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Analyzing the Effectiveness of Kinesio-taping in Golf-induced Chronic Low Back Pain Management

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ANALYZING THE EFFECTIVENESS OF KINESIO-TAPING IN GOLF-INDUCED CHRONIC LOW BACK PAIN MANAGEMENT

by

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ABSTRACT

The purpose of this study was to investigate the effectiveness of Kinesio-Taping (KT) in golf-induced chronic low-back pain management. The golfing population continues to grow each year, and the risks of golf-induced chronic low back pain (CLBP) remain high. The Kinesio-taping technique is a non-invasive treatment intervention utilized in sports injury rehabilitation and prevention. Due to the lack of research on KT in golf-related injuries, this study addresses the injury mechanism of golf-induced CLBP and the proposed physiological mechanism and therapeutic effects on the musculoskeletal system of KT. This study is a comprehensive review of the golf swing, prevalence and risk factors of golf induced CLBP, treatment modalities for non-specific low back pain, and the use of KT in sports medicine and healthcare settings.

The target population of this study includes active adults and older adults who are at risk or currently experiencing CLBP and those who may golf professionally or recreationally. The literature search (February- October 2022) was performed using multiple databases, including UCF Libraries, PubMed, GoogleScholar, SagePub, ScienceDirect, and Ebscohost. Keywords employed by this research include “low back*” “golf*” or “golf swing*” “Kinesio-tape*” or “Kinesio-taping*” and “pain*” or “injury*”. Search results were carefully screened, and relevant literature was selected for this study. A total of 78 scientific studies were included in this review. This literature review found insufficient empirical evidence to support the application of KT in golf-induced low back pain management. Although the subjects’ contextual effects should not be overlooked, the reasoning behind how KT physiologically affects target injury sites remains unclear. Further research is suggested to examine the effectiveness of KT in treating golf induced CLBP.

DEDICATION

I dedicate this thesis to three important people in my life:
My mom, my dad, and my partner Alex.
To my mom and dad:
who have taught me the value of hard work and perseverance.
Your guidance and support have been instrumental in shaping who I am today,
and I am proud to be your daughter.
Your unconditional love and sacrifices have made all my achievements possible,
and I am eternally grateful for the unwavering belief you have in me.
To my boyfriend and my best friend, Alex:
you have always been my rock,
my support system, and my constant source of happiness and encouragement.
Your presence in my life has made everything brighter.
Thank you for being my biggest supporter,
for believing in me, and for being my loving partner.

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INTRODUCTION

The golfing population has been increasing over the past two decades. At the beginning of the twenty-first century, there were approximately 55 million golfers worldwide (Farrally, 2003). This number continues to grow. In 2020, the National Golf Foundation reported that there are 24.8 million people who play golf in the U.S., an increase of 500,000 and 2 percent over 2019 (Statura, 2021). Compared to most sports, golf is relatively low-impact and “senior-friendly”. Its’ inclusiveness to age, gender, and levels of athleticism makes it a good source of leisure and exercise. However, like other sports, golf is often associated with musculoskeletal injury risks. The most common golf-induced injury happens in the low back (Fradkin et al.,2007; Finn, 2013; Gluck & Spivak, 2008; Hosea & Gatt,1996; McHardy et al., 2007a; McHardy et al., 2007b). Reported by McHardy et al. (2007 b)’s prospective survey of amateur golfers in Australia over one year, the most common injury site was in the lower back (18.3%), the elbow and forearm (17.2%), the foot and ankle (12.9%), and shoulder and upper arm (11.8%).

Kinesio-taping (KT), invented by Dr. Kenzo Kase from Japan in 1973, has gained popularity in sports since being used by elite athletes. According to Kase (2005), KT was initially developed for medical use and was almost exclusively by medical professionals until it was discovered by Japanese volleyball players and made its way into competitive and recreational sports. The most successful kinesiology tape brand today is the KT Tape®. This has been the official kinesiology tape licensee in the Olympics and Paralympics of team USA since the 2016 Rio Olympic Games. The popularity of KT surged after the KT Tape® was donated to 58 countries during the 2008 Beijing Olympic Games and was seen being used by high-profile athletes (Williams et al., 2012). Since then, KT has become a desirable, non-invasive intervention used by athletes and sports professionals for musculoskeletal injury management. As reported by Jessop (2014) on Forbes.com, from 2009 to 2012, the revenue of KT Tape® soared from $682,000 to $9.1 million. Today, KT Tape® is found in some of America's largest retailers, such as Target and Walmart. KT intervention has become popular among golfers since seen being used by world-famous golfer Tiger Woods during the 2018 British Open for neck pain (Sens, 2018). In recent years, the KT Tape® company has formulated a product explicitly marketed towards golfers: the KT TAPE PRO® golf. It is sold at the PGA Superstore and on their website for $20.99 per roll (20 precut strips).

Multiple factors have been identified by research as potential causes of low back pain (LBP) and chronic low back pain (CLBP) in golfers. These factors include individual style of the golf swing, demographic and physical characteristics, and volume of play/practice. (McHardy et al., 2007b; Smith et al., 2018; Sutcliffe et al., 2008). The biomechanics of a full golf swing produces tremendous stress on the spine, especially near the lumbosacral and sacroiliac joints, which may lead to chronic discomfort and pain in the low back (Hosea & Gatt, 1996; Lindsay & Vandervoort, 2014). The emphasis on body "coiling" to generate torque and force transition in the modern golf swing is manifested by the "X-Factor." In simple terms, this means the shoulder-hip angular differences produced during the transition of the backswing to the downswing (Cheetham et al., 2001; Gluck et al., 2008; Hume et al., 2005; Smith et al.,2018). The "X-Factor" can be a source of mechanical stress in the low back. The modern golf swing also facilitates lateral bending and hyperextension of the lumbar spine during the release portion of the swing (Finn, 2013; Gluck et al., 2008; Hosea & Gatt,1996). These mechanics cause the lumbar spine to experience forces from all directions (Hosea & Gatt,1996; Sutcliffe et al., 2008), and repetitive insult over time can lead to CLBP (McHardy et al., 2007b).

While less than optimal swinging mechanics and poor downswing sequence may increase the risks of golf-induced LBP (Geisler, 2001; Hume et al., 2005), low back overuse injuries in golfers may also occur with higher playing/practice frequency (Edwards et al., 2020; Hosea & Gatt,1996; Lindsay & Vandervroot, 2014; McHardy et al., 2007b). Golf-induced low-back injuries are associated with lumbar muscle strains or spasms, stress injuries in the facet joints, and intervertebral disc disorders (Hosea & Gatt,1996). In addition, limited spinal mobility or preexisting degenerative disc disease may predispose the golfer to experience golf-induced chronic low back pain (Sutcliffe et al., 2008). Despite limited clinical research on the diagnosis and treatments for golf-induced LBP, it is suggested that the “best practice” for rehabilitation and prevention of low back injury in golf appears to be through a multidisciplinary approach (Finn, 2013; McHardy et al., 2007a).

On the continuum of invasive to non-invasive methods for treating LBP, the application of KT sits at the far end of the non-invasive treatment because the tapes remain superficial to the skin. According to Kase (2005), the primary functions of KT include muscle support, removing congestion to the flow of body fluids, activating the endogenous analgesic system, and correcting joint problems. However, the extent to which these mechanisms contribute to any clinical effects is unknown. Kase (2005) further addressed that the elasticity of KT tapes facilitates circulation in the target joints and muscles and promotes the free range of motion in the target area. This makes KT fundamentally different from conventional athletic taping. Conventional athletic taping primarily functions in compression and immobilization. The non-elastic nature of the athletic tape reduces lymphatic fluid and blood from circulating underneath the skin and restricts the range of motion in the target area.

Although widely used in clinical practice by medical and sports professionals, current evidence is limited to support the effectiveness of the KT intervention for facilitating low back injury recovery or alleviating sport's related LBP. The comprehensive review of Trofa and colleagues (2020) on common nonsurgical modalities in sports medicine suggested a lack of high-quality studies in KT. The clinical practice guidelines published by the American College of Physicians (ACP) and the National Institute for Health and Care Excellence (NICE) in the UK did not suggest the use of KT for low back pain management. It is recommended that treatment for CLBP should be initiated with non-invasive and nonpharmacologic interventions, and exercise. Nonsteroidal anti-inflammatory drugs may be selected if pharmacologic is indicated for treatment (National Guideline Centre (UK), 2016; Qaseem et al., 2017).

Nonpharmacologic treatment interventions suggested by the ACP include acupuncture, mindfulness-based stress reduction, tai chi, yoga, motor control exercise, progressive relaxation, electromyography biofeedback, low-level laser therapy, operant therapy, cognitive behavioral therapy, or spinal manipulation (Qaseem et al., 2017). NICE recommended that treatment for LBP and sciatica should include manual therapy as part of the treatment plan in addition to exercise and/or psychological therapy (National Guideline Centre (UK),2016). Despite the popularity of superficial treatment modalities, ACP and NICE did not recommend the use of KT, back support belts, or corsets for low back pain management. Current research studies on KT have provided insufficient evidence to support the effectiveness of KT in CLBP and other musculoskeletal conditions. An in-depth review of the quality of evidence on other common non-invasive modalities for the treatment of CLBP will be covered in a later section of this study.

