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Primary Prevention of Non-Specific Low Back Pain in young elite golfers (12 to 15-year-olds)

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Abstract

The aim of this thesis was to search evidence-based literature in the primary prevention of non-specific low back pain amongst elite young (12 to 15-year-old) male golfers. The information gathered of NSLBP in this thesis was to increase awareness of primary prevention of NSLBP.

An electronic booklet was created based on the current theoretical and clinical knowledge available today. This exercise booklet is available for use by accredited PGA certified golf instructors and most importantly for the young elite golfers.

The literature gathered and used for this thesis was mainly from the previous 10 years, although some literature and evidence gathered was published more than 10 years ago, they were still considered applicable in relation to the thesis topic. The newest literature was used towards the main categories which were prevention of injury and evidence towards specific exercises.

Key words
Low back, Pain, Primary prevention, Exercise, Adolescent golfers.

CONTENTS

1 INTRODUCTION

Golf is an Olympic-Level sport. In the modern era each sport has become more demanding in multiple aspects, physically and mentally and golf is no exception. The game has entirely changed since the late 1990's and early 2000's when Eldrick "Tiger" Woods burst on to the scene, utilizing his amazing athleticism to transform the golf swing and most importantly the game. The golf swing as mentioned earlier puts tremendous stress on the body and golfers at younger ages need to start preparing their bodies towards their hopefully future profession. Tiger Woods was known in the United States as a young prodigy and was seen on television at the age of 2 and many during that time were predicting him to become the Mohammed Ali (Boxing) or Michael Jordan (Basketball) of golf. He went on to win the Renowned Masters Tournament (one of 4 Golfs Major Championships) in 1997 at Augusta National Golf Club in Augusta, Georgia USA. Following his sensational win, he was known around the world, whether you were a golfing fan or not, he changed the game forever. In recent years younger and younger golf athletes are entering the Professional Golf Tours (PGA Tour & European Tour). Players are more prepared physically and mentally. Golf as an exercise modality is fantastic for cardiovascular health and overall fitness. The most common type of pain or condition golfers have is Non-Specific Low-Back Pain (NSLBP).

This thesis is aiming to bring awareness of theoretical and evidence-based knowledge of the most common non-pathological condition and specifically towards young elite golfers aged from 12 to 15-year-old males within Finland.

As of August 2020, there was approximately 148 000 registered male and female golfers within Finland, 12 000 of these were registered male golfers and 4000 female golfers respectively, under the age of 18. (Suomen Golfliitto (SGL): Jäsenmäärät 2020).

Factors that are taken into consideration include present and the primary prevention of NSLBP in these rising future golfing athletes. Theoretical knowledge and literature reviews will play a major role in providing information of NSLBP.

This thesis will include basic understanding of the biomechanical aspects during a golf swing, this includes mechanical and anatomical interaction within the body. An exercise-based strategy in primary prevention of NSLBP for young competitive golfers will be implemented.

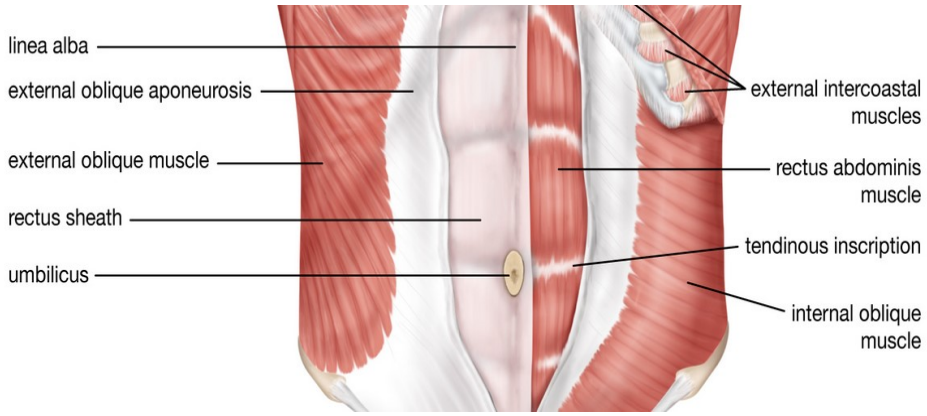
2 AIM AND OBJECTIVES

The aim of this thesis is to search evidence-based literature in the primary prevention of NSLBP amongst elite young (12-15 y.o.) male golfers. This literature will be the basis for an exercise-based booklet, which will be made available in an electronic format. This exercise booklet will be available for use by authorized PGA certified golf instructors and most importantly for the young elite golfers.

The objective is to improve awareness of NSLBP within the young golfing community. The importance of lumbar region stability and mobility will be highlighted in this thesis which has been aimed to prevent NSLBP in young elite golfers. During the theoretical part of this thesis there will be specifically selected exercises included in this booklet which will be explained and why there is an increased need of prevention in NSLBP among young elite golfers in the modern era. Consequently, this exercise booklet will benefit and maximize the understanding of young elite golfers towards a healthier career.

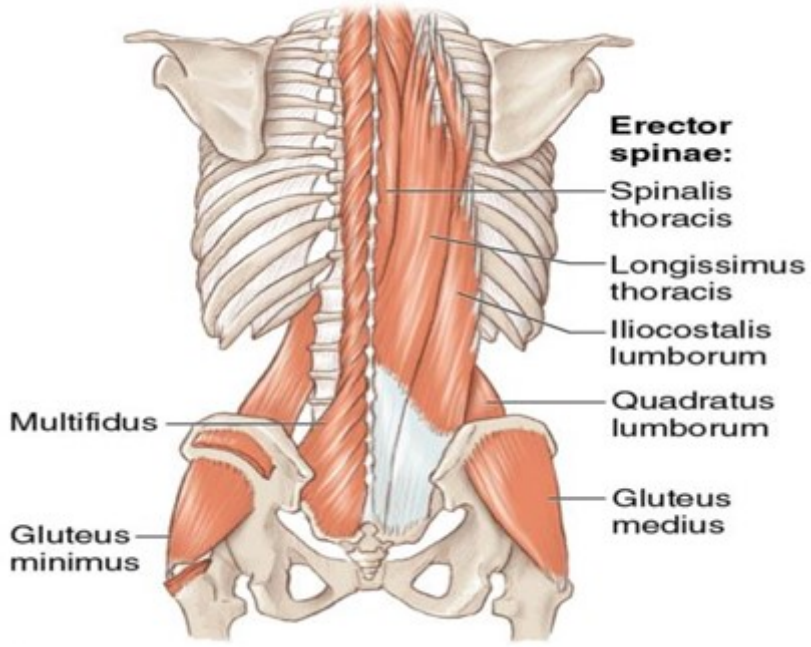
3 ANATOMY AND PHYSIOLOGY OF THE LUMBAR REGION

Muscular forces have two (2) properties to resist and creation of movements within the body. Each muscle's physiological cross-sectional area will determine the amount of force it can produce, and each muscle has an attachment and insertion points, either to soft tissue or bone, these attachment and insertion points will determine the action or movement of each muscle's force. (Tallarico, Madom & Palumbo 2008, 32-38.) Anterior and posterior muscles of the trunk have a large affecting on stability and mobility within the lumbar spine. Anterior muscles of the trunk create rotation, flexion and lateral bending and provides stability throughout the spine. Flexion of the trunk refers to movement of the upper body moving anteriorly and inferiorly towards the lower body, while the flexion of the hips refers to movement that produces anterior and superior movement of the lower extremities towards a stationary upper body. Rectus Abdominis (RA) mainly creates trunk flexion with three other abdominal wall muscles such as the Transversus abdominis (TA), Obliquus Internus (OI) and the Obliquus Externus (OE), these muscles are illustrated in picture 1. Each muscle from the abdominal wall has a moment of increased flexion due to their attachment to the Linea Semilunaris also known as the semilunar line. The OE, OI, and TA muscles also create rotation and lateral bending of the trunk. The OE, OI, and TA provide stability to the spine, specifically with axial compression forces, by forming a circular type of structure around the abdomen, the structures stiffen when load is performed. (McGill, 2007, 58-75.)



