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The Effect Of Various Decline Squat Angle On Knee Extensors Activation

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THE EFFECT OF VARIOUS DECLINE SQUAT ANGLE

ON KNEE EXTENSORS ACTIVATION

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ABSTRACT

Bilateral eccentric decline squatting has been well documented as a rehabilitation exercise; however, little information exists on the optimum angle of decline. This study aimed to examine the effect of 15°, 20°, 25°, and 30° decline squat angles on knee extensors activation using Electromyography (EMG) in healthy subjects when 60° knee flexion was achieved. Twenty-eight participants [male (n = 14) and female (n = 14) (aged 21.29 ± 1.89 years, body mass 154.44 ± 35.63lb, height 170.81 ± 10.07 cm)] completed a standardized warm-up, Maximal Voluntary Isometric Contractions (MVIC) at 60° knee flexion and then performed each of the 4 decline angles with 3 squat reps (4 sets x 3 reps) with a 2-minute rest period between sets. The vastus lateralis (VL), rectus femoris (RF), and vastus medialis (VM) were examined using EMG. The results indicate that VL, RF, and VM % EMG peak and mean were not significantly different ($p > 0.05$) on each of four decline squat angles (15°, 20°, 25°, and 30°). Data from this study demonstrates that from 15° to 30° decline squat angles produce no difference on quadriceps muscle activation. The result indicates these four decline angles can be used for rehabilitation exercise; however, numerous client depended aspects that should be taken into consideration when selecting exercise during the rehabilitation process.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Patellar tendinopathy sometimes referred to as jumper's knee, is an injury to the patellar tendon, which is clinically characterized by load-dependent pain at the inferior pole of the patella. It is an overuse injury, and commonly there is a gradual onset of pain (Rudavsky & Cook 2014). This condition is common in sports where athletes accrue large amounts of repetitive landing forces, such as volleyball, basketball, high jump and long jump (Purdam et al. 2004; Young et al.,2005; Jonsson & Alfredson, 2005). The prevalence of patellar tendinopathy is high in jumping sports, for instance, in elite volleyball and basketball players, 45% and 32%, respectively (Leeuwen et al, 2009; Murtaugh & Ihm, 2013). Patellar tendinopathy symptoms are often described as a sharp and stabbing pain to the localized area around the patellar tendon, but in severe cases, patients feel steady dual pain immediately after exercise (Visnes & Bahr, 2007). Zwerver et al. (2007) points out that based on the pathology of patellar tendinopathy, inflammation is not the main cause of failed healing: it is a degenerative abnormality in the tendon leading to insufficient healing, which may cause lifetime impairment (Young et al., 2005; Cook & Purdam, 2009). Therefore, the treatment aim should be to achieve a balance between tendon loading and stimulating tendon regeneration rather than using anti-inflammatory treatment (Zwerver et al., 2007).

Eccentric exercise, especially, eccentric decline squats (EDS) are considered a valuable exercise intervention in a rehabilitation program for patellar tendinopathy (Jensen & Fabio, 1989; Purdam et al., 2004; Richard et al., 2008; Zwerver et al., 2007; Richard et al., 2016). Ohberg et al. (2002) suggested that eccentric exercise helps to remodel the injured tendon, reduce neovascularization, and restore the collagen fibers. Furthermore, Kongsgaard et al., (2006) pointed out that the EMG activity of quadriceps indicates more muscle involvement during EDS and suggests extra tension on the quadriceps and the patellar tendon produces bio positive effects, which facilitate faster adaptation and recovery.

EDS tendinopathy rehabilitation researchers suggest that decline squats help to reduce chronic pain and strengthen the patellar tendon and the muscles of the knee (Cannell, 2001; Cook and Khan, 2001; Richard et al., 2008; Richard et al., 2016). Research has been conducted comparing EDS with the different exercises, and it has been shown to be more effective at reducing pain and increasing strength in patellar tendinopathy patients than other exercises (Purdam et al., 2004; Young et al., 2005).

Both Purdam et al. (2004) and Young et al. (2005), measured pre and post intervention pain levels in a population with patellar tendinopathy by dividing exercise interventions into decline squats and standard squats. They concluded that the decline squat group experienced a significant reduction in the pain level associated with patellar tendinopathy after 12 weeks of treatment compared to the standard squat group. Richard et al. (2008) and Richard et al. (2016) focused on biomechanical factors and muscle involvement during EDS treatment. They concluded that 15° and 20° are the best angles for patellar tendinopathy rehabilitation because, at these angles, the gastrocnemius and biceps femoris muscle tension starts to increase as decline angle increases and stabilize knee from posteriorly. Also, Zellmer et al. (2017) evaluated a single leg squat (SLS) on the decline board and found out that a decline angle between 15° to 30° helps to increase patellar tendon force by as much as 40%. Overall, these results suggest that eccentric training in patients diagnosed with patellar tendinopathy may help them to reduce pain and get back to activity, but the optimal angle of decline has not been elucidated.