Current research studies and systemic literature reviews have concentrated on the effectiveness of KT on diarthrosis joints that are more susceptible to sports injuries (e.g., ankle, knee, shoulder, and elbow). When investigating the effectiveness of KT in the lumbosacral, sacroiliac joints, and low back pain, the number of studies is dramatically reduced in the databases, especially under sports settings. Therefore, the scope of this literature review has expanded to areas in the lower and upper extremities as well as the low back to compare the effectiveness of KT compared with placebo-taping and/or with no treatment, with other treatment methods in healthy individuals, or individuals with concomitant musculoskeletal conditions. Current research has found inconsistent results on KT's effectiveness in musculoskeletal injury rehabilitation, injury prevention, and sports performance. Several studies reported KT to be clinically effective in reducing pain, improving joint function and range of motion, and increasing strength when comparing KT to no treatment (Biz et al., 2022; Castro-Sanchez et al., 2012; de Oliveira et al., 2019; Fu et al., 2008; Rahlf et al., 2019; Seo et al., 2016), to placebo-taping (Cho et al., 2018; Hsu et al., 2009; Li et al.,2019; Miller et al., 2013; Rahlf et al., 2019; Shin & Heo, 2017), to other treatment interventions (Eraslan et al., 2018, Miller et al., 2013), or in addition to other interventions (Balki and Göktas, 2019, Farhadian et.al 2019, Labianca.et al.,2022). However, other studies reported contradictory or clinical insignificant results when comparing KT with no taping or placebo-taping (Al-Shareef et al., 2016; Chang et al, 2013; Donec & Kibilius, 2020; Eraslan et al., 2018; Espí-López et al., 2019; Grześkowiak et al., 2019; Halseth et al., 2004; Jassi et al., 2021; Nunes et at., 2021; Paoloni et al., 2011;

Peñalver-Barrios et al., 2021; Pires et al., 2020; Zhang et al., 2016); or when KT was applied in addition to other interventions (de Oliveira et al., 2021; Espí-López et al., 2019; Kachanathu et al., 2014; Kamali et al., 2018; Li et al., 2019). Multiple studies comparing KT with placebo taping have suggested that KT may produce psychological effects that influence treatment effectiveness in musculoskeletal injuries and disorders (Al-Shareef et al., 2016; Cho et al., 2018; de Souza Júnior et al., 2020; Jassi et al., 2021; Li et al., 2019; Grześkowiak et al., 2019; Peñalver-Barrios et al., 2021). Although the physiological mechanism of KT remains undetermined, health professionals who regularly employ KT in their practice reportedly believe that KT stimulates skin mechanoreceptors, improves local circulation, and reduces pain intensity (Cheatham et al., 2021).

The goal of this study is to present additional information to healthcare professionals, amateur and professional golfers, and golf teaching professionals on the effectiveness of KT in the treatment and prevention of golf-induced chronic low back pain. Further, this study intends to increase awareness in the field of kinesiology and sports rehabilitation science on the potential misinformation with the use of KT and re-evaluate the scientific evidence of KT in clinical practice. Due to the increasing number of golfers and the development of the modern golf swing, the risk of low back injuries remains high. Improving the quality of treatment and prevention methods for golf-induced chronic LBP will allow more individuals to enjoy the game of golf with lower risks and fewer incidences of reoccurring LBP. This literature review revealed inconclusive findings on the effectiveness of KT in treating golf-induced chronic low back pain (CLBP). Further research is suggested on this topic.

METHODOLOGY

A literature search (February- December 2022) was performed using multiple databases, including UCF Libraries, PubMed, GoogleScholar, SagePub, SportsDiscus, ScienceDirect, and Ebscohost, as the research method of the study. Keywords used in the search engine include "low back*" "golf*" or "golf swing*" "Kinesio tape*" or "Kinesio-taping*" and "pain*" or "injury*." The search results were carefully screened with predefined inclusion and exclusion criteria, and relevant literature was selected for this study. This study included clinical research studies, national guidelines, meta-analyses reviews, and systemic reviews published between 1994 and 2022. This literature review excluded the discussion of golf-induced LBP in children and adolescents. Studies of KT in treating and preventing CLBP in pregnant women and KT in treating post-traumatic LBP were also excluded from this review. Case studies were not included in the study as they are not indicative of, or applicable to, the general population. General internet searches were performed to identify websites and articles for background information on the KT tape, the sport of golf, and treatment interventions for golf-induced low back pain. Literature that discussed the classical and modern golf swing were also selected to illustrate the golf swings' mechanisms and their relative effects on low back injuries. Due to the lack of clinical studies in golf-induced chronic low-back pain, the literature review primarily addressed studies on KT treating non-specific chronic low-back pain comparable to golf-induced low-back pain. Studies examining KT's effectiveness in musculoskeletal disorders of other body areas were also included as points of reference for investigating the underlying treatment mechanism of KT.

The target populations for selected studies included, but were not limited to, adults and older adults (age 65 or above) with chronic low back pain who play golf professionally or recreationally, and who have reported or are at risk for golf-induced low back injuries. To complete a more comprehensive investigation, this study examined the biomechanical effects of the golf swing on the muscles and joints involved with the low back, the injury mechanism in golf-induced chronic low-back pain, common noninvasive treatment interventions of acute and chronic low back pain, the effectiveness of KT comparing to no taping, placebo-taping and or with other interventions in treating musculoskeletal disorders including low back pain.

Research question: Is Kinesio-taping (KT) an effective intervention in treating and preventing golf-induced chronic low back pain?

Limitations

The initial search in the database found very few studies on the application of KT for golf-induced chronic low back pain. Therefore, the search parameters had to be expanded to examine the effectiveness of KT for non-specific low back pain and other sports-related musculoskeletal disorders. Consequently, the research subjects in several selected studies are not identified as golfers, which complicates the investigation of the specific treatment outcomes of KT in golf-related low back injuries. Finally, the elimination of individual case studies could also unduly restrict or confound the findings in this literature review.

REVIEW OF THE LITERATURE

Overview of Golf-Related Low Back Injuries

Because golf is considered a low-risk and low-impact sport, it is an inclusive recreational activity regardless of age, gender, and athleticism. While fewer acute injuries occur, overuse injuries are the most common experienced by golfers (Fradkin et al., 2007; Gosheger et al., 2003; McHardy et al., 2007a.b.). The low back is by far the most common area of injuries (Fradkin et al., 2007; Hosea & Gatt,1996; McHardy et al., 2007a, b). An epidemiological study in Germany by Gosheger and colleagues (2003) investigated golf injuries from 1999 to 2000. The study consisted of 703 adult participants, of which 643 participants (456 male and 187 female) were amateur golfers, and 60 participants (54 male and 6 female) were professional golfers. Their study found that 82.6% of reported injuries were overuse injuries. They also found that back injuries comprised 24.3% of total reported injuries, and 92.3% of reported back injuries were due to overuse mechanisms. Their study reported that professional golfers are more prone to injuries than amateur golfers, as 36 out of 60 professional golfers (60%) reported 110 injuries (average three injuries/ player), and 255 out of 643 (39.7%) amateur golfers reported 527 injuries (average 2 injuries/player).

The epidemiological study by McHardy et al. (2007a) consisted of 1634 adult amateur golfer participants (1316 men and 318 women) in Australia. They reported that 25.3% of golf-related injuries were in the low back, making it the most cited area of injury. In addition, 46.9% of golf-related lower back injuries were found to be due to poor swing mechanics, and 24.5% of low back injuries were due to overuse. A one-year follow-up study by the same authors (McHardy et al., 2007b) reported the low back to be the most commonly injured areas (18.3%)

and that 46.2% of reported injuries were due to poor golf swings, while 23.7% reported injury mechanisms were due to overuse. The second study also revealed that most reported golf-related injuries occurred during the golf swing. The injuries were most frequently sustained at the ball impact position (23.7%) and the follow-through position (21.5%). A further epidemiological study by Fradkin et al. (2007) on golf-induced injuries in the United States consisted of 304 adult golfers (71.4% male) and reported that low back was the most often injured region (36%). Their study found that 29.7% of reported injury mechanisms were due to overuse, and 26.1% were due to overexertion. Fradkin et al. (2007) also reported that healthcare professionals most often consulted by injured golfers were chiropractors (13%), primary care physicians (12%), orthopedic surgeons (11%), athletic trainers (6%), and physical therapists (6%).

Golf-induced injuries can be multifactorial, as there may be a combination of improper techniques and musculoskeletal imbalances exacerbated by the overuse (Edwards et al., 2020; Hosea & Gatt, 1996; Lindsay & Vandervoort, 2014). Studies have also shown that participation/practice time may be a significant risk factor in golf-induced injuries (Fradkin et al., 2007; Gosheger et al., 2003; Lindsay & Horton, 2002; McHardy et al., 2007b). A study by Lindsay and Horton (2002) found that golfers with LBP, on average, practiced more and "tended to hit 2.5 times more balls per month than the golfers without low back pain". Professional golfers experience overuse injuries more often because of the increased frequency of practice with reduced golf swing variance (Edwards et al., 2020; McHardy et al., 2007b). However, the specific relationship between handicap/skill level and risk of injury remains unclear. Hypothetically, golfers with higher-level skills spend more time playing, practicing, and refining their skills and are, therefore, at higher risks of overuse injuries. Gosheger and colleagues (2003) reported that professional golfers were injured more often than amateur golfers. However, the same study also reported that injury risks did not appear to be determined by playing skills or handicaps among recreational golfers. The literature review by Edwards et al. (2020) also reported that skill level does not seem to determine injury prevalence in golf. Amateur golfers often play without proper warm-up and with poor swinging techniques that may increase their risks for injury (Hosea & Gatt,1996).

Age remains an uncertain factor in this review of golf-induced injuries. The study of Fradkin et al. (2007) reported that older adults spend more time golfing than the other age groups and they are more likely to seek treatment for their injuries than middle-aged golfers. Gosheger et al. (2003) separated their study subject, a total of 703 golfers (643 amateur and 60 professional golfers), into five age groups. They found no significant differences in injury prevalence between the groups. However, the same study also reported that injury incidence increased with time spent on the golf course or the driving range. This could indicate that retired adults who spend more time golfing are potentially at higher risk of developing golf-related injuries.

Studies have found no significant association between the risk of injury with gender (Fradkin et al., 2007; Gosheger et al., 2003), although few variables between gender might increase the risk of golf-induced injury in one gender over the other. One variable observed by Fradkin et al. (2007) is that male golfers often spend more time practicing golf than female golfers. As mentioned in the previous studies, there has been a positive correlation established between playing time and golf injuries. Another variable may be found in the body anatomical differences between genders. The study of Horan et al. (2011) found that skilled female golfers exhibited higher thorax and pelvis variability for axial rotation during downswing and impact position. However, it is undetermined how this variable may be related to golf injuries. More studies are suggested to investigate whether gender-related variables may cause one gender to have higher injury risks.

Body type and composition may predispose some golfers to develop LBP regardless of their golf swing technique (Edwards et al., 2020). The systematic review and meta-analysis by Smith and college (2018) reported greater body mass is associated with more LBP incidence in recreational golfers, similar to nongolfers. The authors suspected that the greater body mass increased spinal loading during golf, which increases the risks of low back injuries. However, a longitudinal study of young golfers (aged 18-35) by Evans et al. (2005) reported that there is a negative correlation between body mass index (BMI) and golf-induced LBP. Golfers with BMI < 25.7 kg/m2 reported more frequent episodes of moderate-to-severe LBP. The authors speculated that taller, slender young golfers are more susceptible to LBP due to longer swing arc, thereby increasing the load on their spine. Further research is suggested to address this topic in golf-induced injuries.