Picture 1. Anterior view of abdominal muscles. (Website of Britannica. 2021)

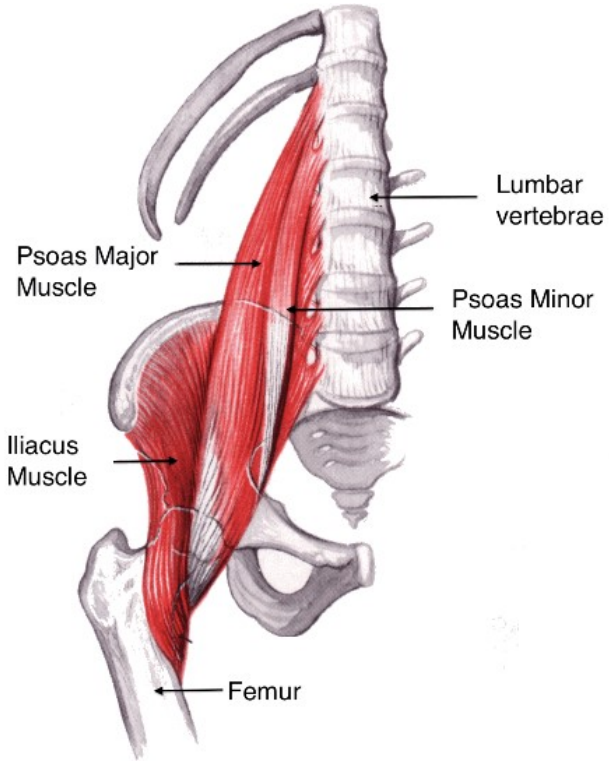
The Latissimus Dorsi, Multifidi and Erector Spinae (ES) perform extension of the trunk can be seen in Picture 1. Longissimus Thoracis and Iliocostalis Lumborum create extension movements of the trunk and are stabilizers for anterior shear forces to the lumbar spine. (McGill, 2007, 58-75.)



Picture 2. Extensor muscles of the back. (Website of Integra Health Centre. 2021)

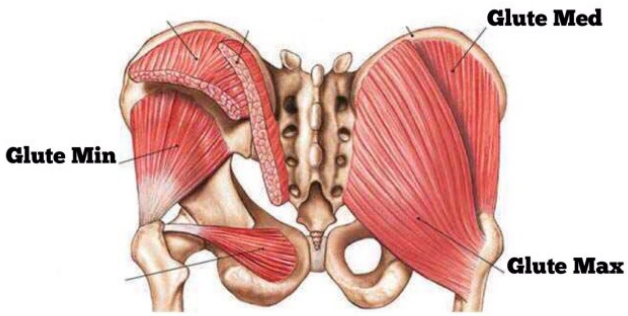
Multifidus muscles seen in Picture 2, create extension but are very short and their main principals are to create small corrections and provide support to each vertebral structure during different movements, these small muscles also create minimal rotation movements within the transverse plane. The ES stabilizes the trunk during flexion through the production of posterior shear torque resulting in stabilization of the vertebrae. The Quadratus Lumborum adds additional stabilization to the trunk during lateral bending, extension, and flexion tasks. (McGill, 2007, 58-75.)

When inspecting the Hip flexor muscle group seen in picture 3, the Psoas Major (PMa) It has been shown in EMG testing that PM activates only during flexion of the hip, while the Iliacus provides flexion and medial rotation of the thigh. The Psoas Major also provides stability to the lumbar spine when there is hip flexor torque. (McGill, 2007, 58-75.)



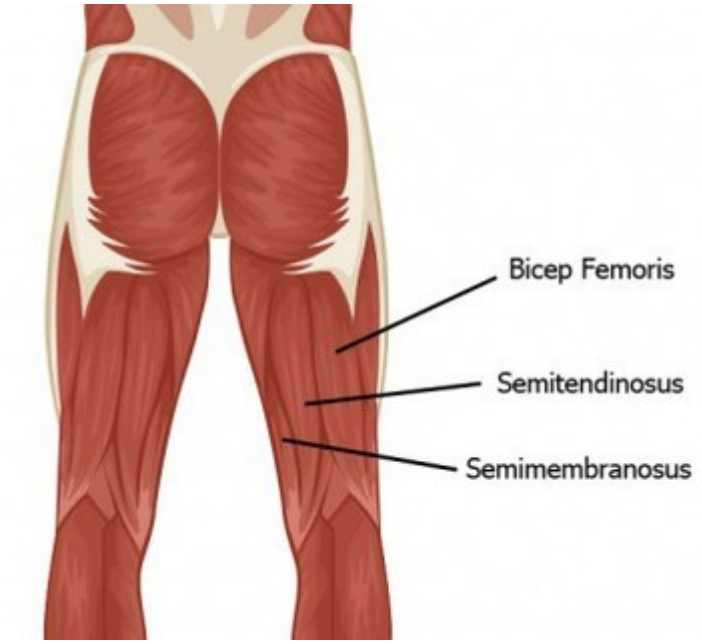
Picture 3. The Hip Flexors. (Website of The Doctors of Physical Therapy 2021)

Multiple muscles in the lower extremity attach from the lumbar spine of the pelvis (e.g., Psoas Minor and Psoas Major) and effect in stability and mobility of the spine. Picture for illustrates the gluteal muscles, Gluteus Medius (GMe) provides stability to the hip through external rotation and abduction with support of the Gluteus inimus (GMi), while the Gluteus Maximus (GMx) performs extension of the hip. (McGill, 2007.)



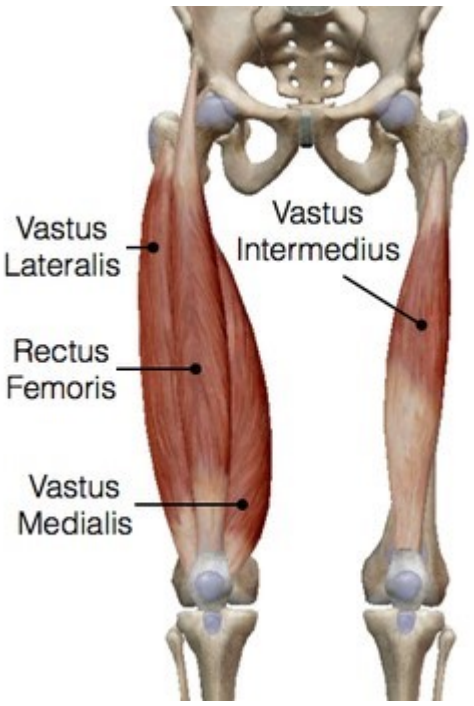
Picture 4. The Gluteal Muscles. (Website of Chris Butler Sports PT 2021)

The Semitendinosus, Biceps Femoris and the Semimembranosus illustrated in Picture 5 create flexion of the knee and extension of the hip these muscles originate from the Tuberosity of the Ischium and insertion to the fibula and tibia. (McGill, 2007.)



Picture 5. Flexors of the Knee. (Website of Ann West Yoga. 2021)

Picture 6 show cases the Quadriceps muscles shown in group is gathered by 4 muscles and perform extension of the knee Vastus Lateralis, Vastus Medialis, Vastus Intermedius and Rectus Femoris respectively, these muscles create extension of the knee. The Rectus Femoris also creates flexion of the hip. (McGill, 2007.)



Picture 6. The Quadriceps muscle group. (Website of Mobile Physiotherapy Clinic 2021)

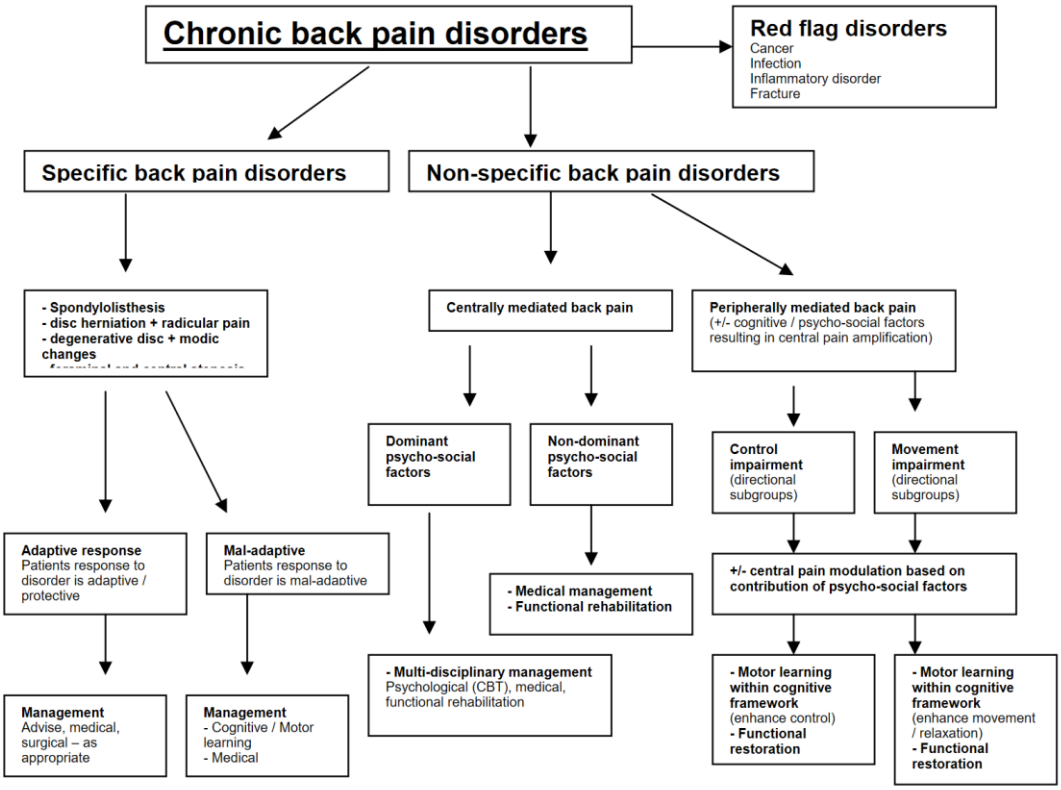
4 NON-SPESIFIC LOW-BACK PAIN

Non-specific low back pain is defined as unknown source or unrecognizable pathology in the human body (Physio-pedia 2021). The lifetime prevalence of non-specific low back pain is estimated at 60% to 70% in industrialized countries, one-year prevalence 15% to 45%, adult incidence 5% per year (World Health Organization 2021). However Specific low-back pain can be related or attributed from a clinically discovered pathology e.g., lumbar spine fracture, cauda equina, osteoporosis among other diseases. NSLBP can be categorized in 3 different subtypes these include acute, sub-acute and chronic LBP. These different subtypes have been categorized on the duration of the LBP experienced. Acute LBP is defined with pain sensations less than 6 weeks. Sub-Acute LBP is defined from 6-12 weeks and Chronic LBP of a pain duration of at least 12 weeks or more. (Physio-pedia 2021.)