Although, many researchers have used single leg EDS in their study (Purdam et al., 2004; Young et al., 2005; Richard et al., 2008), McCurdy et al. (2010) compared EMG activation of lower body muscles and found out that double leg squat (DLS) focuses more on quadriceps muscle and SLS on hamstring and glutes. They stated that the SLS is useful as a progressive exercise tool after achieving a DLS with stable and proper technique. Moreover, McCurdy et al. (2010) mentioned that the unstable nature of SLS exercise may affect proper technique of exercise and result in the inability to produce proper tension on the primary muscle group. Therefore, it seems that DLS are a safer alternative for individuals with patellar tendinopathy at the beginning of treatment; however, SLS is considered as a progressive state of treatment intervention in an athletic population.

1.2 Gap in the Literature

While many studies have examined and shown that EDS has a beneficial effect on patellar tendinopathy (Purdam et al., 2004; Young et al.,2005; Richard et al., 2008; Zwerver et al., 2007; Richard et al., 2016), there is limited research regarding recommendations of a particular decline angle in clinical protocol.

Three studies have researched EDS in patellar tendinopathy and suggested different decline angles for exercise intervention. Purdam et al. (2004) demonstrated pain reduction in patellar tendinopathy using a 25° decline angle, they believed that 25° helps to reduce calf tension, force ankle into plantar flexion and target the knee extensors. Richard et al. (2016) suggested that, according to knee and ankle muscle involvement, 15°to 20° is most effective in rehabilitation protocol. In contrast, Zellmer et al. (2017) noted that 30° decline squat angle and 60°- 90° knee flexion during a squat is most effective because of patellar tendon load increases after 60°. Overall, these researches are inconsistent regarding the ideal decline squat angle for patellar tendinopathy rehabilitation.

1.3 Purpose of Study

Therefore, this study aims to examine the effect of 15°, 20°, 25°, and 30° decline squat angles on knee extensors activation using Electromyography (EMG) in healthy subjects when 60° knee flexion is achieved.

1.4 Significance of the Study

The study will explore the effectiveness of 15°, 20°, 25°, and 30° decline squat angles on knee extensor muscle activation; it is intended that the results of the study can be used to determine the most effective decline angle for knee extensor activation. This information can be applied to exercise interventions that will assist clinical populations with tendinopathy, athletes, medical staff, trainers and coaches to more effectively treat tendinopathy.

1.5 Limitations

1. EMG of healthy subjects is similar to those diagnosed with patellar tendinopathy.

2. Higher activation of knee extensor muscles will cause more tension on the patellar tendon and therefore, result in increased adaptation of the patellar tendon.

1.6 Hypothesis

Between the angles of 15°, 20°, 25°, and 30°, the 25°decline squat angle will produce the most EMG activation of knee extensors muscles.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The use of EDS as an exercise intervention for patellar tendinopathy has long been a focus of researchers. The purpose of this literature review is to discuss the effects, specifically muscle involvement, during various declined angled eccentric squats.

This section starts with a review of the anatomy of the patellar tendon and the pathology of patellar tendinopathy; it also includes a review of biomechanical forces on the patellar tendon. There is a brief explanation of the treatment options for patellar tendinopathy. Lastly, there is a review of the methods, interventions, and results of studies using decline squat exercise interventions.

2.2 Patellar Tendon Anatomy, Pathology, and Biomechanics

2.2.1 Patellar Tendon Anatomy

The patellar tendon is a ligament, which is connected to two bones, the patella, and the tibia. It attaches to the bottom of the patella (kneecap) and to the top of the tibial tuberosity. The patella is connected to the quadriceps tendons and to the quadriceps femoris muscles (e.g., vastus lateralis (VL), rectus femoris (RF), vastus medialis (VM), and vastus intermedius); thus, the patellar tendon is an extension of the quadriceps femoris muscles (Khan et al., 1998).

The tendon is well vascularized through an anastomotic ring, which lies in the thin layers of loose connective tissue covering the dense fibrous expansion of the rectus femoris. The contributory vessels are the medial inferior genicular, lateral superior genicular, and anterior tibial recurrent artery (Vincentini & Khan, 1998). Scapinalli (1968) reported that the proximal attachment of the inferior half of the patellar and infrapatellar fat pad is very well vascularized; however, the distal part of the patellar tendon at the tibial tuberosity contains an avascular zone between a ligament and bone.

2.2.2 Pathology of Patellar Tendinopathy

Damage occurs when the tendon fails to adapt to the onset of load and many factors have been speculated as to the reason for tendon failure (Hunter, 2000). Hunter (2000) states, that in a cycle of tendinopathy, the tendon either adapts or does not repair sufficiently. If insufficient time is given to a tendon to adapt and repair, the excessive strain may cause the death of tenocytes within the tendon, which reduces collagen and extracellular matrix production, which may cause reinjury (Khan, 1998).