The KT Intervention

Kinesio-taping (KT), invented by Dr. Kenzo Kase, is a popular non-invasive intervention for sports injuries. The popularity of KT surged after the KT company donated their products to 58 countries during the 2008 Beijing Olympic Games and was seen being used on high-profile athletes (Williams et al., 2012). Since then, it has become a desirable, non-invasive intervention used by athletes and sports professionals in musculoskeletal injury management.

On the non-invasive to invasive treatment continuum, KT is found at the far end of the non-invasive side. The manufacturer of KT tape claimed that the application of KT is a modality treatment that facilitates the body's own natural healing process (Kase, 2005). Although there is a lack of scientific evidence as to its effectiveness in chronic low back pain management, multiple studies have found KT to be effective in various musculoskeletal conditions. (Al-Shareef et al., 2016; Biz et al., 2022; Castro-Sánchez et al., 2012; Cho et al., 2018; de Oliveira et al., 2019; Eraslan et al., 2018; Farhadian et al., 2019; Hsu et al., 2009; Jassi et al., 2021; Labianca et al.,2022; Lee & Yoo, 2012; Lim & Tay, 2015; Paoloni et al., 2011; Peñalver-Barrios et al., 2021; Pires et al., 2020; Rahlf et al., 2019; Seo et al., 2016; Shin & Heo, 2017). However, other studies reported contradictory results (Chang et al., 2013; Espí-López et al., 2019; Fu et al., 2008; Grześkowiak et al., 2019; Gülenç et al., 2018; Halseth et al., 2004; Jassi et al., 2021; Kamali et al., 2018; Li et al.,2019; Nunes et al., 2021).

According to Kase (2005), KT tape has thin and elastic characteristics that permit it to stretch to 140% of its original length. Thus, when the KT tape attaches to the skin while the muscle is in a stretched position, the tape recoils and presumably increases the space between the skin and muscle. KT's elastic and adhesive characteristic allows it to be applied on the skin's surface without pressuring the underlying tissue. This mechanism hypothetically leads to improved fluid circulation between the skin and muscle. The KT manufacturer also claimed that KT affects the target muscle and joints by relieving pain, increasing ROM, preventing fatigue, reducing inflammation, and correcting joint problems (Kase, 2005; Kase et al., 1996).

KT Application Techniques in the Low Back

Some common techniques for KT application in the low back include, but are not limited to, the Y-shape technique, the I-shape (or muscle technique), the transverse space technique, the Star shape (or star-space technique), and the fascia technique. (de Souza et al.,2020; Jassi et al., 2021; Kase,2005, Kase et al. 1996). According to the KT application manual by Kase (2005), KT for injuries relating to joints and ligaments should be applied with medium to full stretch while the target area is maintained in a functional or stretched position. The basic principle of KT in muscle injuries is that the skin of the target area must be manually stretched before applying the tape. Further, Kase (2005) mentioned that the KT tape should be applied from the origin to the insertion of the muscle if the goal is to treat weakened muscles. However, the direction of application should be reversed (from insertion to origin) if the goal is to prevent cramping and over-contraction of the muscle.

The Y-shape method of KT for the low back requires two strips of KT tapes (Kase, 2005; Kase et al., 1996). While having the patient perform lumbar flexion to keep the low back in a stretched position, the taping begins at the sacrum (at the origin of the erector spinae muscles). Then, the tapes travel along the erector spinae muscles toward the insertion on each side of the back (Kase, 2005). The I-shape/muscle technique also requires two strips of KT tape. Each strip is applied to one side of the back parallel to the lumbar spine. The tape is stretched to 10%-15% of tension from the sacroiliac joint to the thoracic vertebra while the low back is stretched by lumber flexion (de Souza et al., 2020; Peñalver-Barrios et al., 2021; Pires et al., 2020). The transverse space technique requires at least one strip of KT tape to be applied horizontally at the painful area of the low back. The center of the tape should be stretched at 50%-75% tension while 0% tension is maintained at the end of the tape (Peñalver-Barrios et al., 2021). The Star-shape/space method consists of four strips of KT tapes that overlap in a star shape with 25% tension maintained over the lumbar area where the maximum pain is experienced (Castro-Sanchez et al., 2012; Jassi et al., 2021; Peñalver-Barrios., 2021). The fascia technique requires only one strip of KT tape, while half of the tape is cut horizontally at the center. The tape is applied transversally over the paravertebral muscle fibers in the low back. The uncut side of the tape is applied at the medial side of the muscle, while the cut side of the tape is extended at an angle along the muscle towards the distal side of the body (Peñalver-Barrios., 2021).

The Golf Swing: Classic VS Modern

The golf swing has evolved and has been refined over the past few decades. Although every individual's golf swing is unique, the golf swing can be divided into two main swing styles: the "classic" golf swing and the "modern" golf swing (Gluck & Spivak, 2008; Hosea & Gatt,1996). Differences have been observed between the "classic" golf swing, which originated in Scotland, and the "modern" golf swing utilized by most professional tour golfers today. The "classic" golf swing utilizes a shallower back swing plane with large hip and shoulder rotation. The swing allows the golfer to finish in an upright position (Gluck & Spivak, 2008; Hosea & Gatt,1996). The "modern" golf swing emphasizes coiling the body to create torque power by restricting hip rotation while shoulder rotation remains greater (Hosea & Gatt, 1996). Golfers can synchronize the angular difference between the rotation of the shoulder joint and the hip joint. This is known as the "X-factor" (Cheetham et al., 2001; Gluck & Spivak, 2008; Smith et al.,2018), during the transition phase between the back swing and the downswing to transfer the rotational force of the body into maximum club head speed at impact (Hume et al., 2005).

Other characteristics of the “modern” golf swing include lateral bending and hyperextension of the low back. This is commonly called the "reverse C" position, during the downswing and follow-through. (Finn, 2013; Gluck & Spivak, 2008; Hosea & Gatt, 1996). These characteristics are suspected of causing compression, shear, torsional, and lateral-bending forces that act on the spinal joints in the low back and may lead to the development of golf-induced LBP (Geisler, 2001; Gluck & Spivak, 2008; Hosea & Gatt, 1996; Lindsay & Vandervoort, 2014; Smith et al., 2018). The game of golf requires the combined skills of accuracy and consistency together with distance and power. As the technologies of golf equipment continue to improve, players are expected to seek ways to maximize their ball distance to gain a competitive edge. This distance-chasing mindset makes the “modern” swing the dominant swing style among amateur and professional golfers (Gluck & Spivak, 2008). This literature review chapter will primarily focus on the kinetics and kinematics of the “modern” golf swing and its related risk factors for CLBP. The “modern” golf swing is more relevant than the “classic” golf swing to the development of CLBP in current and future golfers.

The Golf Swing Kinetics and Kinematics

Today, golf professionals agree that the full golf swing can be discussed in several different phases. These involve the set-up, backswing, downswing, follow-through, and finish, respectively (Geisler, 2001; Gluck & Spivak, 2008; Hume et al., 2005). Although variations of golf swing mechanics exist between players, this chapter discusses the fundamental elements of the golf swing during each phase.

The first phase of the golf swing is the set-up. Geisler (2001) stated that the set-up "should align the golfer properly with the target…and place the golfer in a biomechanically sound and advantageous position from which to execute the ensuing golf swing." Two spinal angles are meant to be established during the set-up. According to Geisler (2001), the first or primary angle is created by hip hinge and forward trunk flexion, "The hip joints serve as the axis of rotation, whereas the mid-trunk and thigh serve as the lever arms to form the angle". Geisler (2001) emphasized that a set-up without first forming the primary spinal angle would lead to spinal stress and decrease free rotation during the swing. Geisler (2001) further stated that the secondary spinal angle is produced by the "lateral bending to the right in the spinal segments and slight depression and downward rotation of the arm and scapula". This angle is the indirect result of the grip position. For right-handed golfers, the right hand should gripe below the left hand closer to the golf ball, which causes a right-side shoulder tilt and right lateral bending in the spine at the set-up.

According to Seaman and Bulbulian (2000), for right-handed golfers, "In order to place less stress on the latter joints and to facilitate pelvic rotation about the left hip joint, golfers flare the left foot 20-30° to address the target." Reported angular knee flexion values during the set-up of the golf swing vary between authors. Seaman and Bulbulian (2000) suggested approximately 30° of knee flexion during set-up, producing a stance "similar to the position of a football quarterback." Geisler (2001), however, suggested that the knees should be slightly flexed to 20-25°. The knee and trunk flexion, combined with the right lateral bending of the spine during the set-up, establish and maintain the base of support in the golf swing. Therefore, the set-up plays a critical role in performing the following phases of the golf swing.

Having adequate mobility and flexibility is crucial in achieving optimal backswing positions in golfers. According to Geisler (2001), "Maintaining both spine angles and achieving a full 90-degree shoulder turn and a 45-degree hip turn requires the golfer to have excellent hip, shoulder, and torso flexibility with minimal lateral weight shift". Although the backswing and the downswing follow a similar path, the velocity of the backswing appears slower than the downswing. Lindsay and Vandervoort (2014) stated that "the golf swing involves a slow deliberate rotation of the trunk away from the target on the backswing followed by a very powerful rotation of the trunk towards the left (right-handed golfer) on the downswing." As suggested by Geisler (2001) and Hume et al. (2005), the purpose of the backswing is to position the club head and the body's center of rotation in an optimal position to provide a solid foundation for the downswing's kinetic chain. This helps create tension in the muscles and joints that are responsible for producing power in the downswing. The same authors also indicated that to keep the golfer's center of gravity within the base of support, a significant lateral weight shift should be limited in the backswing. Hume et al. (2005) added that "A large weight-shift or weight-transfer can move the golfer's center of mass outside the base of support making the swing hard to control." Geisler (2001) pointed out that "when a golfer over-shifts his or her weight and or attempts to over-rotate into the backswing, he or she often produces a reverse weight shift or pivot." The reverse pivot can make the golf swing less efficient in stabilizing the body during the downswing and could create additional stress on the spine.