NSLBP is a subjective, complicated and a very individual experience which varies from person to person. Management and intensity of pain the person experiences from muscle sprains or strains may be unimaginable but for others they may experience mild to minimal pain symptoms. The episodes of pain experienced can vary from a day to even months gradually increasing in intensity. The possibility of flare up and subsiding pain runs in similar fashion. In other words, LBP symptoms and pain experiences vary tremendously, and it is important as a patient to identify personal pain levels which will benefit in more successful treatment. (Physio-pedia 2021.)

4.1 Non-specific Low-Back Pain and classification

Strong evidence shows NSLBP disorders are associated with combinations of lifestyle, social, cognitive, neurophysiological which includes changes in the central and peripheral nervous system, as well as physical and behavioral factors (O'Sullivan 2005, 242-255). Picture 7 identifies chronic back pains disorders and different classification, with the combination of the mentioned factors, the potential of promoting fear avoidance, hypervigilance, catastrophizing, and negative beliefs which are all under maladaptive cognitional behavior (Vlaeyen & Morley 2005). Movement and pain behaviors may result in a brutal cycle of reinforcing disability and sensitization of pain (O'Sullivan, 2005, 242-255).



Picture 7. Illustration of Chronic Backpain disorders and different classifications. (O'Sullivan 2006)

Many structures in the lower back can cause pain and it experiences heavy forces and loads each day which can be from spinal twisting to unilateral carrying, sitting standing and poor posture. Our bodies being built from bony structures to connective tissues can be prone to injury or overuse causing pain, some common anatomical aspects can create LBP and pain in general such as supportive muscles of the spine, spinal nerves that intervene from the spinal canal, connective vertebrae of the spine and more specifically the facet joints as well as well as intervertebral discs. All these anatomical causes help support the spine in shock absorption, twisting and rotation of the spine. (Physio-pedia 2021.)

4.2 Evaluation of NSLBP

Physiotherapists daily use the visual analogue scale (VAS) in assessing perception of pain whether it is the shoulder or lower back. Other tools to assess pain are Range of Motion (ROM), Oswestry Disability Index (Fairbank, Couper, Davies & O'Brien

1980), to assess functional disability caused by LBP, this form has been standardized in evaluating the functional activity of NSLBP before and after interventions (Seif, Alenazi, Hassan, Kachanathu & Hafez 2015). Table 1 characterizes a movement control test battery created by (Luomajoki, Kool, de Bruin & Airaksinen 2008, 2-4) to evaluate movement control of the lower back, which includes six (6) tests with 2 tests having two (2) variations; Waiter's bow (flexion control), Pelvic tilt (extension control), One leg stance (rotation/lateral flexion control), Sitting knee extension (flexion control), Rocking 4-point kneeling (extension control), Prone knee bend (extension control), Prone knee bend (rotation control).

Table 1. The intertester reliability of the movement control tests of the low back. (Luomajoki, Kool, de Bruin & Airaksinen 2008, 3)

Test	Luomajoki et. Al 2007	Van Dillen et al. 1988	White & Thomas 2002
Waiters Bow (Flexion control)	0.62		
Pelvic Tilt (Extension control	0.65		
One leg stance (Rotational / lateral flexion control	0.54		
Sitting knee extension (Flexion control)	0.72	0.58	0.17
Rocking 4-point kneeling (Flexion control)	0.57	0.78	0.62
Rocking 4-point kneeling (Extension control)	0.68	0.51	0.39
Prone knee bend (Extension control)	0.47	0.76	0.22
Prone knee bend (Rotation control)	0.58	0.43	

This is the first study demonstrating a clear difference between patients with LBP and subjects without back pain regarding their ability to actively control the movements of the low back. There is also a significant difference depending on pain duration. Patients with chronic LBP have significantly more positive tests than those with acute or subacute LBP. (Luomajoki, Kool, de Bruin & Airaksinen 2008, 2-4.)

4.3 Types of NSLBP

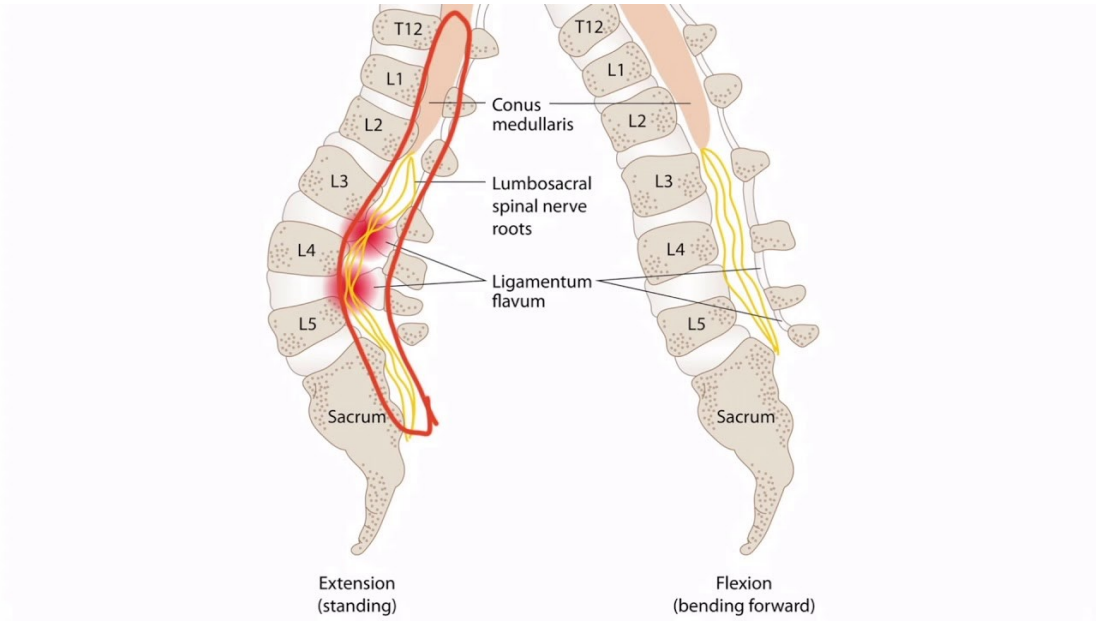
There are 3 main classification types of LBP that have been commonly described when the patient is describing their pain sensations, the area of distribution and relations to symptoms are very important to determine a diagnosis for LBP (Physio-pedia 2021).

4.3.1 Axial

Axial pain is the most common cause of LBP, this type of pain is described and located in one specific area. Axial pain is many times described in numerous ways such as comes and goes, constant, throbbing, dull and sharp. Muscular strains, facet joint and annular tear in vertebral discs is a common cause of axial low back pain. (Physio-pedia 2021.) In a survey made by (Förster et al. 2013) concluded that chronic axial low back pain has a high socioeconomic impact. (Schmidt et al. 2009) concluded that the lifetime prevalence of moderate to severe chronic LBP has a rate of 30–50% in an ageing society which lays a large economical and clinical burden to the society (Schmidt et al. 2009).

4.3.2 Radicular

Radicular pain is mainly caused by a compression or inflammation to the spinal nerve root or spinal canal. Radicular pain is very commonly described as a shooting or an electrical shock-type pain that travels from the lumbar spine to the leg and toes of the feet. Sciatica and radiculopathy are other terms used when describing radicular pain which are accompanied with numbness and / or weakness alongside other symptoms mentioned earlier. Picture 8 illustrates pathological or medically diagnosed specific conditions such as intervertebral disc herniation, spondylolisthesis, or spinal stenosis. (Physio-pedia 2021). Radicular pain is categorized as nociceptive pain, differs in a way that axons are stimulated from the perineurium not in their peripheral terminals (Bogduk, 2005).