Cook & Purdam (2009) explain the three stages of tendinopathy pathology: reactive tendinopathy, tendon disrepair, and degenerative tendinopathy. Reactive tendinopathy is non-inflammatory proliferative response in the cells and matrix of the tendon due to acute overload, subsequently, it results in the thickening a tendon and tendon stiffness (Cook & Purdam, 2009). In reactive tendinopathy, the chances of recovery are higher than in the chronic stage. Tendon disrepair occurs during attempts of tendon healing. In this case, there is an abundant breakdown of the matrix and collagen fibers, which cause swelling around the area (Cook & Purdam, 2009). Furthermore, the swelling results in a more difficult recovery and makes the condition more painful (Cook & Purdam, 2009). They (Cook & Purdam, 2009) suggest there is a chance of reversibility of the tendon disrepair with load management and exercise. Lastly, the degenerative stage is a severe condition in which a large area of matrix is disordered, and rupture of the tendon may occur. Although the tendon may recover, there are fewer chances to return to normal size and morphology compared to the acute stage (Cook & Purdam, 2009; Khan.1998). Cook and Purdam (2009) clarify that these three stages show whether there is a chance of reversibility of pathology or not in tendinopathy.

2.2.3 Risk Factors of Patellar Tendinopathy

Different risk factors and significant biomechanical factors involved in patellar tendinopathy were studied by many researchers. According to Rudavsky & Cook (2014), anthropometric factors like weight, height, muscle strength and structure, body composition and joint range of motion can increase the risk of tendinopathy. Whereas, some studies (Visnes & Bahr, 2012; Janssen et al.,2014) mention the volume and intensity of training, and repetitive ground reaction force increase the risk of triggering patellar tendinopathy. Repetitive jumping and landing in sports create a large load on knee extensor mechanism; and it is thought to be a significant contributing factor to the patellar tendinopathy (Cook & Khan, 2001; Murtaugh & Ihm, 2013; Purdam et al. 2004; Richards et al. 2016). Increased knee flexion during landing on a surface after a jump can increase the risk of developing patellar tendinopathy, consequently, athletes with patellar tendinopathy often flex their knees more during initial contact while landing (Richard et al, 2008). Other studies mentioned that from the view of clinical observations, the athletes who can jump at higher height are more likely to get injured because they generate more force (Cook et al., 2004; Rudavsky & Cook, 2014). Accordingly, tendinopathy symptoms increase with an increasing volume of jump training (Ferretti,1986). According to Khan, (1998) in a single basketball game, players jump an average of 70 times with ground reactional forces six to eight times their body weight. Therefore, it causes high stress to the patellar tendon which can cause collagen fiber failure. However, most researchers suggest that repetitive jumping is the main common contributing factor of tendinopathy (Cook & Khan, 2001; Purdam et al. 2004; Cook & Purdam, 2009; Murtaugh & Ihm, 2013; Purdam et al. 2004; Richards et al. 2016)

Ferretti (1984), postulated a relationship between training frequency and patellar tendinopathy. Ferretti (1984) found out that athletes who participate in less than three sessions of training per week are less susceptible to patellar tendinopathy than athletes participate more than three training sessions per week. For instance, Ferretti (1983) showed that the number of athletic competitions in a year is linked to patellar tendinopathy in volleyball players.

2.3 Treatment Options for Patellar Tendinopathy

Ferretti (1984) suggested that treatment for patellar tendinopathy is usually dependent on the stage of pathophysiology. A patient with patellar tendinopathy often receives conservative treatment first before seeking a surgical option (Peers & Lysens, 2005). Andres and Murrell (2008) demonstrated the best patellar tendinopathy treatment options and their effects. Treatments included anti-inflammatory drugs (e.g., NSAIDs and corticosteroid), physical therapy modality treatment (e.g., ultrasound, electrotherapy, and stem cell treatment), surgical treatment (e.g., tenotomy and bone grafting), and other treatment options like dry needling, heat, ice, massage, and taping. Apart from this, numerous studies suggested that eccentric exercise is the most effective conservation exercise treatment intervention in patellar tendinopathy (Cook & Purdam, 2009; Khan, 1998; Purdam et al. 2004; Richards et al. 2016; Visnes, & Bahr, 2007).

2.4 Single Leg vs Double Leg Squats

Most researchers examined SLS instead of DLS in their studies (Purdam et al., 2004; Young et al., 2005; Richard et al., 2008; Richards et al. 2016). SLS is popular for rehabilitation of lower extremity injuries and for testing purposes. Behm et al. (2002) explains that moderately unstable resistance training like SLS helps to optimize motor recruitment by producing significant forces required to improve muscle strength. Also, hip abductors serve to stabilize the hip joint during exercise and in SLS there is significant hip abductor muscle activation (Fisher J &Wallin.M., 2014). In contrary, McCurdy et al., (2010) examined SLS and DLS on untrained male and female participants for 8 weeks (2 days/ week) and measured similar levels of strength improvement in both groups. They also checked EMG activation of lower body muscles in both exercise type (SLS & DLS) and concluded that DLS activates quadriceps muscle to a greater extend compare to SLS. McCurdy et al. (2010) suggested that to perform SLS correctly, participants must have prerequisite levels of strength in their lower backs and hip abductors. Therefore, DLS can be used to improve overall strength and stability of the focused muscle group before progressing to SLS.