Cheetham and collogues (2001) found that in skilled golfers, near the end of the backswing prior to the beginning of the downswing, their pelvis would decelerate and change to the opposite direction of rotation toward the lead side of the body. Meanwhile, the rest of their trunk, including their shoulders, continues to rotate toward the trail side of the body. As the shoulder-hip separation angle approaches maximum at the top of the backswing, their lumbar and thoracic spine achieves near maximum rotation. According to Gluck and Spivak (2008), "Maximizing the hip-shoulder separation angle…stores potential energy that contributes to increased rotational velocity and translates to increased club head speed in an efficient swing." Transitioning between the backswing and the downswing, the angular differences between the rotation of the shoulder joint in relation to the hip joint created during this phase is known as the "X-factor" (Cheetham et al., 2001; Gluck & Spivak, 2008; Smith et al.,2018). The "X-factor" is a popular concept promoted by golf professionals to transfer rotational force into maximum club-head speed at the ball's impact (Hume et al., 2005; Gluck & Spivak, 2008). A more in-depth review of the "X-factor" will be discussed in the following chapter of this study.

The kinetic sequence of the downswing is crucial to generate maximum speed and power. According to Hume et al. (2005), "The kinetic chain action involves the initiation of the movement with the legs and hips followed by movement of the trunk and shoulders, and finally the hands and wrists. If executed correctly, the amount of kinetic energy is greater than the sum of the parts." Geisler (2001) stated that novice golfers tend to initiate the downswing too soon or too quickly with their hands and arms, putting them at a disadvantage in generating maximum club-head speed. Fast rotation of the pelvis towards the lead side of the body may trigger the muscle spindles in the trunk to quickly shorten, creating forceful contraction during the downswing. Lindsay and Vandervoort (2014) reported that the differences in velocity and movement pattern between the backswing and downswing might lead to different spinal loading in the lead and trail sides of the lumbar spine. This is due to asymmetrical rotational velocity in the trunk. At the impact position of the golf swing, the club head returns to the ball. Spinal positions at the impact position appeared to be different from the set-up. According to Geisler (2001), "At impact, the average amount of secondary spine angle was found to be 28 degrees (16 degrees at set-up), whereas the primary spine angle averaged 34 degrees (45 degrees at set-up)", which indicates greater lateral bending and flexion in the spine. The same author also pointed out that while the club returns to its original position at impact, "the golfer's left glenohumeral joint is ahead of the hands, which are ahead of the club head, all in a straight line." The lateral weight shift towards the lead foot during the downswing contributes to the changes in spine angles at the impact position.

After impacting the ball, during the golf swing's follow-through phase, the hands and wrists of the golfer remain on the swing path (Hume et al., 2005). Seaman & Bulbulian (2000) suggested that upon completion of the follow-through, a right-handed golfer's back of the right shoulder would face the target with assistance from the spinal rotation in the trunk. The left leg performs internal rotation while absorbing most of the body's weight as the hip rotates towards the lead side of the body (Geisler, 2001). At the finish position, the golfer balances on the left leg with the trunk and assumes a position of hyperextension and lateral flexion, also known as the "Reverse-C" position (Lindsay & Vandervoort, 2014; Smith et al., 2018). Geisler (2001) explained that the "Reverse-C" position is the result of the golfer trying to counterbalance their center of gravity post-impact.

The Axial Twisting of the Golf Swing

Multiple body parts are at work to create specific movements in the proper sequence to stabilize the body in areas needed to produce a consistent golf swing. An in-depth analysis of axial twisting in the golf swing helps people gain a fundamental understanding of the injury mechanisms for golf-induced LBP, to be discussed in the following chapter of this study. This chapter focuses on the joints and muscles surrounding the trunk and the movements they produce during the golf swing. As mentioned in the previous chapter, the primary and secondary spinal angles and knee flexion during set-up should also be taken into consideration when analyzing axial rotation in the golf swing. These angles may affect the rotation of the shoulder and the hip joint.

From a biomechanical standpoint, the full swing in golf is a complex and asymmetric series of movements involving all three anatomical planes simultaneously (Mun et al., 2015). During the golf swing, the hip joints perform internal/external rotation, lateral shift (Hume, 2005), axial rotation, and flexion/extension (Lindsay & Vandervoort, 2014; Smith et al.,2018). The lumbar and thoracic spine perform axial rotation, lateral flexion/ extension, and forward flexion/extension (Finn, 2013; Gluck & Spivak, 2008; Lee & Wong, 2002; Lindsay & Vandervoort, 2014). Finally, the shoulder joints perform adduction/abduction and internal/external rotation (Geisler, 2001; Hume et al., 2005; Sutcliffe et al., 2008). Spinal rotation begins at the lumbosacral junction (Seaman & Bulbulian, 2000). The study of biomechanical assessment of axial twisting by Marras and Granata (1995) reported that dynamic twisting of the trunk produced coupled moments in the sagittal and coronal planes. As determined by this study, during twisting exertions, the trunk also generated forces equivalent to a 20% extension maximum in the sagittal plane and 79% maximum lateral exertion in the coronal plane. According to Seaman and Bulbulian (2000), due to the orientation of the facet joints, the range of motion of the L5-S1 joints and the lumbar and lower thoracic spinal joints from L4-L5 through T10-T11 are limited to 0-2° and 1-3°, respectively. The limited range of motion of the spine is insufficient to meet the requirement of the golf swing by itself. Thus, the paraspinal, pelvic, abdominal, and oblique muscles are required to assist the larger spinal-trunk rotation during the golf swing (Finn, 2013; Geisler, 2001; Hosea & Gatt,1994; Seaman & Bulbulian, 2000).

Myoelectric analysis of the golf swing by Hosea et al. (1994) showed that in right-handed golfers, the left external oblique, the left rectus abdominis, and the left L3 paraspinal muscles initiate trunk rotation at the beginning of the backswing. From the top of the backswing through the impact position, as the golfer's torso uncoils, peak muscle forces occur in the right external oblique muscle and the right and left paraspinal muscles as they fire maximally. Seaman and Bulbulians (2000) asserted that the pelvic and spinal rotation during the backswing only serves to develop a proper backswing position. The power of the golf swing is generated by initiating an aggressive weight transfer towards the target (left side for right-handed golfers) before the completion of the backswing. Seaman and Bulbulians (2000) further explained that this weight transfer motion in golf pre-stretches the powerful right oblique, pectoralis major and latissimus dorsi, and stimulates the muscles to quickly contract during the downswing.

Hosea et al. (1994) asserted that differences exist in the magnitude of spinal loading and spinal activity during the golf swing between amateur and professional golfers. Their study found that amateur golfers' overall myoelectric activity during the golf swing reaches nearly 90% of their peak muscle activity compared to 80% for the pro-golfers. This may be explained by the amateur golfers' tendency to swing harder with poor swing mechanics, and larger spinal loads are produced with correspondingly higher myoelectric activity. According to Marras and Granata (1995), the maximum torsional capacity of the trunk is easily exceeded by the task due to its inability to generate rotational torque. The 1995 study reported that muscle coactivity in the low back during twisting exertion was much greater than lifting exertions, which reflects the significant spinal loading during axial twisting.

Although the shoulder joints are not directly connected to the low back, they are part of the "X-factor" in the golf swing. This is a characteristic of the modern swing technique that might be related to golf-induced low-back pain. According to Lindsay and Vandervoort (2014), "the "X-factor" is between an imaginary line drawn from the left to right anterior superior iliac spines of the pelvis, and a second line drawn through the acromion processes of the shoulder." They suspected that since the lumbosacral joint is a symphysis-facet joint with a limited range of motion, the demand for a significant axial rotation to create the "X-factor" may lead golfers to rotate their spine beyond their normal physical limits. This could lead to low back pain. However, more research is suggested to evaluate this theory.

The study by Sim (2017) on torsion load during the transitional phase of the golf swing found that healthy professional golfers were able to produce a larger torsion load in the L5/S1 joint than professionals with a history of low back pain. The study also reported that the torsion load produced by professional golfers was significantly higher than amateur golfers. This seemed to indicate that healthy professional golfers were better able to unitize pelvic and thoracic rotation to generate power in the golf swing. It also suggested that there is a relationship between the history of low back pain and force production through spinal torsion load. The study by Lee and Wong (2002) investigated kinematic patterns of the lumbar spine and hip joints in lateral bending and twisting movements. They found that joints in the low back do not always move simultaneously in all anatomical planes. Their study reported that the spine tends to move earlier than the hip in lateral bending of the trunk on the coronal plane. In contrast, the movement patterns in the sagittal and horizontal planes, such as flexion and extension and rotation, the spine and hip tend to be "in phase." Lee and Wong (2002) concluded that the spine is the main contributor to lateral bending of the trunk, while the hips are the main contributor to twisting or rotation. They suspected that low back pain might develop from variations in the spine and hip movement patterns, while further research is suggested to investigate this topic.

Injury Mechanism of Golf-Induced Low-Back Pain

The modern golf swing has several characteristics that have been recognized as potential contributors to CLBP. They include, but not limited to, the emphasis on the hip and shoulder separation, or the "X-factor," during the transitioning between the backswing and the downswing, and the "reverse-C" spinal position at the follow-through phase of the swing (Cheetham et al., 2001; Geisler, 2001; Gluck & Spivak, 2008; Lindsay & Vandervoort, 2014; Smith et al.,2018). In their study on back pain in golf, Hosea and Gatt (1996) suggested that golf-induced low-back injuries could be described as mechanical (associated with lumbar muscle strains or spasms), intervertebral disc disorders (e.g., a disc herniation that commonly occurs at the L5-S1 joints), spondylogenic (stress injury that causes pars interarticularis defection), or facet joint arthropathy (degenerative facet changes resulting from aging and repeated minor trauma). The mechanism for golf induced-low back injuries may differ between populations. According to

Sutcliffe and colleagues (2008), “Spondylolysis is a stress fracture of the pars interarticularis and is most commonly associated with adolescent athletes but may also occur in the adult golfer.” They also indicated that elderly golfers are more vulnerable to disc herniation due to the increasing physical exertion and asymmetric loading in the low back. In addition, limited spinal mobility or preexisting degenerative disc disease may further increase the risks of back injuries in amateur and senior golfers.