Picture 8. Lumbar Radiculopathy (Intervertebral disc herniation). (Website of Physiopedia. 2021)

4.3.3 Referred

Referred pain (RP) is being experienced in different parts of the body other than the anatomical cause origin. (RP) tends to move around from location to location and varies in pain intensity. E.g., degenerative disc disease is a medically specified/diagnosed LBP disease which may cause pain to the hip area and posterior compartments of the thighs. (RP) is pain that is identified separately from the actual source of pain. (Bonica & Loesser 2001, 196-221.)

5 RISK FACTORS IN NSLBP

LBP is a common indicator for golfers with an increased risk of chronic injury. Repetitive stress and poor loading throughout the body that are stressing ligaments, tendons and other soft tissue accompanied by weak gluteal and trunk muscles

connecting to the vertebrae of the spine may lead to LBP. (McGill, 2007.) Low back pain has been experienced by 3-4 children out of 10, during their adolescence. Approximately half of these children have experienced LBP persisting more than 3 months, impacting important day-to-day activities like school and participation in physical activities. (International Association for The Study of pain 2021.)

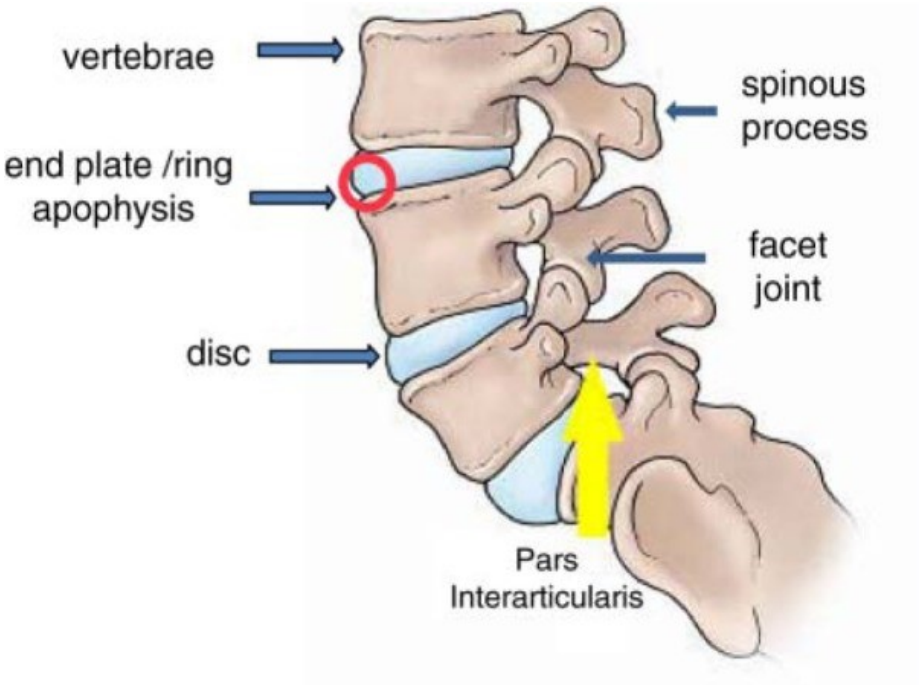
5.1 Age

Age-related factors considering NSLBP may have singular or multiple causes simultaneously, these causes can include periodical growth spurts, which can result in that the soft/connective tissue: ligaments and muscles are failing to keep up with the rates in comparison to bone growth, therefore can result in imbalances of muscle strength as well as a decreased amount of flexibility throughout the body. These imbalances can place young athletes into a greater risk of injury. (d'Hemecourt, Gerbino & Micheli 2000, 663-679; Simon, Jih & Buller 2002, 306-325.) Growth cartilage and secondary ossification centers are present only in the skeletally immature and are more vulnerable in risk of injury, to name a few include imbalanced force transfer, compression, distraction, and torsion injury (d'Hemecourt, Gerbino & Micheli 2000, 663-679; Watkins, RG 2002, 147-165.)

5.2 Anatomy

The anterior column of the lumbar spine (L1-L5) is structured of vertebral bodies also known as vertebrae, each vertebra is separated by intervertebral discs, which are illustrated in Picture 9. Epiphyseal growth plates are located at the top and bottom of each vertebral body, with overlying cartilaginous end plates or ring apophyses. These discs have three (3) main functioning properties: To keep each vertebra in fluent positioning which are held by strong ligaments, to also act as shock absorbers within the spine, and allow minor movement within the spine. (Spine-Health 2017.) The ring apophyses that are located within the vertebral bodies are connected to the outer anulus fibrosus. One cause of injury can be that the intervertebral disc may herniate most commonly posteriorly through the ring apophysis, which is a secondary ossification

center, with repetitive flexion. Injury to the ring apophysis may result in avulsion fractures (Purcell & Micheli 2009, 212-222.)



Picture 9. Anatomy of the lumbar spine. (Purcell & Micheli 2009, 212-222)

The posterior column of the lumbar spine consists of a neural arch, which includes the Spinous processes, facet joints and the pars these anatomical parts are illustrated in picture 9. Ossification of the posterior column of the spine progresses from front to back (anterior to posterior) and may be naturally incomplete in the superior portions of the pars interarticularis of the lower lumbar vertebrae, particularly in the L5 section, predisposing to spondylolytic stress fractures. (d'Hemecourt, Gerbino & Micheli 2000, 663-679; Zetaruk 2007, 109-140.) Worth mentioning is that the presence of spina bifida occulta which is located at the lumbosacral junction may appear to be another additional risk factor for spondylolysis, although this categorized as a medical diagnosis of the spine. In addition to that the Cartilage within the facet joints and spinosus processes of the posterior arch are subjected to traction from dorso lumbar fascia and lordotic impingement. (d'Hemecourt, Gerbino & Micheli 2000, 663-679.)

5.3 Gender and puberty

It has been shown that overuse injuries occur more often in athletes experiencing rapid growth during puberty (d'Hemecourt, Gerbino & Micheli 2000, 663-679; Zetaruk 2007, 109-140). Puberty is the transition period from early childhood to adolescence all the way to adulthood and takes place only in a couple years, both the body and mind is undergoing changes. The most evident morphological changes happen with increased height and changes in body composition. These changes have been proposed to have impact in low back pain. During growth spurts, it has been found that an average gain of 10-cm in height may occur per year. (Malina & Bouchard 1991.) This could be considered a particularly vulnerable period due to the sudden mechanical loading changes happening within the spine. Puberty is very well known as an important and crucial time period towards the hormonal development within boys and girls, also the different pubertal stages are positively associated with the level of sex hormones in both boys and girls. (Yilmaz et al. 2005, 476-482.) Consequently, it has also been suggested that hormonal changes within boys and girls appearing at puberty may be influencers to the perception of pain experienced (Racine et al. 2012, 602-618).

The significance of gender and puberty separately or combined can play a large role of possible low back pain starting in early childhood (Calvo-Muñoz, Gomez-Conesa & Sanchez-Meca 2013; Kjaer, Wedderkopp, Korsholm & Leboeuf-Yde 2011, 98). Two previous systematic literature reviews made by (Calvo-Muñoz, Gomez-Conesa & Sanchez-Meca 2013; Hill, Keating 2009, 272-284) mentioned that the lifetime prevalence of low back pain increases between the ages of 7 and 12 (on average from 1% to 17%) possibly. In consideration of low back pain, it appears that puberty is the time for a possible rapid increase. During this time the risk of low back pain during growth spurts may also continue to later stages of adolescence all the way up to the age of 20. (Leboeuf-Yde & Kyvik 1998, 228-234.) Rate of growth and maturation is individual and varies from child to child, resulting in significant differences in strength, size, and skeletal maturity among children of the same chronological age. Children between the ages of 6 and 10 years of age, on average, may grow approximately 5 to 8 cm per year and may gain approximately 2 to 3 kg per year. During each child's adolescence, the rate of growth increases, with typically height

occurring first, which is then followed by weight increase. When comparing girls to boys they enter their adolescent growth periods approximately 2 years in advance to boys which is shown in table 2 and reach their maximal growth velocity approximately 2 years earlier. Girls also tend to gain weight and height simultaneously while reaching their maximal growth during puberty. In addition, girls tend to gain about 7 kg in fat-free mass per year, whereas boys gain almost twice the amount. (Malina & Bouchard 1991.)

Table 2. Growth characteristics during the adolescent growth spurt for girls and boys. (Malina & Bouchard 1991)

Growth Characteristics	Girls (years)	Boys (years)
Age at start	9-10	11-12
Age at maximum growth	12	14
Age at which growth slows	>12	>14
Age until growth continues	16-18	18-20
Age at maximum length growth	11-13	13-15

Timing and tempo of growth periods vary among children. Smaller or skeletally less mature children may potentially be at higher injury risk when in contact with bigger children / players, this is more problematic in contact sports such as ice hockey. (Simon, Jih & Buller 2002, 306-325; Zetaruk 2007, 109-140.) When taking into consideration other factors such as training intensity and increased volume may also lead to injuries (Malina & Bouchard 1991).