2.5 Review and Analysis of Studies with Eccentric Training using Decline Board

There are numerous studies that compare EDS versus other exercise interventions and results show that EDS is most effective in reducing pain and improving tendon health among all the choices (Stanish et al. 1986; Cook & Purdam, 2009; Richards et al. 2016; Young et al., 2005; Purdam et al. 2004). These studies also identified that EDS shifts the load to the tendon at a greater level to develop strength and reduce pain (Stanish et al. 1986; Cook & Purdam, 2009; Richards et al. 2016; Young et al., 2005; Purdam et al. 2004). Some studies compared pre and post tendon pain level using eccentric training in rehabilitation and most of them find EDS is more effective at reducing pain compared to the standard squat (Purdam et al. 2004; Young et al., 2005; Jonsson & Alfredson, 2005; Stanish et al. 1986; Visnes, & Bahr, 2007). Whereas, three studies investigated muscle involvement while performing squat on different decline angles, and these three studies suggested different decline angles for clinical use (Zwerver et al., 2007; Richards et al. 2008; Richards et al. 2016).

2.5.1 Eccentric Decline Squat Angle

Three studies have used 25° decline board and rationalized that it increases the load and stress on the patellar tendon, which helps to develop muscle strength, improve tendon weight bearing capacity and reduce pain (Purdam et al., 2004; Young et al., 2005; Kongsgaard, 2006). Richard et al. (2016) used six different angles (0°, 5°, 10°, 15°, 20° and 25°) to examine muscle involvement at various decline SLS position. They summarized that increasing the decline angle increased the load on rectus femoris and biceps femoris muscles and reduced tibialis anterior involvement during a squat. Similarly, Zwerver et al. (2007) used six angles (0°, 5°, 10°, 15°, 20° and 25° degrees) with extra weight; however, they used a 30° angle without loading and summarized that between 15°and 30° can be used to avoid extreme dorsiflexion. Unlike other studies, Richard et al. (2008) implied four different angles (0°, 8°, 16°, and 24° degrees) in their study and found that there is an increase in calf muscle activity from 16 ° to 24°. They also highlighted that this muscle involvement finding is important because performing EDS in clinical conditions demands this knowledge. Although these researchers' focus was to find the optimal declination angle for an exercise intervention in patellar tendinopathy patients, they all have different suggestions for the optimal angle of declination.

2.5.2 Review of Biomechanics and Muscle Involvement in EDS

In patellar tendinopathy, there is a gradual decrease in quadriceps strength, often due to the imbalance between load and loading capacity of the tendon including pain and inhibition of the quadriceps. Also, in this condition, patients are often unable to absorb forces applied to the tendon (Zwerver et al., 2007). In rehabilitation programs, eccentric exercises aim to improve muscle-tendon loading capacity and function, it also optimizes the kinetic chain. EDS has been described as the application of a positive maximal load to the knee extensors in an eccentric manner (Jonsson, P. & Alfredson, 2005). These following three studies explore various decline angles' effect on muscles, joints, and force production of patella femoral joint and quadriceps muscles (Zwerver et al., 2007; Richard et al., 2008; Richard et al., 2016).

Richard et al. (2016) study question was to find out the effect of different decline angles on the biomechanics of DLS and its implication on clinical protocol. They included eighteen healthy subjects (9 males, 9 females, ages 20 to 46 years) in their study. All participants in this study were trained how to squat in the practice trial and they were asked to perform squats on a decline board (0°, 5°, 10°, 15°, 20° and 25°) with knee flexion as much as possible for experimental trial. They were asked to complete 5 trials. They measured ankle and knee ROM using video analysis and evaluated EMG of the calf, tibialis anterior, biceps femoris, and rectus femoris muscles. The decline squats were performed on a force plate so the researcher could examine patella femoral joint force (PFF), patellar tendon force (PTF), and quadriceps force (QF). They concluded that as the decline angle increases all these three forces increase.

