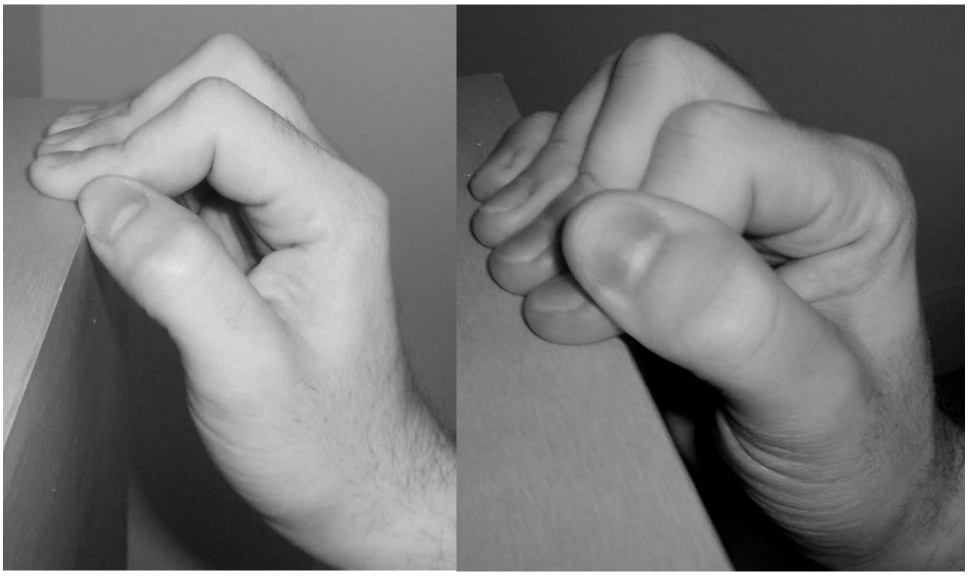
7 GRIP TECHNIQUES AND INJURIES

Climbing grips can be summarized in four main categories: open grip, pinch grip, open crimp and closed crimp. Open grips usually do not stress particularly the hand. however, a subgroup of them called pockets (picture 8), involves decreasing the number of fingers used, therefore increasing the load. At times, the whole weight of the body can be supported in this way. The grip may cause digitorum profundus avulsion, especially if the climber falls and one or more fingers remain trapped in the pocket. The pinch grip is useful on small ledges that allow for a grip between the thumb and the other finger, because it leverages to squeezing power generated with the recruitment of the thumb (picture 9). Therefore, it its mostly associated with first metacarpal joint pain. (Kubiak, Klugman & Bosco, 2006)

Picture 8: Open grip in a pocket (Kubiak, Klugman & Bosco, 2006)

Picture 9: Pinch grip (website of Mountaineering Methodology 2020)

Finally, the crimp grip is used to exert maximal force on a small ledge. The characteristics of this grip is a flexion of 90-100 degrees of the proximal interphalangeal joints (PIPJ) and a hyperextension of the distal interphalangeal ones (DIPJ) (picture 10). The grip is commonly associated with pulley raptures and injuries, while becoming progressively more common in harder climbs. (Kubiak, Klugman & Bosco, 2006.) The position can then be subdivided in two additional categories, open and closed crimp. The classification refers to the position of the thumb that can "lock" the DIPJ and provide the maximal holding force or rest aside the other fingers. The recruitment of the thumb in this way is unique to the crimp position and makes it an advantageous grip to use on smaller and more difficult hand holds. However, overuse of this techniques, especially of the closed grip, can lead to pulley injuries. It has been estimated that a recreational climber can load the A2 pulley with forces around 380N when using this position. A2, which is the strongest annular pulley, can withstand forces only up to 400N. Furthermore, the closed crimp position places on the pulleys the additional forces of thumb, increasing the load. (Crowley, 2012.)