Hosea and Gatt (1996) also suggested that, compared to professional golfers, amateur golfers were found to generate approximately 80% greater peak lateral bending and shear loads, 50% greater swing torques in the L3-4 spine, and averaged significantly more peak shear load (560N vs. 329N). The significantly greater spinal loading observed in amateur golfers is attributed to the increased effort associated with swinging the golf clubs to compensate for poor swing techniques. Gluck and Spivak (2008) made a similar assertion in their study on the lumbar spine and low back pain in golf. They disclosed that golf-induced low back injuries in professional golfers were mainly due to the excessive repetition of spinal rotation. In contrast, they stated that low back pain in amateur golfers was primarily due to less-than-optimal golf swing mechanics. The study by Finn (2013) on rehabilitation of golf-induced LBP stated that, “The risk for paraspinal muscle tears and strains are inherent, as the paraspinal muscles are compromised by fatigue and stress imbalances, especially in the amateur golfer.” Amateur golfers generally have more swing irregularities than professional golfers, which could make them more at risk than professional golfers for low back injury with increased playing time.

The study by McHardy et al.(2007b) found that most back pain incidents reported by golfers were developed over time rather than from one traumatic incident. Acute low back injuries occur when the forces applied to the low back tissues, such as the lumbar discs and extensor muscles, exceed the zone's plastic threshold (ultimate strength) during one instance. For chronic low back injuries, the forces applied to the tissues do not surpass the plasticity threshold. However, persistent loading and constant stress can increase tissue strain and eventually result in injuries. The lumbar spine endures four types of forces during the golf swing: the lateral bending force, shear force, compression force, and torsional force (Hosea & Gatt,1996; Sim, 2017; Sutcliffe et al., 2008). Recurrent asymmetric spinal loading may become problematic over time. The downswing in golf produces substantial forces to the low back that have been suspected as significant contributors to golf-induced low back injuries (Lindsay & Vandervoort, 2014).

Studies have reported that golfers who emphasize the technique of creating a large "X-factor" (hip-shoulder separation angle) to produce a more forceful transition to the downswing may be more susceptible to a low back injury (Finn, 2013; Lindsay & Vandervoort, 2014). Geisler (2001) found that the lumbar spine and the hip joint tend to rotate excessively during the downswing, while the golfer's upper torso rotation remains limited. This characteristic of rotation and separation in the golf swing is suspected to be a risk factor for low back injuries. According to Lindsay & Horton (2002), golfers with low back pain tended to exceed their maximum range of axial rotation in their golf swing. However, Vad et al. (2004) reported a negative correlation between lead hip rotation and lumbar range of motion with a history of LBP in professional golfers. They speculated that when the lead hip rotation decreases during the downswing and follow-through, the forces generated from the momentum of the golf swing are transmitted to the lumbar spine, which increases the load in the low back and may contribute to low back pain in golfers. Although, golfers with a history of LBP may subconsciously or purposely decrease their lead hip and lumbar spine rotation to avoid the reoccurrence of pain in their low back. More research is suggested on the topic of hip and lumbar spine rotation and force transmission during the downswing of golf.

Golfers who utilize large muscle groups to generate club head speed in their golf swing also tend to use an excessive lateral shift in their base of support. This results in a greater tendency to attain the “Reverse-C” position of the spine (Geisler,2001). The “Reverse-C” position causes hyperextension in the lumbar spine. Prolonged exposure to this position can lead to injuries to the vertebrae disks, soft tissues, and muscles around the spine (Finn, 2013; Geisler, 2001; Lindsay & Vandervoort, 2014). The study by Brolinson et al. (2003) on sacroiliac (SI) joint dysfunction in athletes stated that any sport that generates biomechanical stress through the lumbar spine and the pelvis could lead to SI joint dysfunction. Thus, the SI joint is a common source of LBP in athletes. They discussed that rowing and cross-country skiing are examples of common sports that put athletes at risk for SI joint dysfunction. Both sports require repetitive motions in the body while the pelvis is proportionally stabilized throughout the movements. Therefore, the force loads acting upon the athlete’s transverse plane are transferred to the lumbosacral region of the spine. The golf swing presented a similar characteristic. The hip is required to remain slightly flexed to maintain the primary spinal angle developed at the set-up position during the entire swing until after impact. When the pelvic rotation comes to a momentary pause at the impact position, the forces generated from the downswing are transferred to the golfer’s lumbosacral region of the spine. Here, there is an additional asymmetric load transfer to the trail side of the low back. The SI joint serves as a transfer link between the spine and the lower body which sustains high force loads during athletic activities such as golf. When the forces acting on the transverse plane are transferred to the SI joint and lumbosacral joint during the downswing, impact, and follow-through position, golfers are at risk of pain and dysfunction in these joints.

The study by Hosea and Gatt (1996) found that the forceful rotation of the trunk towards the lead side of the body during the downswing with a five-iron golf club can generate a peak spinal shear load up to 600N and spinal compression forces ranging from 6000-7500N, which is equivalent to 8-10 times the body weight for a 75kg person. Compared to other sports, a Divisional 1-A college football lineman can produce lumbar compression forces of 8,679±1,965 N when hitting a blocking sled (Gatt et al., 1997), which seems to make golf an equally high-risk sport for lumbar spine injury. The comparable results from these studies indicated that golf, even as a seemly mild sport, may produce as much compressional force on the spine as high-impact sports. The forces produced by the golf swing can put athletes at high risk for low back injuries. Understanding the injury mechanism that causes golf induced CLBP is an essential step before investigating the treatment interventions for LBP and the effectiveness of those treatments. Movement patterns required by the golf swing, the golfer's physical abilities, and individual swinging tendencies can all affect the forces applied to the low back and suggests more studies should be conducted in the future.

KT's Effectiveness for Musculoskeletal Injuries

This literature review chapter primarily investigated the effectiveness of KT for CLBP management and overall effectiveness in musculoskeletal injuries. Studies on KT's effectiveness for upper and lower body musculoskeletal injury rehabilitation, injury prevention, and postsports injury functional performance are also included as references. Previously conducted systemic reviews and meta-analyses on the effectiveness of KT on various musculoskeletal injuries appear to be inconsistent with the claims of the KT manufacturers (Drouin et al., 2013; Mostafavifar et al., 2012; Nelson, 2016; Williams et al., 2012).

The study of Mostafavifar and colleagues (2012) reported that KT application may provide immediate pain relief in musculoskeletal injuries. However, there was insufficient evidence for sustained pain relief beyond 24 hours. They also found no evidence supporting that KT application improves return-to-play time for sports. Based on these findings, the authors concluded that there is insufficient evidence to support the use of KT for treating musculoskeletal injuries. They suggested that alternative pain relief methods should be considered before KT. The meta-analysis conducted by Williams and colleagues (2012) investigated evidence of KT's effectiveness in sports injuries treatment and prevention. They concluded that there was insufficient evidence to support the use of KT over another type of elastic taping. The literature review by Drouin et al. (2013) indicated there was a lack of evidence to support the use of KT for improving athletic performance in healthy individuals. The systemic review by Nelson (2016) concluded that KT should not be considered a substitute for physical therapy or exercise but may be used as adjunctive therapy in improving range of motion, muscular endurance, and motor control. A systemic review by Hörmann et al. (2020) investigated the use of KT on postoperative edema. Their study found unconvincing evidence of KT's effectiveness in increasing lymphatic drainage and reducing postoperative swelling due to the limitation of research on the specific subject.

A descriptive survey conducted by Cheatham and colleagues (2021) with 1083 healthcare professionals shed insights on shared beliefs and treatment reasons for KT in healthcare in the U.S. Their study indicated that the most common reasons for treatment with KT by U.S. healthcare professionals include post-injury treatment (74.24%), pain modulation (66.85%), and neuro-sensory feedback (60.30%). Interestingly, 73.68% of respondents believed KT creates a placebo effect together with its' physiological mechanism, and 40.44% of respondents used KT in treatment for this specific therapeutic reason. Besides the placebo effect, Cheatham and colleagues (2021) also indicated that the most believed physiological mechanisms of KT are stimulation of skin mechanoreceptors (77.00%), improvement of local circulation (69.16%), and pain modulation (60.2%). Their study provided insight into how healthcare professionals utilize KT for treatment and prevention and highlighted the gaps between research and clinical practice.

KT Effectiveness - Low Back

Previous research has reported contradictory results on the effectiveness of KT for CLBP. The clinical practice guideline by ACP suggested that there is low-quality evidence of KT's effectiveness in treating LBP, and no differences have been found between KT and sham taping in treating pain or improving function in the low back (Qaseem et al., 2019). The study by Castro-Sanchez et al. (2012) found immediate improvement in pain intensity, disability, and trunk muscle endurance in patients with CLBP treated with KT compared to the control group treated with sham/placebo taping. However, the study's four-week post-intervention assessment reported that the resulting differences between the two groups were clinically insignificant. Al-Shareef et al. (2016) also found that KT made more improvement in pain, disability, and trunk flexion range of motion than placebo-taping in patients with CLBP after two weeks of treatment. However, their data suggested that the effects of KT fell short of being clinically meaningful. The study by Shin and Heo (2017) on the effects of KT on erector spinae muscles and sacroiliac joint function in healthy adults reported significant improvements in the range of motion in lumbar flexion, lateral flexion, and rotation when compared to placebo-taping. Their study suggested that KT application to the erector spinae muscles and sacroiliac joint may improve lumbar function and may be utilized as a preventive treatment method for low back pain.

Pires et al. (2020) compared the effects of KT to placebo-taping in patients with CLBP by testing the EMG signal intensity of the trunk extensor, the longissimus, and the iliocostalis muscles with back pain intensity. Their study found no significant differences between KT and placebo-taping on both muscle signal and perceived pain intensity. Therefore, they concluded that KT was ineffective in reducing muscle pain intensity in treating CLBP. de Souza Júnior et al. (2020) compared the effects of KT in female patients with CLBP and investigated the psychological effects of KT in those patients. They divided the patients into two groups. One group self-reported having fears and beliefs related to physical activity, and the other group did not report fear and beliefs related to physical activity. Their study found an immediate improvement in peak torque of the erector spinae muscles in patients with CLBP and fears and beliefs for physical activity. However, the effect in peak torque of the erector spinae muscles was not observed with patients with CLBP who did not have fears and beliefs for physical activity. They found no differences on muscle activity and muscle fatigue between both groups of patients. Therefore, their study suggested that the observed improvement of peak torque erector spinae muscle with KT in people with CLBP was not due to the improvement of muscle recruitment but more likely with the patients' expectations of the benefits of the intervention.