Using repeated ANOVA Richard et al., (2016) noted that, there was a pairwise significant difference between all five decline angles (0° & 10°, 0° & 15°, 0° & 20°, 0° & 25°, 5° & 10°, 5° & 15°, 5° & 20°) of six angles ($p < 0.05$) except between 20° and 25° and they concluded that for rehabilitation purpose 15° and 20° is most effective on knee extensors. Moreover, the result of the study shows a significant increase in PTF up to 20° declination, there is no significant difference in PTF between 20°and 25°decline angles. In an EMG report of muscle activity, repeated ANOVA in tibialis anterior vs rectus femoris showed a significant difference ($p < 0.05$), but for biceps femoris and gastrocnemius there was no significant difference ($p>0.05$). This research identifies that there is less effect of 0° and 10° declination angles on knee extensor muscles activation; however, research also explains that there is not a significant difference between 20°and 25° declination angles. These studies help to classify the difference between all declination angles.

Similarly, Richard et al. (2008) assigned 10 participants (age 21 ± 6.7 years, mass 70.7 ± 11.5 kg) to perform three trials of SLS at various angles. In this study, they had variations in decline angle (0°, 8°, 16°, and 24°) and they randomized trial by switching the order of decline angle. Richard et al. (2008) were seeking to examine the involvement of gastrocnemius vs rectus femoris muscle with 60° knee flexion while squatting on a decline board. Similar measurement procedures were used by Richard et al. (2016) and Richard et al. (2008). Richard et al. (2008) in their study questioned what the involvement of the gastrocnemius and rectus femoris muscles at the ankle and knee joint moments is 60° of knee flexion while performing a single-limb squat at different decline angles. They verified statistically pairwise significant difference ($p <0.05$) between four declination angles (0°, 8°, 16°, and 24°) declination angles at 60° of knee flexion. Additionally, Richard et al. (2008) concluded that the 16° decline angle provided the maximum benefit for the knee extensors with the minimum effect for the ankle and the 24° decline angle provided a greater challenge to the ankle and targeted the knee extensors more compared to 16° declination.

Zwerver et al. (2007) investigated knee movement and patella femoral force during single-leg squat on a decline board. They had 5 participants (2 male, 3 female) perform squats on decline board at declination angles 0°, 5°, 10°, 15°, 20, 25° and 30°. Previous studies had a decline angle between 0°and 25°, this study added 30° decline angle. Similar to the two studies mentioned before, this study measured the ground reactional force of patella femoral joint by using force plates. They measured joint movement (hip, knee, and ankle) using two-dimensional inverse dynamics. Zwerver et al. (2007) applied an extra external load of 10 kg to participants.

Zwerver et al. (2007) focused on the relationship between knee movement and patellar tendon load during SLS on a decline board. They observed that performing single leg EDS at ≥ 15° declination increases 40% higher knee movement and patellar tendon force compare to standard squat. Also, the difference in knee movement at 0° and 15° and 30° were significant ($p < 0.05$). Zwerver et al. (2007) identified that at decline angles of 15° and higher, knee movement increased by 40% whereas hip and ankle movement decreased. They suggested that any decline angle between 15° - 30° could be used for clinical purposes. Zwerver et al. (2007) had a different suggestion of range of decline angle than other two studies (Richard et al., 2008, 2016) because Zwerver et al. (2007) was only the one who used additional 30° decline angle in their study to find muscle involvement at 30° decline angle.

2.5.3 Review of Effect of Standard vs EDS on Pre and Post Pain level in Patellar Tendinopathy

Clinically patellar tendinopathy described as pain at the proximal segment of the tendon where the patellar tendon attaches to the bone (Rudavsky & Cook, 2014). EDS intervention has shown a significant effect on reducing pain. Two studies aimed to compare standard vs EDS and compare pre and post exercise pain levels in a painful patellar tendinopathy population (Purdam et al., 2004; Young et al., 2005).

Purdam et al. (2004) performed a non-randomized pilot study, comparing eccentric training on a decline board (9 participants) and a flat surface (8 participants, without decline board). Participants were asked to squat slowly to 90° of knee flexion. Purdam et al. (2004)

recruited 17 participants for 12 weeks of treatment, exercise prescription 3 sets of 15 reps 2 times daily period for both standard and EDS with further follow up for 12-15 months.

Purdam et al. (2004) questioned the differences in pain reduction and recovery of function, using an eccentric SLS program, on a flat surface and a decline, in patients with patellar tendinopathy. In Purdam et al. (2004) study, subjects were restricted from participating in any sports competitions during eight weeks of exercise protocol. After eight weeks they were progressively allowed participation in previous activity. After 12 weeks there was a significant ($p = 0.004$) decrease in the amount of pain during activity in the EDS group compare to the standard squat group.

Young et al. (2005) had the same number of participants (13 men, 4 women) with painful patellar tendinopathy and the same intervention period (3 sets of 15 reps, 2 times per day) as Purdam et al. (2004) in their study. However, Young et al. (2005) hypothesized that there is the short-term (12 weeks) and long-term (12 months) effect of eccentric exercise on decline board (25°) versus same exercise on a step stool (10 cm) on pain level. Another difference in both studies is knee flexion level. Young et al. (2005) had 60° knee flexion limit in a squat. Both studies used Visual Analogues Scale (VAS) to measure tendon pain level; however, Young et al. (2005) also used a Victorian Institute of Sports Assessment (VISA) for knee function.