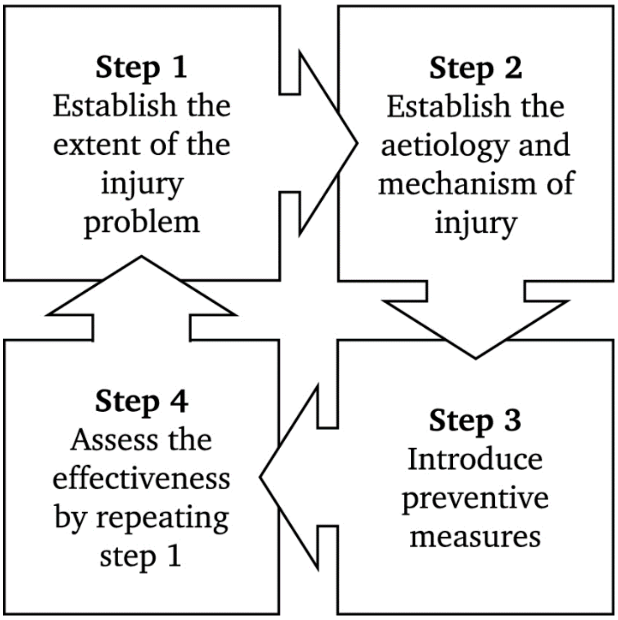


Picture 10: Open and closed crimp grips (Crowley, 2012)

8 PREVENTION

Prevention is defined by the Cambridge Dictionary as the act of stopping something from happening (Website of Cambridge Dictionary 2020). Therefore, injury prevention is the act of stopping an injury from manifesting itself (Website of Physiopedia 2020). Prevention can then be broken down in three main categories: primary, secondary and tertiary prevention. Primary prevention aims to stop the condition before it manifests itself by modifying dangerous behaviors and educating on safe practices. Secondary prevention tries to reduce the effects of a condition which is already present. Lastly, tertiary prevention aims to reduce the impact of an ongoing condition with lasting effects in the long-term. (Website of Toronto Institute for Work & Health.)

In 1992 Van Mechelen developed a four-step model of the injury prevention process (picture 11) which became the foundation of every prevention program since. The four steps include in order: establish the extent of the injury problem, establish the aetiology and mechanism of injury, introduce preventive measures, assess the effectiveness and repeat. (Von Mechelen W, Hlobil H, Kemper HC., 1992.)