5.4 Exercise competence

In a study made by (Zetaruk 2007, 109-140), concluded that injuries may occur more often with young athletes participating in sports that are spent over longer periods of time such as tournaments and training camps.

One challenge specifically with young athletes in training is the difficulty determining appropriate amounts of training volume to withstand different training tolerances, some players may tolerate a more intense training program than others during puberty. (Zetaruk 2007, 109-140.)

5.5 Conditioning

Poor technical movement patterns and sequencing have an increased risk of injury at any age. Weakness of; abdominal muscles, hip flexors, hamstring, tightness of thoracolumbar fascia as well as thoracic kyphosis are all factors that increase the risk of LBP. (d'Hemecourt, Gerbino & Micheli 2000, 663-679; Zetaruk 2007, 109-140.) These risk factors have an influence on increased lumbar spine lordosis which place additional mechanical stress on the spine (Purcell & Micheli 2009, 212-222).

BMI has been positively related towards LBP in recent years (Edwards, Dickin & Wang 2020, 10-18). In a cross-sectional study, results showed that it is important to consider that the assessments based on BMI, could be a complicating factor due to the changes in body composition that occur during sexual maturation of the adolescent. (Silva, Badaro & Dall'Agnol 2014, 402-409.)

Clinical evidence has shown that smoking cigarettes including nicotine, a toxic chemical called nicotine enters the bloodstream causing inflammation in the blood vessels and causes blood vessels to narrow. In result of this, nutrition to the bones, joints, nerves among other soft tissue as well as the functioning of the heart and lunges start to degenerate. (International Spine & Pain Institute 2021.)

6 OVERVIEW OF THE GOLF SWING

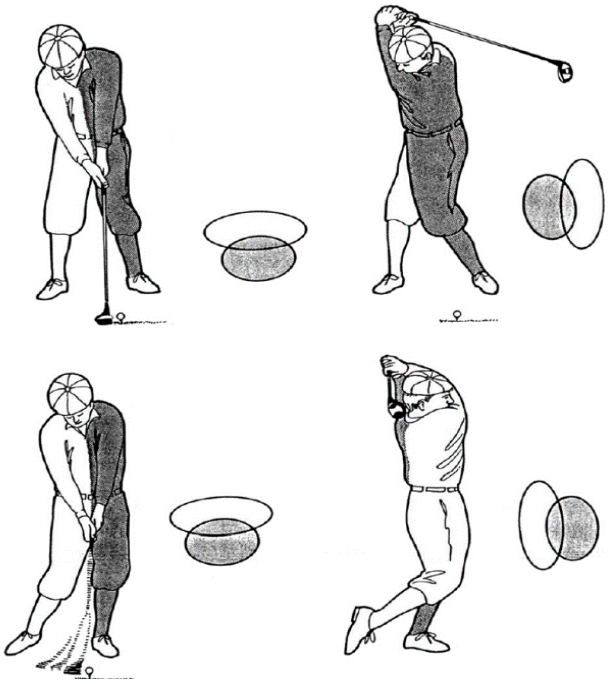
The golf swing to a non-golfing person may look like a somewhat simple and non-loading movement, however the ability of creating an effective and repetitive perfect swing is not one easy activity. Currently there is a vast amount of information and literature available about the golf swing, as well as the increasing camera / computer technology available (e.g., golf club and swing-path analyzers) we can quickly analyze, improve, and enhance each swing to a more efficient outcome. The golf swing is typically sectioned in to 4 different stages; take away, downswing, ball striking and follow-through (Adlington, 1996, 26). Each player's golf swing can be as unique as their fingertip or DNA with many different club movements, but in general terms the golf swing can be categorized in to two main styles that have different swing patterns and adoption of body movement in different sequences. These swing comparisons that are seen in table 3 are called the "Classic golf swing" and the "Modern golf swing" both of these swings have their unique characteristics that will be portrayed below. (Finn, 2013, 313-319.)

Table 3. Comparison of the Classic and Modern swing during each swing phase (Finn, 2013, 313-319)

Swing Phase	Classic Swing	Modern Swing
Address	Similar to modern swing	Similar to classic swing
Backswing	Body moves in relative union	Separate hips and shoulder
Top of Backswing	Shoulder/hip rotation relatively same Body sway to trail side	X-factor (shoulder/hip separate as much as possible Pivot on trail leg
Downswing	Entire body starts downswing as 1 unit	Hips start downswing, followed by shoulders and then arms.
Impact	Shoulder/hip relatively equal and Minimal trunk flexion toward trail side	Hips open to target more than shoulders. Increased lateral trunk flexion toward trail side.
Follow-Through	Lumbar spine neutral	Reverse C (Lumbar hyperextension)

6.1 Classic swing

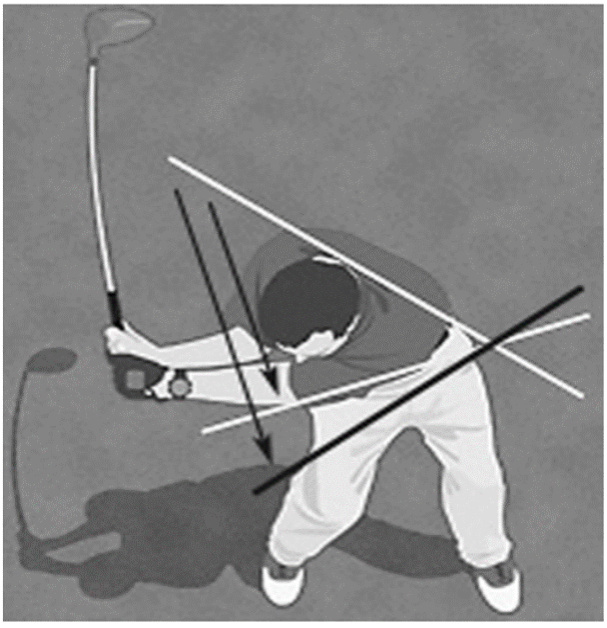
The classic golf swing highlights a reduction of the "X-Factor", in comparison to the modern golf swing the classic golf swing features a rising heel of the front foot during the take-away which ultimately increases hip rotation, the classic golf swing often features a shortened take away or a combination of the large hip rotation mentioned previously (Stover, McCarroll, & Mallon 1994, 97-108; Hosea & Gatt 1996, 37-53, By creating this movement, the separation of hips and shoulder at the top of the swing decreases spine torsion and loading to the soft tissues and facet joints of lumbar spine. Alongside the reduction of hip and shoulder separation the classic golf swing has a reduced amount of lateral bending or also known as "crunch factor", in comparison to the modern swing the classic swing which can be seen in picture 10, is concentrated more on a balanced and upright position during the finish position of the swing. With these differences studies have shown that the classic golf swing has a decrease of club head speed and ball-striking deficiencies. (Bulbulian, Ball & Seaman 2001, 75.)



Picture 10. The swing sequence of the "Classic golf swing" featuring increased hip and shoulder rotation (top right). White circle: shoulder positioning & Black circle: hip positioning. (Gluck, Bendo & Spivak 2008, 778-788)

6.2 Modern swing

The modern golf swing highlights in a larger shoulder rotation with restriction of hip turn. This reduction of hip turn is mainly affected by the minimal heel elevation of the front foot moving of the ground during the take-away stages of the golf swing, with this movement is thought to minimize extra activity in lower extremities and leading to a more consistent strike of the golf ball by more effectively returning the golf club to its starting position. (Gluck, Bendo & Spivak 2008, 778-788.) The maximum hip and shoulder separation angle increases spine torsion loading at the end of the takeaway or also known as the "top of the golf swing" during this position the viscoelastic elements are in their maximum stretch and the increase of rotation which allows the player to deliver the golf club to the golf ball with increased club head speed, this maximum hip and shoulder turn, also known as the "X-Factor" in the golfing community (Lindsay & Horton 2002.) This maximum separation is illustrated in picture 11 below with lines being located along the axial orientation of the hips and shoulders, during the transition from the top of the swing to the start of the downswing (Gluck, Bendo & Spivak 2008, 778-788).



Picture 11. Illustration of static (white lines) and dynamic (black lines) of the "X-Factor" (Gluck, Bendo & Spivak 2008, 778-788)

The modern swing also creates a “reverse C” position. This position may also become problematic for golfers performing the modern swing due to the increase amount of lateral bending on the trailing side of the body. In golfing terms this also known as the “crunch factor” allocating an exaggeration of hyperextension in the follow through phase of the swing, however these exaggerated positions of supramaximal rotations and separation of the lower and upper body tend to put excessive strain on to the body causing possible trauma especially to the lower back. (Gluck, Bendo & Spivak 2008, 778-788.)