The Primary study question for Young et al. (2005) was, what is the immediate (12 weeks) and long term (12 months) efficacy of two eccentric exercise programs for the treatment of patellar tendinopathy. Unlike Purdam et.al (2004) results, Young et al. (2005) found out that both groups improved in pain significantly ($p < 0.05$) at 12 weeks and 12 months in VAS and VISA Questionnaire. However, there was no difference between groups at either outcome measure at any time.

Also, both studies concluded that they needed a larger number of participants to confirm which treatment is most effective (Purdam et al.,2004; Young et al.,2005). Purdam et al. (2004) also noted that randomized studies comparing different models of squat exercise are needed to confirm their results. Apparently, in these two studies they are in favor of the EDS intervention benefits to reduce pain in painful patellar tendinopathy.

2.6 Summary

The literature review provides support for EDS as an exercise intervention in patellar tendinopathy and explains how EDS helps to improve strength and reduce pain (Purdam et al., 2004; Young et al., 2005). Zwerver et al., 2007, Richard et al., 2008 and Richard et al., 2016 studies summarized that by increasing declination in squats you can reduce the load on the ankle muscles, increase knee movement and increase muscle activity of knee extensors. Thus, different decline angle has a potential role in the training of patellar tendinopathy patients (Zwerver et al., 2007; Richard et al., 2008; Richard et al., 2016). It remains unclear what the optimum angle dosage of EDS exercises should be. To our knowledge, no studies have been investigated knee extensors that is VL, RF, and VM muscle activation at different decline squat angles.

CHAPTER 3

METHODS

This next section will cover participants and criteria, equipment, study design and treatment protocol.

3.1 Participants and criteria

According to Malliaras et al. (2015), patellar tendinopathy is a condition primarily more common in the age range between 15 to 30 years old. However, in Morgan et al. (2016) meta-analysis on patellar rehabilitation mentioned that most studies only included participants older than 18 years. Therefore, in this study participants inclusion criteria were between the ages of 18 to 30 (men & women). Other inclusion criteria were healthy participants with ≤ 21 mm skinfold at the thigh. Exclusion criteria was there should be no history of surgery in hip, knee and ankle joint. Additionally, they should not have recent injury or pain at hip, knee and ankle joint. For exclusion and inclusion criteria two questionnaires were be completed. These two questionnaires included were: Research Criteria Questionnaire for pain and surgery history and Exercise Pre-participation Health Screening Questionnaire by Riebe and Magal (2016). Informed consent was collected from each subject prior to data collection and approval was gained from the Indiana State University Institutional Review Board.

3.1.1 Control

Participants followed certain criteria during the research study. Participants were not allowed to perform any kind of lower body exercise seventy-two hours prior to the experimental session. This is because lower body workouts may cause muscle soreness, which could affect the result of electromyography (EMG) of knee extensors. They were asked to wear shorts and shave the sensor site at thigh to improve signal of EMG. Also, participants with high fat over the thigh region were excluded to avoid inaccurate result of EMG. The measurements of quadriceps fat were taken using skinfold caliper during recruitment and participant. According to De la Barrera & Milner (1994), quadriceps skinfold thickness for EMG will be limited to $\leq$ 21 mm.

3.2 Equipment

1) Electromyography (EMG)

Knee extensors muscles activation (i.e. VL, RF, & VM) were collected by Delsys TRIGNO™ Wireless System (Model PM-W01): surface electromyography. For the VM, the electrode was placed on the VM muscle belly, approximately 4 cm proximal to the superomedial border of the patella. For the VL, the electrode was applied over the VL muscle belly, approximately 8 cm proximal to the lateral joint line of the knee. For the RF, the electrode was placed at 50% of the distance from the anterior superior iliac spine to the superior pole of the patella (Matheson et al. 2001). All electrodes were placed parallel to the corresponding muscle fiber. A ground electrode was placed on the proximal surface of the tibia to eliminate any occasional external interferences. Each sensor contained two silver contact bars (10 mm x 1 mm diameter) that are spaced 10 mm apart with a common mode rejection ratio of 92 dB and has a maximal sampling rate of 2000 samples per second. A hypo-allergenic adhesive was applied onto the conducting surface of each sensor to allow it to stick to the skin. Prior to placing the sensors, an isopropyl alcoholic swab was used to clean the skin of any dry skin cells, oil or other contaminants. If excessive body hair existed on the thigh region, the participants were asked to shave prior to testing session. Muscle activation data was collected and analyzed using EMG works (version 4.0.9) software.

2) Electronic Goniometer

Knee flexion was measured using Vernier electronic goniometer (Model GNM-BTA) placed on the knee joint at the lateral epicondyle. The electronic goniometer is fully supported with LabQuest 2 (version 2.8.5) software. Placement of the arms of electronic goniometer was aligned with the femur and the tibia. The purpose of the goniometric measurements was to ensure that participants are achieving 60° knee flexion, the data of was not be used in any statistical analysis.