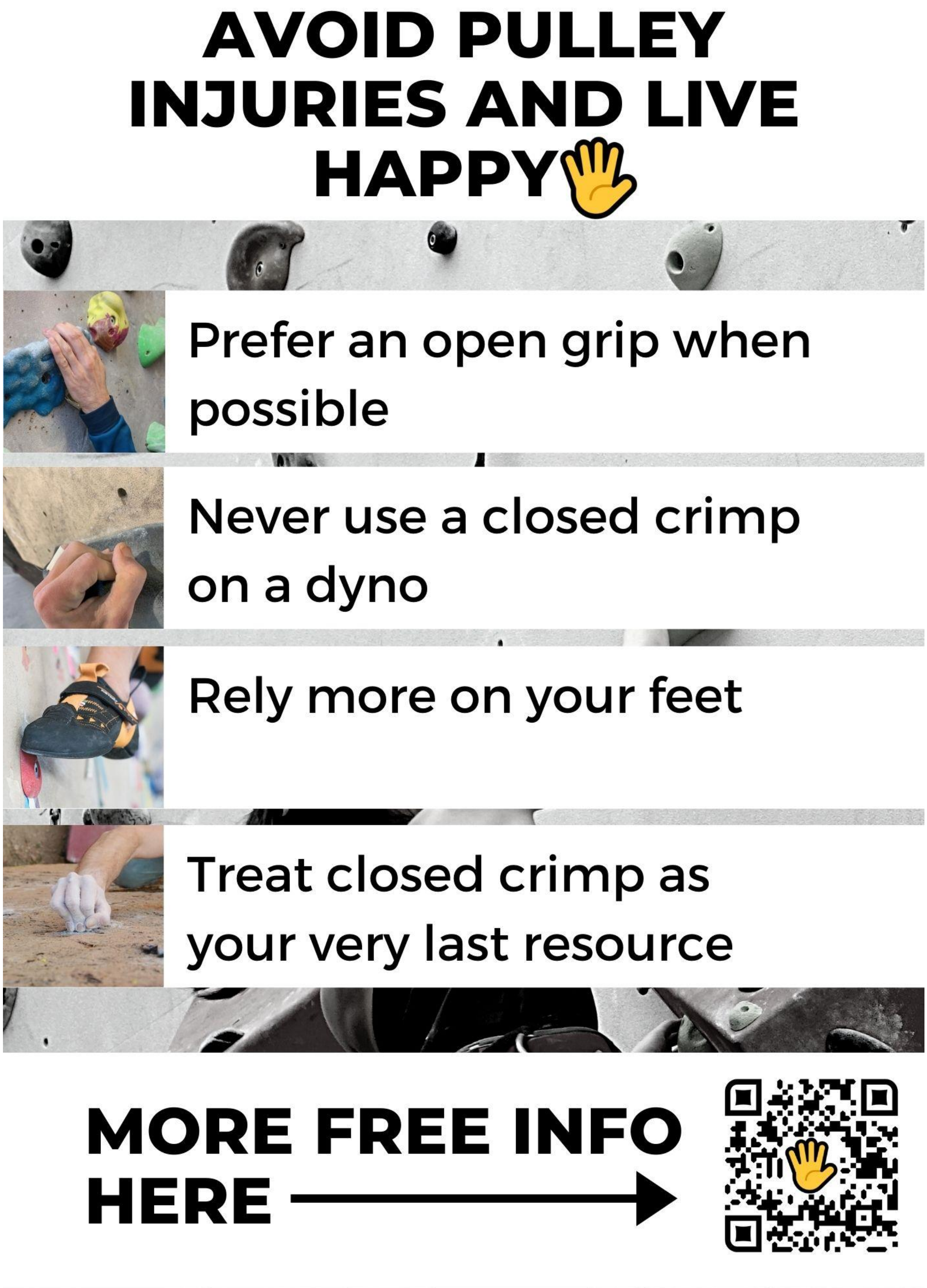


Picture 11: Injury prevention process by Van Mechelen (Website of Physiopedia 2020)

Motivation is *"the reason of action, that which gives purpose and direction to behavior."* (Website of Online Etymology Dictionary 2020). Client motivation is therefore the reason that moves a person to follow a specific behavior. This has been thoroughly implemented in the advertisement industry resulting in strategies to attract user attention and guide costumer behavior. One of the most impactful tools is the use of colors and contrast to drive the focus of the costumer. (Stillman et al., 2020.) Furthermore, the use of shapes, visual hierarchy and curiosity driven attitude can stimulate interest and attention, especially on visually predominant media such as paper and screens. These principles can be translated to the health industry and used to promote education and behavioral change. (Visschers, Hess & Siegrist, 2010.)

9 THE PRODUCT

In 2019 Emery and Pasanen stated *“The "best" injury prevention program is the one that can and will be adopted and sustained by athletes, coaches, and sporting bodies.”* (Emery, Pasanen, 2019). The biggest challenge at the present day is to provide cheap injury prevention protocols that still perform in real life circumstances (Website of Physiopedia 2020). This product, eliminating the need of “in-person” education and minimizing the equipment needs, aims to fill that gap. The theory displayed in the thesis summarizes the first two steps of the injury-prevention model (picture 12), while the product implements the third one to the extent possible given the current knowledge. The structure of the product is composed by two main parts. The fist component is a paper infographic, that holds basic directions to avoid injury, and acts as a gateway to the web-based resource. The second pillar of the product is the website, that stores in-depth information on all the aspects touched inside this thesis (the website can be accessed using this link). The goal of the web resource is to bring the user from knowing nothing about the injury to having a complete understanding of the injury mechanism and risk factors. The education provided by this process empowers the user to independently make conscious decisions during training, recognize dangerous behaviors and adapt preventive strategies that fit his/her training.



Picture 12: infographic part of the product

9.1 User experience strategy

The product developed in this work is meant to be used as a tool of primary prevention in the climbing training setting. The product is designed with a specific behavioral strategy in mind that aims to maximize its effectiveness. The user will first get in contact with a simple infographic displayed on paper or on a screen. This first product uses the tools described in chapter 7 (Client Motivation) to capture the users' attention. The infographic covers simple preventive strategies on a strictly practical level, to give the user actionable insights in exchange of very small effort. Additionally, the infographics acts as a gateway to website, where the user can find more in depth, detailed information on the injury and its prevention. The website aims to educate the user on a deeper level regarding the injury-mechanism, which will ultimately lead to a more effective prevention strategy.

9.2 The client

The product has been built for Climbing Club Oy, a climbing association operating in Pori. Climbing Club Oy represents the most important meeting point for climbers around the Pori area, proving tools, teachers and facilities for them to train. The client agreed to display the product inside their climbing gym to help decreasing the injury rate of their customers.