Grześkowiak et al. (2019) investigated the short-term effects of KT compared to placebo-taping in patients with lumbar disk herniation. They found that after seven days of treatment with KT, there were no significant effects on lumbar paraspinal muscle function and range of motion in patients with lumbar disk herniation. Interestingly, they found that when comparing the effects of reducing disability and pain intensity, both the KT group and the placebo-taping group showed improvement. However, the results of the KT group were not superior to the placebo-taping, which suggested a psychological effect in KT. A similar observation was reported in the study by Peñalver-Barrios et al. (2021). They found that when comparing the immediate and medium-term (six-month) effectiveness between KT and placebo-taping in patients with CLBP, there were significant reductions in pain and disability in the low back in both KT and placebo-taping groups at post-treatment time. Although only the effects of the KT group remained statistically significant after six months compared to the baseline, the intragroup differences between KT and placebo were statistically insignificant. Therefore, the authors suggested no difference in the outcomes between KT and placebo taping in treating CLBP.

Jassi et al. (2021) studied the effects of the star-shape KT method compared to sham KT and minimal/no intervention on CLBP. Their study found improved pain intensity for the group treated with the star-shape KT compared to the group treated with minimal intervention. However, the difference between these results fell short of reaching clinical significance. They also found no differences in pain intensity between the group treated with star-shaped KT and the group treated with sham KT. The authors concluded that no meaningful effects of the star-shape KT were found in reducing CLBP. They suggested that the observed improvement in both KT and sham KT groups could be due to general expectations of the treatment or, in other words, the placebo effect. Paoloni et al. (2011) investigated the effects of KT with exercise on pain, disability, and lumbar muscle function in patients with CLBP. The study consisted of three treatment groups: KT-only, exercise-only, and KT with exercise groups. They found immediate pain relief and improvement of lumbar muscle function after KT. After four weeks of treatment, they found significant improvement in pain intensity in all three groups compared to baseline, but only the exercise-only group showed reduced pain-related disability. They suggested that KT may be used as adjunctive therapy in physical rehabilitation for short-term pain control in patients with CLBP.

Kamali et al. (2018) studied the effects of spinal manipulation with or without additional KT in athletes with CLBP. They found decreased pain intensity and disability and improved trunk flexor-extensor muscles' endurance in both spinal manipulation-only and spinal manipulation with KT groups. However, their data showed that there were no significant differences between groups. The authors concluded that adding KT to spinal manipulation did not provide additional effects in athletes with CLBP. Kachanathu et al. (2014) compared the effectiveness of physical therapy programs with or without additional KT application for treatment of CLBP. Their study reported improvement in pain, function, and range of motion in both physical therapy with KT and physical therapy-only groups. However, there were no significant differences in pain and function outcomes between groups. They concluded that physical therapy programs, which included muscle strengthening and stretching exercises alone, were beneficial for treating CLBP regardless of the additional use of KT. The systematic review that included ten research articles and 627 total participants by Li et al. (2019) found KT was not superior in reducing CLBP when compared with sham/placebo taping. They also found that the additional application of KT with physical therapy produced no additional positive effects on the outcomes, which appears to agree with the study by Kachanathu et al. (2014). However, Li et al. (2019) found a significant reduction of reported disability in patients with CLBP when comparing KT to placebo taping.

KT's Effectiveness - Lower Body

This segment of the literature review chapter focuses on the effectiveness of KT in joints and muscles in the lower half of the body aside from the low back. This includes the hip, knee, lower leg, and ankles. Miller et al. (2013) investigated the immediate effects of KT applied on the lateral hip in patients with unilateral patellofemoral pain syndrome (PFPS). They found significantly greater improvements in balance and squatting range of motion with KT compared to lumbopelvic spinal manipulation and to sham-taping. They suggested that KT applied in the hip area that activates the gluteus medius muscles might be a superior intervention than lumbopelvic manipulation and sham-taping in lower extremity functions. Balki and Göktas (2019) compared the effectiveness of KT to sham-taping used as an additional treatment for muscle facilitation in hip muscle strength in rehabilitation for post-ACL reconstruction patients. Their study reported that KT had a superior outcome than sham-taping in improving postoperative hip muscle strength. They suggested that KT can be paired with muscle facilitation in treating hip muscle weakness after ACL reconstructive surgeries. Fu et al. (2008) studied the effects of KT on isokinetic muscle strength in the quadriceps and hamstring muscles in healthy athletes. They found no significant difference in muscle performance before and after KT. They suggested that KT on the anterior thigh did not affect muscle strength in uninjured athletes.

Rahlf and colleagues (2019) investigated the effectiveness of KT on knee osteoarthritis. They found that KT significantly improved self-reported symptoms of patients with knee osteoarthritis compared to sham-taping and no intervention. Favorable, but statically insignificant improvement in standing balance was also observed in KT in the study. They concluded that applying KT for over three days improves self-reported pain, joint stiffness, and joint functions of knee osteoarthritis. Donec and Kibilius (2020) evaluated the effectiveness of KT in function and mobility in knee osteoarthritis and the patient's subjective value of symptom relief with KT. They found improvements in gait speed, range of motion, and function within both KT and the sham-taping groups but no differences in outcomes between groups. However, they reported that KT appeared to have superior patient-perceived outcomes on symptoms and mobility improvements compared to sham-taping. Espí-López et al. (2019) found significant improvements in dynamic and static knee balance and flexibility in both KT and sham-taping when combined with balance training. They also found no difference in outcomes between groups. Thus, they suggested that the improvements produced in the study were due to balance training instead of the KT intervention.

Labianca et al. (2022) investigated the effects of adding KT to standard rehabilitation protocol in early-stage ACL rehabilitation. They found significant improvements in pain and edema in standard rehabilitation treatment with additional KT compared to the control group that were treated without additional KT. However, after four weeks, only the improvements in edema remained significant between the groups. Pain intensity in both the KT and control groups was found to be similar. Their study suggested that KT was not an effective addition to early ACL rehab. Gülenç et al. (2018) studied the effects of KT in postoperative knee effusion and edema. They found a significant decrease in knee diameter but not in other diameters around the knee (thigh and the ankle), when comparing treatment with KT and sham-taping following knee arthroscopy. Their study also found no significant reduction in subjective pain intensity. Therefore, they concluded that KT could be an effective method in relieving postoperative knee effusion but did not deliver significant reductions in pain or edema level.

de-la-Torre-Domingo and colleagues (2015) investigated the effects of KT in individuals with chronic ankle instabilities. Their study found immediate and prolonged effects (7 days) in both KT and placebo-taping on improving ankle balance in patients with chronic ankle instability. Their data reported there were no differences between groups. Thus, the authors suspected that the observed improvement within both groups was primarily due to the placebo effect. Seo et al. (2016) studied the effects of KT on ankle proprioception in individuals with a history of an ankle sprain. Their study found improvement in proprioception in ankle dorsiflexion and inversion after KT. Therefore, they suggested that KT could be effective in ankle sprains treatment and prevention. However, the lack of a control/placebo group in this study weakened the validity of the results. Another study on ankle proprioception with KT in people without ankle sprain was completed by Halseth et al. (2004). They found that KT application was not superior to no-taping in ankle proprioception in healthy subjects. Their study did not support the hypothesis that KT reduces errors in ankle motions in healthy individuals. The systematic review and meta-analysis by Nunes et al. (2021) investigated the effectiveness of KT on ankle functioning performance in adults and older adults with or without ankle injuries.

Their study suggested that there was insufficient evidence to support the application of KT for ankle performance regardless of the patient population. The results of this study are contradictory to the suggestions of Biz et al. (2022). Their study found that KT may benefit athletes with chronic ankle instabilities, such as improving gait functions and ankle movements, modifying ankle muscle activation, and decreasing unwanted postural movements that affect the ankle. However, they also reported that "dynamic balance, lateral landing from a monopodial jump, and agility tests did not improve significantly by applying KT to the ankle joint." They concluded that KT might improve ankle functioning performance in some, but not all, areas for athletes with chronic ankle instabilities.

KT's Effectiveness - Upper Body

This segment of the literature review chapter will focus on the effectiveness of KT for chronic pain and musculoskeletal disorders in the upper body superior to the thoracic spine. This area includes the muscles and joints of the shoulder girdle and the upper extremities.

Hsu et al. (2009) reported that KT could positively affect scapular kinematics and muscle performance in baseball players with shoulder impingement syndrome. The scapular kinematic changes observed in the study were statistically insignificant between KT and placebo-taping. However, the study found improvement in the lower trapezius activity during 60–30° of the lowering phase of arm scaption and an increase of scapular posterior tilt at 30° and 60° when comparing KT to placebo-taping. Therefore, the authors supported the use of KT as a treatment aid for shoulder impingement. The study by de Oliveira et al. (2019) investigated the immediate effects of KT on acromiohumeral distance and shoulder proprioception in individuals with symptomatic rotator cuff tendinopathy. They reported immediate positive effects of KT on acromiohumeral distance with abduction at 60° and no effects on shoulder proprioception in people with rotator cuff tendinopathy. However, a later study by the same authors in 2021 found no additional benefits of adding KT exercise-based physical therapy for rotator cuff-related shoulder pain. The study by de Oliveira et al. (2021) concluded that KT is not an effective supplemental treatment in rotator cuff-related shoulder pain rehabilitation programs.

Cho et al. (2018) investigated the effects of KT on grip strength in individuals with chronic lateral epicondylitis. Their study found that both KT and sham-taping produce immediate pain relief and improved grip strength during resisted wrist extension in patients with chronic lateral epicondylitis. They concluded that, although there is a noticeable placebo effect with taping, KT exhibited additional effects in pain management during resisted wrist extension than sham-taping. The study by Eraslan et al. (2018) compared the short-term effects of KT and extracorporeal shock wave therapy (ESWT) when used as a combination treatment with physiotherapy in individuals recently diagnosed with lateral epicondylitis (tennis elbow). Their study found a decrease in pain, an increase in function, and an increase in max grip strength in all groups by the end of treatment. Experimental groups that were treated with additional KT and ESWT yielded better results in function than the groups with physiotherapy alone. They also found that KT with physiotherapy showed significantly better results in recovering pain-free grip strength than the other groups. They concluded that KT could be an effective additional treatment to physiotherapy in treating lateral epicondylitis. Chang et al. (2013) studied the effects of KT in athletes with medial elbow epicondylar tendinopathy (MET, or golfers' elbow). They found an immediate improvement in absolute force-sense error in grip strength in both placebo-taping and KT in healthy athletes and athletes with MET. However, they reported that KT and placebo-taping did not affect maximum grip strength when compared to no treatment. They concluded that KT might not be as effective as the KT manufacturer has claimed, and more studies are suggested on this topic.