6.3 Anatomy and biomechanics during the swing

Despite golf may look like a less physically demanding sport, the swing generates vast amounts of different forces. Studies have shown that Axial twisting itself has been identified as a potential risk factor for LBP. (Marras & Granata 1994.) The exposure of strong compressions, lateral bending, torsion, and anterior-posterior shearing towards the lumbar spine can increase the risk of developing low back pain. One of the main loading structures during the golf swing is cancellous bone of the vertebra managing approximately 50% of the compression forces created, as the shock absorber the nucleus pulposus takes the main role, as well as 20% of spinal compression is placed on the facet joints according to studies. (Hosea & Gatt 1996, 37-53.) A study done by the same authors (Hosea & Gatt 1996, 37-53) had been performed to discover compression loads with the use of surface electrodes located to L3 & L4 vertebral levels on the external obliques, rectus abdominis and the erector spinae muscles, The myoelectric data showed that the golfer produced approximately 8 times their body weight of compressive forces to L3 & L4 vertebral levels or approximately 6,100 ± 2,413 N in amateur golfers and 7,584 ± 2,422 N in professional golfers during the golf swing. A study had been made of measuring similar compression forces of Div. 1-A collegiate American football players creating loads of 8,679 ± 1,965 N when tackling blocking sleds (Gatt, Hosea, Palumbo & Zawadasky 1997, 21). These forces have shown to being tremendous when taking into consideration that cadaveric studies that have been made showing the possibility of disc prolapses with compression loads of 5,448 N (Ekin & Sinaki 1993, 70).

Facet joints resist over 50% of anterior – posterior shear loading (White & Panjabi 1990). Studies have also shown estimated peak shear forces of 596±514 N in amateur golfers (Hosea, Gatt, Galli, Langrana & Zawadasky 1990, 8). In addition to these forces lumbar spine compression fractures have related to an increased risk in patients diagnosed with osteoporosis (Ekin & Sinaki 1993, 70). The rotation of the lumbar spine is limited due to the anterior parts of annulus and posterior facet joints, however flexion and extension combined with moderate lateral bending is achievable, although minimal axial rotation is secondary to the orientation sagittal to the posterior facet joints (Grauer & Panjabi 2002, 41). According to (Farfan & Gracovetsky 1984, 9) microtrauma in the facet joint within the lumbar are can already occur with 2–3 degrees of intersegmental rotation. This can be problematic with golf instructors who emphasize on loading the lumbar spine with large amounts of torque to ultimately increase speed throughout the golf swing, evidence has shown that the most common cause of lumbar spine disc herniation is caused by the increase of lateral bending with a combination of torsion and compression, despite the fact, that all of these are significant components in the golf swing. (Tall & DeVault 1993, 8.)

6.4 Etiology related to the swing

Some muscles of the lower extremity that create movement of the hip can apply forces onto the pelvis due to their points of insertion. The orientation of the lower extremities, pelvis and lumbar spine have a direct effect on the efficiency of the stabilizing muscles in the surrounding areas, also the muscles' ability to create forces are required to perform proper movement patterns. Low back disorders have large variance in etiologies in correlation with pain in different areas of the body due to the complexity of movement. In a study made by (McGill, 2007), came to conclusion that individuals experiencing chronic LBP, specific gluteal muscle activation training decreased the amount of experienced pain in the past (McGill, 2007).

Lumbopelvic movements depend on the individual's personal movements and the activity's the required muscles anatomical patterns require. Repetitive movements result in adaptations of muscles which can accommodate the movement demands. (Edwards, Dickin & Wang 2020, 10-18.) In a study made by (Sadeghisani,

Shaterzadeh & Karimi 2017) concluded that individuals who performed in rotational activities more than two times per week had an increase of external hip rotation to their dominant limb. Some limitations in pelvic or lumbar regions caused the other are to compensate through abnormal movement patterns, influencing risk to injury (Redmond, Gupta, Nasser & Domb 2015, 49-55).

Based on analysis the limitation of lumbar spine axial rotation and compressive torsional loading, there is a reason to believe that the most common cause of acute or sub-acute LBP is because of soft-tissue damage which can include: Degradation of the internal disc, muscle strain as well as trauma to the facet joints (Chilton & Nisenfeld 1993, 55). The golf swing being a repetitive movement creating vast amounts load to the lumbar spine, is unfortunately disposing golfers to potential injuries including muscle strains mentioned earlier to herniation of nucleus pulposus, vertebral and pars interarticularis stress fractures, spondylolisthesis, and facet joint arthropathy (Hosea, Gatt, Galli, Langrana & Zawadasky 1990, 8).

6.5 Overuse injuries as a risk factor

Overuse injuries are frequent with golfers, but prevalence of injury is not based on skill levels. The levels of skill differences between amateur and professional golfers often reflect to the amount of practice time towards improving technical aspects in the game of golf as well as performance related physical training. Professional golfers tend to experience overuse injuries because of increased frequency of practice with reduced golf swing variance. (Gluck, Bendo & Spivak 2008, 778-788; Horan, Evans & Kavanagh 2011, 1474-1483; McHardy, Pollard & Luo 2007, 1345-1360.) In comparison injuries of amateur golfers tend to be multifactorial; injuries frequently occur from improper swing technique alongside muscle imbalances. The lower back, elbow, and wrist are at higher risk towards overuse injuries. The Lower back is the most commonly injured area for professional golfers and amateur golfers and for both male professional and amateur golfers, the lower back is the most frequently injured area. (McHardy, Pollard & Luo 2007, 1345-1360.)

6.6 Poor swing technique as a risk factor

Injuries to the lower back, often denoted by low back pain (LBP), have a wide etiology. The golf swing represents one element that contributes to lower back injuries and muscular imbalances because of its asymmetric nature (Murray 2008, 10-14). In this same literature review concluded by (Murray 2008, 10-14) they mentioned that the risk of developing LBP increases when there are technique flaws present in the swing that cause the improper loading of spinal structures. In a one-year follow-up study it was determined that with adequate physical preparation, the body can adapt to and manage the stresses of the golf swing. However, injury risk further increases if a golfer lacks adequate mobility. Because improper golf swing technique compounds musculoskeletal stresses experienced during the swing, technique flaws are a leading contributor to LBP in amateur golfers. (McHardy, Pollard & Luo 2007, 1345-1360.)

7 PREVENTION OF NSLBP FOR YOUNG COMPETITIVE GOLFERS

As the game has become more demanding physically, golf coaches have started to slowly recognize the importance of stability and mobility within the body to cope with the strain and stress the golf swing creates, with young rising athletes. Players and coaches are starting to put more emphasis on training (not only towards the golf swing) with fitness trainers as well as physiotherapists to avoid LBP, although the player is in the leading position and has the ultimate decision, they are becoming more informed of what it takes to become a fulltime athlete. Prevention in sports has become very important in the modern world and more awareness should be carried out, especially with young athletes in their early stages in their careers. (Thorborg, Opar & Shield 2020, 145-164.)

There are 3 different approaches to sports injury prevention: Primary Prevention (PP) prevention of the initial injury. Secondary prevention (SP) improving as well as

reducing the impact of current injury that has occurred. Tertiary prevention (TP) improving treatment and recovery. (Thorborg, Opar & Shield 2020, 145-164.)

In previous decades, initiatives have been undertaken to develop strategies towards injury prevention. There has been an exponential increase in knowledge, research, technological developments, implementation efforts and even international conferences focusing on sports injury prevention. (Thorborg, Opar & Shield 2020, 145-164.)

7.1 Primary

Primary prevention (PP) where the exposure to possible injury is reduced, meaning that prevention techniques are done before an injury or accident occurs, although in many instances this is not a possible option. (PP) techniques may be used also in the secondary prevention approach with aims of increasing stability and mobility throughout the body. (Thorborg, Opar & Shield 2020, 145-164.)

Only minimal evidence is available concerning primary prevention on NSLBP, although high relevance is present despite modern days. A systematic review showed that only physical activity and exercise have a possibility of preventing LBP from occurring (Borghuis et al. 2008). They also concluded that e.g., spinal bracing and avoidance of lifting or carrying heavy loads do not prevent NSLBP. As a result, effectiveness of a preventative multi-model exercise program including essential physical activities which include muscle strengthening, motor control, endurance and postural control exercise seemed encouraging. The regularity and individualization of the listed exercise modalities have shown vast potential towards primary prevention of NSLBP. (Steffens et al. 2016, 199-208.)

A systematic review and meta-analysis recently published by the same authors (Steffens et al. 2016, , 199-208) confirmed these results. 23 data manuscripts were pooled which included a tremendous 30,850 attendees. Moderate level evidence supported the hypothesis of exercising combined with patient education reduced the risks of NSLBP occurring (relative risk = .55) Exercise only showed to be effective

but had a higher risk towards NSLBP (relative risk = 0.65) and patient education with very low quality evidence showed not to be effective in prevention of NSLBP, the same was concluded also with other intervention techniques such as shoe insoles and spinal belts, which neither showed any indications of preventing NSLBP. (Steffens et al. 2016, 199-208.)