10 THESIS PROCESS

The thesis process has been conducted according to the following timetable.

TIME FRAME	TOPIC
October - November 2019	Topic research
December - June 2020	Development of theoretical background
July – September 2020	Creation of the product
October 2020	Finalizing of the thesis

November 2020	Thesis presentation

The methodology of the thesis went through several iterations before reaching a satisfactory outcome, especially in the implementation part. The main aim has always been to deliver information, but the ways to do that could be many. At first, the idea was to create an informational booklet to distribute among climbers. However, this idea got soon discarded. The physical booklet would have been uncomfortable to read and carry for most of the people. Furthermore, the booklets would have needed to be printed and “built” before distributing them, which would have ended up being costly and cumbersome. Lastly, there would have been only a set amount of copies, drastically limiting the number of people that would access the information, defying the main aim of the project. After the booklet, I decided to proceed with a more direct approach. I would have hosted a workshop at the gym to educate people on the subject. Unfortunately, this methodology had many flaws as well. First, only the people present at the workshop would have had access to the information. Secondly, the information would have been hard to retain without any reference to check when in doubt. thirdly, while contemplating this methodology, the COVID19 pandemic started to become a reality, impairing any kind of in-person teaching setting, especially for larger audiences. Luckily, at the same time I was developing an interest in web technologies, which ended up being my main medium of choice. A website could have been accessed by anyone at any time, without restrictions. Additionally, the information that could have been stored online didn’t have obvious restrictions like paper or in-person mediums had. Lastly, a website could have been built, hosted and maintained for virtually no money, given the right competences. However, there was still a big flaw in my implementation. I needed a way for people to reach the website. To accomplish that, I decided to leverage cellphones and curiosity. The QR technology offers a simple and quick way to transition from paper to digital. I decided to create a poster that would halve held the basic principles of my work, alongside the QR-code. In this way, the poster would have delivered basic valuable directions, while acting as a gateway for the website.

11 DISCUSSION

The thesis process began in the summer of 2019 with the selection of the topic. At the time I was practicing indoor bouldering. I noticed that most of my peers, especially the more experienced ones, had undergone some kind of severe injury, even if they practiced only at an amateur level. While getting to know more and more people from the climbing community, a trend started to become clear. The vast majority of the injuries that my peers were facing where hand injury, and almost always they were linked to the pulley-flexor tendon system. I was told that it was an injury that virtually any climber at some point would have experienced. To avoid it myself, I began researching preventive strategies and injury mechanics. I found that the information around the subject was scarce and scattered across different sources. Additionally, most of the higher quality information was secluded over paywalls in scientific papers. At that point, the topic and the aim of my thesis were clear. I wanted to make information about pulley injuries easy to reach and follow, with the sole purpose of making it easier for climbers to avoid them.

The theoretical background, developed between December 2019 and June 2020, is probably the weakest part of the thesis. The pool of sources regarding the injury is to this day very limited and only few of these excel in quality. As a result, the conclusions that we observe are not as strong as in other fields. Furthermore, while this thesis selected only the most reliable information, it is not its main aim to conduct a systemized literature review on the topic. The thesis relies on previously conducted systematic literature reviews and peer-reviewed articles, but a strict and well-defined systemized review would enhance the reliability and validity of the product. On the other hand, the anatomy background lies on very solid and well-established foundations.

Lastly, while working on this project, it became obvious how many realms this work encompasses. By definition, a bachelor thesis should be as focused as possible on a very narrow topic. However, while the topic chosen is narrow, the very nature of the work covers many different backgrounds. For these reasons, the best way to improve this work would be to separate the different topics in multiple theses and work as a group toward a more refined outcome. In particular, the different aspects that could be handled independently are: the selection of the applicable resources via a systemized literature review, the creation of the prevention material to be used based on the literature provided, and the creation of the product on both its physical and web component, with a specific focus on client engagement and user experience flow.

In summary, I believe that this thesis is only the first iteration of a more modern way to approach primary prevention. The work has its flaws, which I already discussed. However, it can be used as starting template for similar projects. Most importantly, in the future, especially if conducted as a group project, this type of work has the possibility to lead to higher quality, more easily accessible and cheaper products that can truly have an impact on sport specific injuries.

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