Zhang et al. (2016) studied the acute effects of KT on forearm muscle strength and fatigue in tennis players. They found no difference between KT, placebo-taping, and no-taping in forearm muscle moment, power, and total work of isometric and isokinetic muscle contractions. Their study also found no improvement with KT in muscle strength during post-intervention assessments. However, KT was reported to yield improvement in wrist flexor muscles' fatigue resistance compared to no-taping. They concluded that KT might be effective in muscle fatigue resistance in healthy athletes during repeated concentric muscle contractions. Farhadian et al. (2019) compared the effectiveness of hand exercise with or without additional KT on pain reduction, range of motion, hand strength, and function KT in individuals with hand osteoarthritis (HOA). Their study found that KT, combined with hand exercise, significantly improved hand pain and functions compared to exercise alone. Although both groups of patients showed better wrist extension range of motion and hand strength post-intervention, hand exercise with additional KT yielded superior results compared to hand exercise-only. The statistically significant difference in pain, strength, and wrist range of motion between groups was maintained after two-month. They concluded that including KT with hand exercise could produce positive treatment outcomes in patients with HOA.

Other Low Back Pain Treatment Interventions

Treatment options for patients with LBP vary, depending on the causation and severity of the pain. While few cases of severe LBP require invasive approaches, most can be managed with non-invasive treatment interventions. According to Sahu (2014), "Clinically, the natural course of LBP is usually favorable; acute LBP frequently disappears within 1-2 weeks. In some cases, however, acute LBP becomes chronic and quite difficult to treat and has a major socio-economic impact". Two guidelines, one published by the American College of Physicians (ACP) and the other published by the National Institute for Health and Care Excellence (NICE), are used as references in this literature review to compare the quality of evidence and clinical recommendations for LBP treatment interventions.

According to the National Guideline Centre (UK) (2016), standard invasive treatment for LBP and Sciatica includes surgery, epidural injections, disc replacement, spinal injections, spinal fusion, spinal decompression, radiofrequency denervation for facet joint pain, and epidural injections. Invasive procedures are not further investigated due to the purpose of this study as they are not a standard protocol for treating CLBP. Standard non-invasive treatments for LBP include manual therapies, oral or cutaneous medications, exercise therapies, orthotics and appliances, postural therapies, electrotherapies, psychological interventions, pharmacological interventions (National Guideline Centre (UK), 2016), acupuncture, massage therapy, taping, and cupping (Trofa et al., 2020). Trofa and colleagues (2020) investigated the evidence of common nonsurgical modalities for injuries in sports medicine. Their comprehensive review suggested a need for more high-quality studies and convincing evidence in current studies to support the effectiveness of KT in LBP and other musculoskeletal conditions.

According to the guideline published by ACP, there is low-quality evidence showing that KT, along with ultrasound and transcutaneous electrical nerve stimulation (TENS), had no effects on pain or function compared with control treatments. The guideline also suggested that, with or without treatment, patients with acute or subacute low back pain would experience improvement over time (Qaseem et al., 2017). For acute and subacute back pain management, the ACP guideline recommended, “nonpharmacologic treatment with superficial heat (moderate-quality evidence), massage, acupuncture, or spinal manipulation (low-quality evidence)” and that clinicians and patients should select nonsteroidal anti-inflammatory drugs or skeletal muscle relaxants if pharmacologic treatment is needed. For the treatment of CLBP, the ACP guideline recommended that “clinicians and patients should initially select nonpharmacologic treatment with exercise” (Qaseem et al., 2017). Suggested nonpharmacologic treatment interventions listed by the ACP guidelines included acupuncture, mindfulness-based stress reduction (listed as moderate-quality evidence), tai chi, yoga, motor control exercise, progressive relaxation, electromyography biofeedback, low-level laser therapy, operant therapy, cognitive behavioral therapy, or spinal manipulation (listed as low-quality evidence).

The National Guideline Centre (UK) (2016) made similar recommendations that one should “Consider manual therapy (spinal manipulation, mobilization or soft tissue techniques such as massage) for managing low back pain with or without Sciatica, but only as part of a treatment package including exercise, with or without psychological therapy.” They further stated, “Consider oral nonsteroidal anti-inflammatory drugs (NSAIDs) for managing low back pain, taking into account potential differences in gastrointestinal, liver and cardio-renal toxicity, and the person's risk factors, including age.” A recent systemic review of nine clinical guidelines by Price and colleges (2022) reported that NSAIDs were the most frequently recommended class of medication for both acute and chronic low back pain in clinical practice guidelines (CPGs). Their study reported that "oral corticosteroids, benzodiazepines, anticonvulsants, and antibiotics were not recommended by any CPGs for acute or chronic LBP." The ACP guideline did not recommend using opioids for treating low back pain due to the low quality of evidence to support its effectiveness in treatment and the risks of side effects.

Although acupuncture and spinal manipulation were recommended in clinical guidelines published by ACP and NICE as treatments for CLBP, the review by Qaseem and colleagues (2017) found low-quality evidence on both interventions' effectiveness in improving pain and function in the low back compared to sham treatment. On the other hand, the systemic review by Coulter and colleagues (2018) reported higher evidence quality on spinal manipulation in treating CLBP. They stated that "There is moderate-quality evidence that manipulation and mobilization are likely to reduce pain and improve function for patients with chronic low back pain; manipulation appears to produce a larger effect than mobilization." The literature review by Trofa et al. (2020) concluded that, although research studies have shown favorable results in acupuncture for low back pain as an adjunction treatment, there is insufficient evidence of its effectiveness.

Other common non-invasive CLBP relief devices that are easily accessible include back support belts, corsets, and dry cupping. The National Guideline Centre (UK) (2016) suggested low-quality evidence of the benefits of improving pain and function with these appliances. Their guideline stated that "The evidence identified was agreed as sufficient to recommend that belts and corsets should not be used for the management of low back pain with or without Sciatica."

Almeida Silva et al. (2021) found negligible effects of dry cupping on pain and function for people with chronic nonspecific LBP. In addition, Trofa and colleagues (2021) found that, although available data may support the use of cupping in treating chronic nonspecific LBP, there is a lack of high-quality research on this modality. The study by Sahu (2014) reported that non-drug, non-invasive interventions, such as a combination of strength, cardiovascular and flexibility exercises with physical therapy and occupational therapy, is efficient in pain reduction and increase function in patients with LBP.

Although herbal medicines and topical analgesics in ointment and patches were not addressed in the previously mentioned guidelines, they are part of non-invasive treatment interventions commonly accessible by the general population and are, therefore, included in this literature review. Jorge et al. (2010) investigated the efficacy and patient adherence in topical preparations for pain relief. Their study reported that buprenorphine patches are relatively safe and produce long-term analgesic effects. According to the authors, "Transdermal buprenorphine matrix allows slow release for up to 96 h. Metabolism is independent of the patient's age, and the drug is not immunosuppressive." The same study also suggested that topical NSAIDS can have pain-relieving effects and are a safer option than oral intake for pain management. However, more studies are suggested to confirm this. The systemic review by Gagnier and colleagues (2016) investigated the effectiveness of herbal medicine for LBP management. They found low-quality evidence that *Capsicum frutescens* (cayenne), *Harpagophytum procumbens* (devil's claw), *Salix alba* (white willow bark), *Symphytum officinale L.* (common comfrey), *Solidago chilensis* (Brazilian arnica), and lavender essential oil are effective in reducing LBP compared to placebo treatments. However, their study indicated that more research is needed to verify these findings. They proposed that topically applied plaster or cream of *C. frutescens* (cayenne) and *S. officinale* (common comfrey) appeared to be more effective in treating LBP than placebo. These ingredients could be considered as a treatment option for chronic and acute LBP, respectively. The overall effectiveness of herbal medicine for LBP management remains inconclusive in this study.

DISCUSSION

The purpose of this literature review is to investigate the effectiveness of KT in golf induced CLBP management. As a relatively mild-intensity sport that can be enjoyed by most people regardless of age, gender, and physical fitness, golf has increased in popularity over the past decade. The most common golf-induced musculoskeletal injury occurs in the low back (Finn, 2013; McHardy et al., 2007; Gluck & Spivak, 2008). Multiple factors have been identified by preceding research as potential factors of LBP in golfers. These factors include individual style of the golf swing, demographic and physical characteristics, and volume of play/practice. (Lindsay & Vandervoort, 2014; Smith et al., 2018; Sutcliffe et al., 2008). The golf swing produces tremendous stress on the spine, especially near the lumbosacral and sacroiliac joints, which can lead to chronic discomfort and pain in the low back (Lindsay & Vandervoort, 2014). This study aims to present additional information to healthcare professionals, amateur and professional golfers, and golf teaching professionals on the effectiveness of KT in the treatment and prevention of golf induced CLBP. This study is also meant to increase awareness of the science on the potential misinformation with KT and encourage more studies to re-evaluate the evidence of KT in clinical practice. With the intention to improve the quality of treatment for golf induced CLBP, this literature review investigated pre-existing studies relative to KT, the golf swing, and CLBP.

The study by Lee and Wong (2002) showed that the lumbar and hip joints make unequal contributions during the trunk's lateral bending and rotational movements. The kinetic sequence in these joints also differs depending on the plane of motion. It is suspected that improper golf swing mechanics or limitations of other body parts during the golf swing may deviate the lumbar spine and the hip from their natural kinematic sequence and cause joint dysfunctions and disorders. Based on the finding in this literature review, clinical research on the diagnosis and treatments for golf induced CLBP appears to be insufficient. It is thought that the optimal practice of golf induced CLBP rehabilitation and prevention is through a multidisciplinary approach. This approach should incorporate, but not be limited to golf swing modification, physical therapy, manual therapy, and exercise training. (Finn, 2013; National Guideline Centre (UK), 2016; Qaseem et al., 2017).