All of these considered patient education combined with exercise have shown the ability to reduce NSLBP from developing. To the amount of exercise needed to show effectiveness a u-shaped association should be assumed. Despite the fact that conflicting evidence has been found, initial hints have indicated that a u-shaped relation is present involving the degree of exercise and NSLBP. (Steffens et al. 2016, 199-208.)

A distinguishable fact is let alone the amount of exercise and physical activities, but the characteristics of them playing a very important role. Heavy workloads as well as unnatural postural positions of the lower back are strong risk factors of developing LBP. (Heneweer, Staes, Aufdemkampe, Van Rijn, & Vanhees 2011, 826-845.) The studies concluded that the importance of exercise plays and important role in preventing NSLBP and that the amount of exercise and physical activity and the individualization of these activities are crucial (Niederer, Vogt & Banzer 2018, 262-266).

7.2 Secondary

Secondary prevention is the most common type of prevention which takes place after injury or trauma and the prevention mainly is therapeutic rehabilitation with the aim of rebuilding stability and mobility post-trauma as much as possible to have a possibility to return to play or normal daily living. (SP) uses proper rehabilitations methods and strategies (e.g., cold therapy, aqua therapy, or ultrasound) to recover from injury in the most optimal way. Primary prevention techniques (e.g., therapeutic exercise) may be used also during secondary prevention. (Thorborg, Opar & Shield 2020, 145-164.)

7.3 Tertiary

Tertiary prevention which is to reduce or eliminate disabilities and long-term impairments as well as minimizing suffering, the main focus of tertiary prevention is dealing with the consequences of injury not that much of pre-injury prevention. (Thorborg, Opar & Shield 2020, 145-164.)

7.4 Injury prevention related to young competitive golfers

Injury prevention has become a more known subject in the sporting world. Each sport has become more demanding physically and mentally, which consequently puts more stress on the body, with an increased risk of injury either through trauma, overuse injuries, poor recovery, or poor diet or with a combination of others or in the worst-case scenario each factor is being neglected. Insufficient warm-up may increase the risk of future injury. (Junge et al. 2011, 57-63.) Injury prevention has a very important role considering future careers in athletes regardless of sport or daily living but seems to be neglected with thoughts that if pain isn't present, injury will not occur. Injuries tend to be treated post trauma or when an accident occurs. Known prevention techniques can be a 5–10-minute warm-up before starting sporting activities this includes a brisk walk of light jog, passive, and dynamic stretching. Off-course mobility and stability training. Strengthening of core and pelvic girdle muscles are key areas for golfers which experience the most stress during the golf swing, with a mixture of flexion, extension, rotation, and lateral bending. The golf swing being a unilateral movement increases the importance of reducing muscle imbalances and improving stability and mobility bilaterally. (Finn, 2013, 313-319.)

Warm-up is a part of a multi-model approach (Ekstrand, Gillquist & Liljedahl 1983). Sports-related warm-up strategies have focused on additional strength and conditioning training aimed towards general injury prevention. These types of warm-up strategies have been studied in relation to other sports, such as balance training using a wobble board in basketball (Emery, Rose, McAllister & Meeuwisse 2007, 17-24.) And specific warm-up exercises in volleyball (Gouttebarge, Zwerver & Verhagen 2017, 333), handball (Andersson, Bahr, Clarsen & Myklebust 2017, 1073–1080.) and

basketball (Bonato, Benis, & La Torre 2018, 1451-60). Each randomized control trial has shown with sports-related warm-ups have been effective in reduction of sports injury rates (Thorborg, Opar & Shield 2020, 145-164).

7.5 Exercise loading, biomechanics, and patient education

Acute injuries occur when forces exceed tissue plasticity thresholds momentarily during movements, in comparison chronic injures do not tend to exceed tissue plasticity levels during movement, repetitive movements expose structural stress leading to injury. Soft tissues allow adaptation to repetitive movement but if either external or internal stresses are occurring, or both simultaneously which are exceeding structural thresholds acute damage may occur, resulting in permanent tissue injury (Flanagan, 2014). Tissues adapt to stress and recover stronger, due to the strain and moderate load experienced during different movements, abnormal movements can produce abnormal tissue stress which can lead to structural damages that may lead to acute, sub-acute or chronic injuries. If proper rest and recovery is not performed tissue fatigue will increase the risk of developing injures. (McGill, 2007, 58-75.)

Interestingly, body mass index (BMI) has been negatively connected towards LBP development in younger golfers (Evans, Refshauge, Adams & Aliprandi 2005, 122-130). Golfers with BMI more than 25 experienced more episodes of LBP from activities outside of golf (Gosheger, Liem, Ludwig, Greshake & Winkelmann 2003, 438-443). Body composition could have an impact on the distribution of forces during movements who have higher BMI (Smith, Hawkins, Grant-Beuttler, Beuttler & Lee 2018, 538-546). Golfers who have wider swing arcs are encouraged to have more musculature to cope with the increased forces to the lumbar (Evans, Refshauge, Adams & Aliprandi 2005, 122-130). Increase of age has also been connected to risk of LBP. Age and BMI should be considered alongside physical abilities and the golfer's technique while addressing LBP. (Finn, 2013, 313-319.)

8 EXERCISE PROGRAM BASED ON EVIDENCE FOR PERFORMANCE ENHANCEMENT

Evidence has shown that correlation of physical imbalance and poor swing techniques should be prioritized within each individual golfer. A randomized controlled clinical trial showed that core strength is essential, and that hip and scapula stabilizers also have a role in preventing LBP (Fukuda et al. 2010, 736-742; Kao, Pink, Jobe & Perry 1995, 19-23). Golf being a unilateral sport the importance of bilateral exercising should be emphasized and that this type of training has lowered the risk of developing LBP in golf (Finn, 2013, 313-319). It has also been shown that muscular imbalance testing for golfers is recommendable every couple of months (Weishaupt, Obermüller & Hofmann 2000, 8). Ankle mobility, hip stability / mobility, thoracic extension / rotation, scapular stability, and shoulder mobility must also be taken into consideration in the golfer (Titleist Performance institute 2011).

Core strengthening has been recommended to be enhanced, and the encouragement of exercises being performed in stable and unstable surfaces has shown to be beneficial for golfers, this has also shown to improve balance and coordination during the golf swing (Imai et al. 2010, 369-375). Although evidence has shown that static anterior & posterior core exercises such as the plank (anterior) and bird dog (posterior) have benefited golfers, also the use of exercise / swiss balls, bosu balls and balance boards have also shown to being beneficial in the prevention of LBP, with the use of such equipment more demanding stability exercises can be done which also include balance and coordination characteristics as these have also shown to beneficial in preventing LBP. (Weishaupt, Obermüller & Hofmann 2000, 8.)

Exercising on unstable surfaces have shown positive signs in the prevention of LBP with the change of primary muscle patterns. For example, curl-up exercises performed on unstable surfaces have showed increased external oblique activity while the activity of the transversus abdominis decreased in comparison to a curl-up performed on a stable surface. (Imai et al. 2010, 369-375.)

The ability to rapidly produce force in the transverse plane can be considered important in a rotational reliant sport such as golf. Medicine ball and cable pulleys have shown to be very useful in rotational sports as they develop and quantify rotational power. (Earp & Kraemer 2010, 20-25.)

The gluteal muscles also play an important role, providing stabilization of the pelvis and creating a base for trunk rotation (Bechler, Jobe, Pink, Perry & Ruwe 1995, 156-160). The inhibition of the gluteus medius specifically during the golf swing also may increase the hip movement laterally and with the potential of increasing lateral bending during impact of the golf ball (Titleist Performance Institute 2011).

8.1 Exercise-Program Feedback

An exercise program was created based on this thesis. One customer utilizing this program is golf instructor Ilkka Helavirta, a certified: Level 5 Finnish PGA coach and instructor. A Titleist Performance Institute (Level 1, Junior Level 1, Junior Level 2 and Power Level 2) certified. The specified exercise program was approved with the concentration in posterior and anterior chain as well as rotation and anti-rotational exercises which are crucial in stability and power development for the golf swing. The exercises included in this program may also be applied as warm-up prior to golf practice and competitive play, as the minimal need of equipment allows movement to be performed regardless of location. (Helavirta, personal communication 3.11.2021.)

9 THESIS PROCESS

The idea of this thesis came from my background in competitive golf and low back pain problems I have suffered during my career. In November 2020 I completed my thesis framework and presented my thesis topic, aims, objectives and thesis schedule

seen in table 4, to the class in December 2020. The literature concerning non-specific low back pain was primarily used from PubMed and NCBI websites, although some literature I was able to obtain from the SAMK-Library. There were difficulties finding literature in relation to the age group that I had for my thesis (12–15-year-olds), as lack of literature on NSLBP for young sporting athletes was evident. While I gathered as much literature needed between February 2021 and April 2021, I was then able to write my thesis without any major setbacks. Writing of the thesis continued over the summer primarily one topic at a time and majority of the thesis was written by the end of September 2021. The writing of the thesis was finished by the end of October 2021, also in October 2021 I researched the exercises to be used in my exercise booklet. The booklet was made in PDF-format by Microsoft PowerPoint, this ensured the easy access and usage for an online PDF-booklet. The exercise booklet was finalized during the first week of November 2021. The thesis was sent for evaluation during the first week of November and the finalized thesis was presented on November 11th, 2021.