3) Decline board

Adjustable incline/decline board rehabilitation (purchased online) device was used. Decline board include 0°, 5°, 10°, 15°, 20°and 25°, and 30° declination angles. However, in this research only four declination angles (15°, 20°, 25°, & 30°) were used.

3.3 Treatment protocol

3.3.1 Experimental Design

To obtain the necessary data for the effect of EDS on the knee extensors EMG, participants completed three DLS trials using an adjustable decline board (rehabilitation device). Each of these trials were randomly assigned decline angles (15°, 20°, 25°, & 30°) and the average was taken from all trials. For the trial to be considered the participants must have achieved at least 60° knee flexion during squats. The variables examined were knee extensors EMG activity specifically the activation level of the: VL, RF, and VM.

3.3.2 Baseline testing and familiarization

1. After participants were determined to meet all criteria, the skin was prepped. Surface electrodes were fixed on the VL, RF, and VM.

2. The electronic goniometer was placed on the knee joint, with its axis attached to the lateral epicondyle of the femur, and the arms aligned with the femur and the tibia. It was placed on participants in the standing position.

3. After the preparation and positioning of the electrodes and electric goniometer, each subject warmed up on a stationary bicycle for 5 minutes.

4. Soon afterwards, they performed squats as a warmup. Participants performed 5 standard DLS on a flat surface and 5 squats on each of the four chosen decline angles. During the squat warm-up each participant was provided with the oral instructions 3, 2 and 1 to slow the squat eccentric motion, when they achieve 60° knee flexion as determined by electric goniometer they were asked to come up with the same cue. Controlling the squat speed helps limit the use of the stretch-shortening cycle and increases participant safety. Cueing used during warm-up was consistent with the cueing used during the experimental trial. Additionally, during all squats participants were barefoot or in socks because wearing shoes may affect the decline angle of the squat.

5. Maximal voluntary isometric contraction of quadriceps was measured, the EMG signals, obtained in millivolts (mV), was rectified (full wave), filtered at 25 Hz, and normalized by maximal voluntary isometric contraction (MVIC). For all MVIC tests, the participants were asked to seat on the table. The MVICs of all portions of the quadriceps were tested with the knee of the participant fixed manually at 60° of extension (0° equal to full extension), and resistance was applied using strap tied to the table to just above the ankle in the extension direction (Dionisio, Azevedo, & Siqueira, 2013).

3.3.3 Experimental trial

1. The order in which the decline angles were assigned to the participants was randomized using a random number generator in excel. They were not be verbally told the angle of the board; however, they might have been able to discern the angle visually.

2. At the beginning of the test participants were instructed to step on a decline board and allowed to stabilize before squatting. The decline board was located within reaching distance from a wall. Participants were asked to perform DLS with the 3, 2, 1 cue until they reach at least 60° knee flexion and come back slowly with cueing to an upright position. Cueing was similar to the squat warm-up. Participants performed three trials on each of the decline angles and EMG data was collected.

3. Between each of the 4 decline angle sets with 3 squat reps on each decline angle (4 sets x 3 reps), there was 2-minute rest period intended (total 4 minutes rest), to avoid muscle fatigue.

4. An average of each muscle trial EMG recording was taken.

5. For decline squats data, EMG signals were band-pass filtered with a cut-off frequency of 20-450 Hz, respectively. Furthermore, signals were full wave rectified and smoothed using a root mean square (RMS) filter along a 250 ms moving window. The average peak and mean muscle activity of the repetitions three decline squat repetitions for each angle were normalized to the peak amplitude during the MVIC for the respective muscles for each participant. Both the eccentric and concentric phases were analyzed for all repetitions.

3.4 Statistical Analysis

IBM® SPSS® statistics software package, version 24 (SPSS Inc., Chicago, USA) was used to measure outcomes. A repeated one-way ANOVA was used to compare the three muscles EMG report and four decline angles. The significance level set at 0.05, for verification of significance.

CHAPTER 4

RESULTS

4.1 Introduction

This chapter is divided into two sections.

The first section provides a description of the subjects that participated in the study. The second section presents the decline squat angles effect on muscle EMG results for the participants.

4.2 Subject Characteristics

Thirty-eight subjects were recruited during this study; ten subjects did not qualify due to having a thigh skinfold measurement > 21 mm. Therefore, twenty-eight subjects participated in the study, 14 males and 14 females (aged 21.29 ± 1.89 years, body mass 154.44 ±35.63lb, height 170.81 ± 10.07 cm). The thigh skinfold measurement and force production during MVIC for the 28 participants were 15.93 ± 4.14 mm and 356.05 ±159.37 N, respectively. One participant's data for RF peak and mean muscle activity was removed prior to data analysis because the amplitude analysis did not show three trial muscle contraction. Resulting in 28 participants' data for VL and VM muscles EMG and 27 participants' data for RF muscle EMG.