KT is a popular non-invasive intervention in musculoskeletal injury management that athletes and sports medicine professionals have used extensively for joint and muscle support, stabilization, and pain management in the tissues. This study observed that current research had paid close attention to the effectiveness of KT application in diarthrosis joints such as the ankle, shoulder, elbow, and knee, because these joints are susceptible to sports injuries and musculoskeletal conditions. However, when investigating the effectiveness of KT for the low back, such as lumbosacral and sacroiliac joint pain in the athletic population, the amount of published research and peer-reviewed literature appears to be dramatically reduced. Research findings on the effectiveness of KT on CLBP appear to be inconsistent. However, as Al-Shareef et al. (2016) pointed out, "the KT discrepancy results in comparison to the placebo taping may be attributed to the differences in taping application." KT techniques in treating CLBP and other musculoskeletal injuries vary between studies, which may complicate comparing the results between research as one technique may be more effective than the other.

Due to the limitation of research on golf induced CLBP, this literature review utilized available studies focusing on chronic non-specific low back pain (CNLBP) and CLBP in the general population to investigate the effectiveness of KT. It was assumed that golf induced CLBP shares similar symptoms and injury mechanisms with general CNLBP and CLBP. In the literature reviews on KT's effectiveness on CNLBP, both Al-Shareef et al. (2016) and Castro-Sanchez et al. (2016) found immediate improvements in pain intensity, function, and range of motion in KT compared to placebo-taping in individuals with CNLBP. However, they also reported that those effects are clinically insignificant after two to four weeks. This could indicate that KT may produce short-term, immediate effects for CNLBP but not for the long term. Similar to the study of Al-Shareef et al. (2016) and Castro-Sanchez et al. (2016), the Pires et al. (2020)'s study also investigated the effects of KT on subjective pain intensity in individuals with CLBP with the addition of testing electric signal intensity in trunk muscles using electromyography. The study found no difference in the outcomes in muscle electric signal intensity and pain intensity between KT and placebo. Alternatively, Shin and Heo (2017) found significant effects in range of motion with the application of KT compared to placebo-taping in healthy adults. This may indicate that KT could potentially improve paraspinal muscle joint proprioception as a preventive mechanism for LBP in healthy individuals. In another two studies that investigated the effects of adding KT to physical therapy (Kachanathu et al., 2014) and spinal manipulation (Kamali et al., 2018), no additional positive effects were found in adding KT to those treatment interventions in patients with CLBP. Although golf-induced disk herniation is unlikely, it is worth noting that Grześkowiak et al. (2019) reported short-term KT and placebo-taping both showed improvements in disability and pain in patients with disk herniation. However, the KT was not superior to placebo-taping.

As advertised by the KT manufacturer, and believed by numerous healthcare professionals, the primary functions of KT application include muscle support, removing congestion to the flow of body fluids, activating the endogenous analgesic system, and correcting joint problems (Cheatham et al., 2021; Kase, 2005). This literature review has yet to determine the extent to which these mechanisms contribute to any clinical effects. A major claim made by the KT manufacturer is that the KT tape's elasticity facilitates circulation in the target joint and muscle and promotes free range of motion in the target area (Kase, 2005). This would make KT advantageous in treating musculoskeletal injuries over nonelastic interventions, such as athletic taping, which works to constrict and immobilize the target area and reduces body fluids circulation. However, this literature review found insufficient evidence to support this claim. It is also important to address that the contextual effects of KT should not be overlooked. The reasoning behind KT's mechanism in pain modulation and facilitating injury recovery remains undetermined. Researchers have attempted to explain the observed effects on musculoskeletal injuries made with KT by proposing mechanisms other than the claims made by the KT manufacturer. These include the placebo effects, gate-control theory, and neuro-sensory feedback. However, more studies are suggested to investigate these hypotheses.

The Placebo Effect

Several studies have indicated the impact of the placebo effect of KT in CLBP management as comparable improvements were found in patients treated with KT and with sham/placebo-taping (Al-Shareef et al., 2016; Cho et al., 2018; de Souza Júnior et al., 2020; Jassi et al., 2021; Li et al., 2019; Grześkowiak et al., 2019; Peñalver-Barrios et al., 2021). It is rational to propose that short-term improvements with KT observed in patients with CLBP may be due to the subject's contextual effects. In the 2020 study , de Souza Júnior et al. (2020) stated that "[kinesio-]taping had no effect on the outcomes evaluated & possible explanation for the results is that subjects with low back pain with the presence of psychological aspects can benefit from expectations regarding the tape and present improvements in muscle function." They suggested that KT's effectiveness in LBP management can be formed with the patient's expectations. Similar assertions were made by Peñalver-Barrios et al. (2021) and Jassi et al. (2021). Both studies found that, regardless of the improvements observed in both groups of patients, there were no differences in the treatment outcome between KT and placebo-taping on pain intensity in individuals with CLBP. These authors suggested that improvements made in both KT and placebo-taping groups on LBP could be due to general expectations of the treatment by the subjects. In other words, the placebo effect. However, Peñalver-Barrios et al. (2021) suggested that, due to the positive patient outcomes observed during their study, the application of KT may still be a considerable treatment intervention for CLBP.

Cho et al. (2018) stated that although there is a noticeable placebo effect with KT on pain relief and improving pain strength, KT exhibited additional effects in pain management during resisted wrist extension than placebo-taping in individuals with tennis elbow. If found present, the placebo effect in KT could be utilized as a potent treatment mechanism for golf induced CLBP management. As indicated in the survey by Cheatham and colleagues (2021), 73.68% of respondent healthcare professionals believed KT created the placebo effects, and 40.44% of respondents utilize the placebo effects of KT as a common reason for treatment. The impact of placebo effect of KT should not be underestimated, and more studies are suggested to investigate this topic.

Gate Control Theory

The underlying mechanism of KT on pain reduction remains undetermined. Aside from the placebo effect, few authors suggested the gate control theory as a potential pain modulation mechanism provided by KT (Al-Shareef et al., 2016; Castro-Sánchez et al., 2012; Kase, 1996; Paoloni et al., 2011). According to the KT instruction manual provided by Kase et al. (1996), the application of KT along the Sciatic nerve may reduce the nerve's painful sensation by introducing non-painful sensations to the brain, thereby reducing Sciatica symptoms. It is hypothesized that KT may interfere with pain signal transmission to the CNS by creating a larger surface area of non-painful stimuli through cutaneous skin stretching, which results in a reduction of pain perception (DeLeo, 2006; Kase, 2005).

Neural Sensory Feedback

Another proposed mechanism with KT in treating musculoskeletal injuries is improved sensory feedback in the target muscles and joints through the neural system (Castro-Sánchez et al., 2012; Kase, 2005; Paonoli et al., 2011). According to Kase (2005), the KT application provides neural feedback that assists muscle contraction, muscle relaxation, and joint proprioceptive stimulation. Paoloni et al. (2011) posed that corrective sensory feedback provided by KT may improve muscle function in the low back and decrease fear of movement in the population with LBP. Al-Shareef et al. (2016) also suggested that cutaneous feedback with KT on the low back might enhance motor recruitment and paraspinal muscle proprioception. However, there is currently a lack of scientific evidence to validate these claims. Further examination is needed to confirm the KT's effects on neurological feedback on muscle function and joint proprioception.

Body Fluid Circulation

One of the most popular beliefs about KT is that it improves lymphatic and blood circulation, thus reducing inflammation and facilitating injury recovery (Cheatham et al., 2021; Kase,2005). The survey by Cheatham and colleagues (2021) reported that 69.16% of healthcare professional respondents believed in the therapeutic effect of KT in improving local circulation, while only 0.28% (3 respondents) believed in decreased edema, swelling, or effusion. However, when survey asked, "What are common reasons you use KT on your clients?" 74.24% of respondents selected post-injury treatment with edema and ecchymosis, which indicates a contradiction in practice and beliefs in KT. The study by Labianca et al. (2022) found significant improvement in edema in ACL rehabilitation for up to four weeks post-operation when KT was utilized as an additional treatment to the standard ACL rehabilitation program. Their study seemed to support the claim by Kase (2005). However, due to the lack of placebo-taping group in this study, it is difficult to determine which mechanism of KT causes edema reduction. As previously mentioned, the mechanism of improved neurofeedback provided by KT may facilitate muscle activation around the injury site, thus improving the ROM. In addition, both the gate control theory and the placebo effects may decrease pain and fear in performing activities in the injured area. This may facilitate the better quality of rehabilitation exercise performance and reduce edema in the knee.

Another study by Gülenç et al. (2018) compared the effects of KT with sham-taping following invasive knee arthroscopy. They found no differences in pain and edema in the operated leg for up to six weeks postoperative. Although a significantly smaller knee diameter was found in patients treated with KT, there were no differences in diameters in other sites near the operated knee, which indicated edema level was not altered. The authors concluded that KT was not an effective treatment option in reducing edema following knee arthroscopy. The systematic review of Hörmann et al. (2020) on KT for postoperative edema found unconvincing evidence of KT's effectiveness in increasing lymphatic drainage and reducing postoperative swelling due to the limited research and conflicting results in existing studies. The effects of KT for improving fluid circulation and reducing inflammation to facilitate golf induced CLBP remains undetermined.

Limitations

There are some limitations that exist in this literature review. One of the main challenges in studying the effectiveness of KT is the lack of standardization in how the tape is applied to the body. There are a variety of different techniques and approaches to applying the KT tape, and each research practitioner may have their own individual style or preferences. This makes it difficult to compare studies and draw conclusions about the effectiveness of KT. As mentioned in Methodology, a preliminary search in the database found very few studies on the application of KT for golf induced CLBP. Therefore, the search parameters had to be expanded to include the effectiveness of KT for non-specific low back pain and other sports-related musculoskeletal disorders. As a consequence, the research subjects in several selected studies were non-golfers, which may complicate the investigation of the specific treatment outcomes of KT in golf-related low back injuries. This literature review did not include the children and adolescent populations with LBP or CLBP. Studies of KT in treating and preventing LBP in pregnant women and KT in treating post-traumatic low back pain were also excluded in this review. Finally, the elimination of case studies in this review could unduly restrict or confound the findings in this review.

CONCLUSIONS

Although widely used in clinical practice by healthcare and sports professionals, current research provided little evidence on the effectiveness of the KT intervention in facilitating the recovery from low back injury or alleviating pain in individuals with golf induced CLBP. The specific mechanisms of KT in musculoskeletal injuries treatment and prevention remains undetermined. Thus, claims made by the KT manufacturer is not supported by current evidence. This literature review revealed inconclusive findings on the effectiveness of KT in golf induced CLBP management. Further research is suggested on this topic.

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