Table 4. Schedule of the Thesis Process.

Time Frame	**TOPIC**
November 2020 – December2021	Thesis basic framework, Thesis plan presentation
February 2021	Finding and reading theoretical research of LBP
May 2021 – September 2021	Writing Thesis
October 2021	Thesis, Exercise Program finalization
November 2021	Thesis completion and Presentation

10 DISCUSSION

The reason I chose this topic for my thesis is because of being a competitive golfer myself. The number of competitive golfers in the golfing community is proximately

1%, although the topic is aimed towards young competitive golfers the research and information gathered is applicable for the average golfer of any age group as well. The idea of this thesis was to develop awareness, educate what it is, and what can be done in the matters of prevention of NSLBP.

An exercise guide was created, with the aim of decreasing the possibility of NSLBP. This product will be utilized within my future physiotherapy career, when working with young competitive golfers as well as other individuals that could benefit from this guide.

LBP is one of the most common injuries that golfers tend to have. The game of golf has become a full-on sport and the professional and elite amateur players have become athletes. Conditioning has become very important in the modern era as the golf swing has become demanding on the human body. Strength, mobility, and flexibility should become the backbones in their training programs as the golf swing has become more and more athletic in the last decade or so.

One of the most talked about aspects of the game still to this day, is golf shot distance. The distance aspect has been one of the largest influencers in professional golfers today, as golf courses become longer. The golfers who are hitting the ball the farthest and topped with accuracy, have become the rulers in the top 20 players in the Official World Golf Rankings (OWGR).

10.1 Prevention of injury

Distance has become so important in golf, it has meant that players are now finding ways to create and enhance this aspect, with strength, flexibility, and speed training. Awareness of injury prevention in golf is starting to become a more known aspect in the game, we are seeing professional golfers experiencing more and more low back pain problems and having to go through months of intense rehabilitation to being able to return to the sport. Although low back pain has been very common in other sports like baseball and ice hockey for years, golf has seemed to become one of these sports,

that initiatives of decreasing low back pain should and are encouraged to be pushed forward.

Evidence has shown that muscle strengthening, motor control, endurance and postural control exercises have seemed encouraging in prevention of NSLBP. Like the saying goes “movement is medicine”, movement must be encouraged for all individuals but more importantly the young growing generation should be emphasized.

In the modern world when many things are being strongly computerized and physical activities decreasing due to the lack of time because of school, work and so on, people are starting to be more passive. Sedentary lifestyle for instance, sitting for long periods of time in front of computers in classrooms or at offices have shown to be potential risk factors in creating NSLBP.

Discussions have been taken place with top swing coaches in Finland about low back pain in young elite golfers who they are currently coaching, and many coaches have mentioned that young golfers in the ages of 16 to 18 are starting to recover from their low back pains that they have been experiencing from their earlier ages 12 and 15 respectively.

It is important to consider the age of these young athletes, when they are discovering new skills and interests, it tends to be that when 12- to 15-year-old athletes are playing and practicing and their main of focus is on hitting golf balls and improving their golf swing and that strength and mobility training is left in the background, this aspect must be taken into consideration as a physiotherapist. On top of that puberty changes are at peak times during these ages which can also be a potential risk factor of creating low back pain because of the anatomical and physiological changes the body is experiencing.

One promoter in strength and conditioning is encouraged by the top golfers in the world via social media e.g., Instagram and Facebook videos of their training sessions with physiotherapists and conditioning coaches are now being published. Young amateur players are starting to exercise in the same matter in the belief of, if a top

ranked golfer in the world is doing this to become better, I will start doing the same. The recognition of conditioning done by the top golfers in the world with encouragement might just be the most effective way of creating awareness in the younger golfing generation.

10.2 Multi-professional team

As the game has become more physically and mentally demanding as mentioned earlier, golf is currently having the opportunity of educating golfers of all ages regarding the basic biomechanics and swing patterns by the modern PGA certified teaching professionals.

Titleist Performance Institute (TPI) is the world's leading organization that is dedicated in studying the biomechanics of the swing. Top tier professional and amateur players around the world are being tested and studied, with the goal of reaching the top level of their game physically. With the data collected from the top professional and amateur golfers, TPI has created a thorough screening and assessment method which measures each player's mobility and stability of their feet, ankles, knees, hips, spine, shoulders, elbows, and wrists. With limitations in range of motion of the hips for example, the information will be taken into consideration on how the golf swing may be biomechanically performed so that the golfer is able to make the most efficient golf swing. TPI has also done analysis if physical limitations within the golfer's body may adversely affect their golf swing, which may lead to potential injury. The Titleist Performance Institute level 1 screen has been growing in popularity among health care, fitness, and PGA professionals, but there is no proven gold standard for performance/injury screening in golf. The sooner imbalances and swing faults are identified and corrected, the less likely the golfer will be injured.

The TPI certification program is strongly recommended for PGA teaching professionals, fitness trainers and medical practitioners. The program is based on evidence and is designed to teach professionals in the golfing industry on how to increase performance, with this being said physiotherapists who are working with golfers can be recommended to obtain a TPI-certification, which increases the

physiotherapists knowledge, on how to test and perform the most adequate therapy methods for these golfers.

One major difference in the golfing community in Finland is that when compared to North America, young golfing prodigies are being scouted to high school and later to collegiate education programs and golf scholarships. These sports programs include same performance possibilities which professional golfers have surrounding their multi-professional team such as PGA certified teaching professionals, conditioning coaches, physiotherapists, doctors etc, and the TPI program is strongly utilized with the goal of creating world-class professional golfers to the PGA & European tours.

10.3 External research possibilities

Golf isn't anywhere near the most popular sport in the world (Football, Cricket & Basketball) to mention the top 3 sports currently, but now that golf is included in the Olympics the game has potential of rising in popularity and it has already made a tremendous improvement in Asia where the game has increased also due to the fact of 2020 Summer Olympic Games being hosted in Tokyo, Japan. With the steady growth of the game globally, there is potential of performing research within the game of golf.

Currently no research has been published considering the ages of 12 to 15 regarding non-specific low back pain golf. Perhaps this age group may seem very challenging, due to the multiple factors related to gender and puberty characteristics, and the different types of changes boys and girls are experiencing which were mentioned in this thesis.

The financial aspect may be playing the largest role of being able to provide such research as well. Currently The Finnish Golf Union would most likely have the most influence on future research regarding injury prevention in golfers within Finland. The Finnish golf national team program is utilizing TPI services within the team programs which could potentially be a good opportunity for LBP research in the future.

10.4 Personal research possibilities in the future

Interestingly I would like to research and evaluate the effectiveness of the test batteries I have included in this thesis and the exercises that I have provided with the aims of primary prevention towards nonspecific low back pain for young golfers. The exercise and prevention period should last a minimum of one to two years.

Regarding myself, working as a physiotherapist in the golf industry is one of my main goals. Golf as a hobby has increased dramatically in 2020 and 2021 due to the COVID-19 outbreak. The population has been forced to try out different sports due to the fact of closure of gyms, swimming halls, ice hockey rinks and so on because of the potential risk spreading of the virus.

During the last two summers golf has become a booming sport. The number of registered golfers in Finland have increased by thousands in all age groups from children of 6-7 years of age, up to the elderly and have fallen in love with the game.

The competition level within the professional tour in Finland (Finnish PGA Golf Tour) has also increased due to the COVID-19 pandemic, the success of Finnish players on the European Tour (top tier in Europe) in recent years have also increased the interest towards golf and level of competition in Finland.

10.5 Physiotherapist perspective

A physiotherapist's role needs be to more proactive with young golfers in the Finnish golfing community. This being said, we should be able to further educate and promote well-being and allowing these golfers to have the optimal opportunity to benefit in psychological and physical requirements which may allow them to perform on the highest level within the sport.

The physiotherapists' role in dealing with young patients regarding physical capacity and lifestyle are things that must be taken into consideration when dealing with

NSLBP. A wide and open view should be utilized when we are looking into the development of these children. The current society unfortunately is leading to more sedentary lifestyles, causing children to be more passive in everyday activities. It is important to encourage these young children to attend as many different physical activities as possible. The benefit of this is to increase cognitive and psychosocial skills. As a physiotherapist expertise is showcased in a wider perspective, although these young golfers have the benefits of swing coaches, fitness trainers and nutritionist, the physiotherapist ensures that proper psychological and physical modalities are applied within the future.

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