4.3 Muscle Activity During Decline Squat Angles Results

A repeated one-way ANOVA was conducted to compare the effect of the four different decline squat angles (15°, 20°, 25°, and 30°) on the muscle activity (VL, RF, and VM). There was no statistically significant difference between the means and peak muscle activity of all three muscles across the different four decline angles ($p > .05$). The decline angle squats did not lead to any statistically significant changes on peak EMG % MVIC: vastus lateralis t(28) $F(3,81) = 1.839$, $p = 0.147$; rectus femoris t(27) $F(3,78) = 0.590$, $p = 0.624$; and vastus medialis t(28) $F(3,81) = 0.447$, $p = 0.720$. Moreover, the decline angle squats did not lead to any statistically significant changes on mean EMG % MVIC: vastus lateralis t(28) $F(3,81) = 0.521$, $p = 0.669$; rectus femoris t(27) $F(3,78) = 1.132$, $p = 0.341$; and vastus medialis t(28) $F(3,81) = 0.597$, $p = 0.619$.

Table 1.

Mean Difference (MD) and Pairwise Comparisons of Peak EMG Activity Between the Decline Angles

Pairwise comparisons	**15°-20°**	**15°-25°**	**15°-30°**	**20°-25°**	**20°-30°**	**25°-30°**
Vastus lateralis						
MD	2.058	5.660	2.169	3.602	0.112	3.491
p	1.000	0.245	1.000	0.182	1.000	1.000
Rectus femoris						
MD	4.061	1.162	2.962	2.899	1.092	1.807
p	0.736	1.000	1.000	1.000	1.000	1.000
Vastus medialis						
MD	0.595	0.224	1.954	0.819	1.359	2.178
p	1.000	1.000	1.000	1.000	1.000	1.000

Table 2.

Mean Difference (MD) and Pairwise Comparisons of Mean EMG Activity Between the Decline Angles

Pairwise comparisons	**15°-20°**	**15°-25°**	**15°-30°**	**20°-25°**	**20°-30°**	**25°-30°**
Vastus lateralis						
MD	0.166	1.329	0.537	1.163	0.703	1.867
P	1.000	1.000	1.000	1.000	1.000	1.000
Rectus femoris						
MD	2.594	1.055	1.276	3.649	1.317	2.332
P	0.619	1.000	1.000	0.638	1.000	1.000
Vastus medialis						
MD	0.658	1.023	0.444	1.681	0.658	1.467
P	1.000	1.000	1.000	1.000	1.000	1.000

Figure 1

Peak muscle activation for select lower limb muscles during decline squat

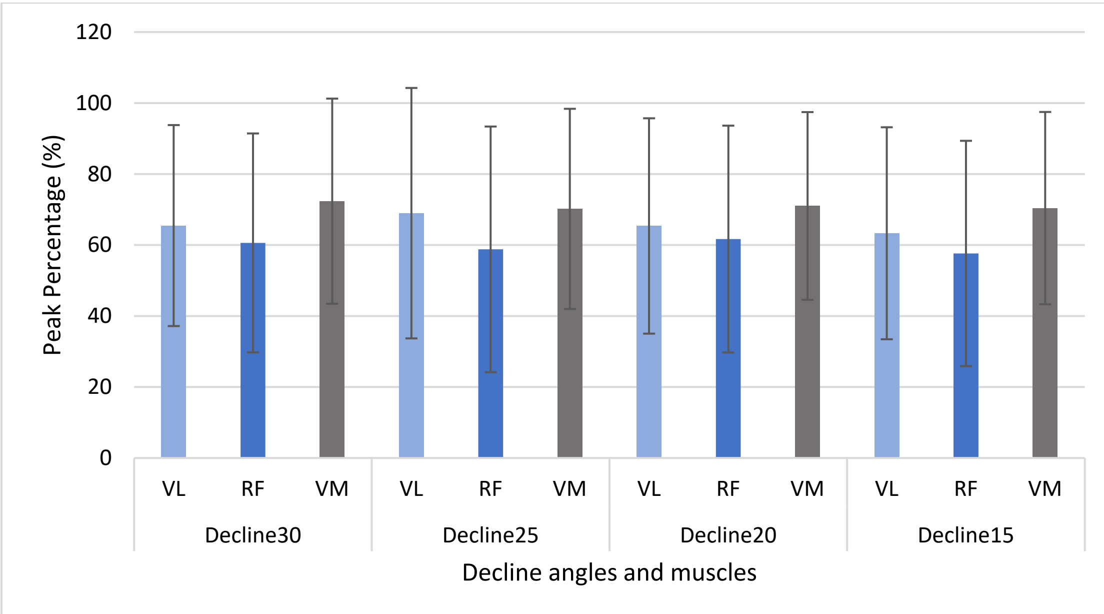
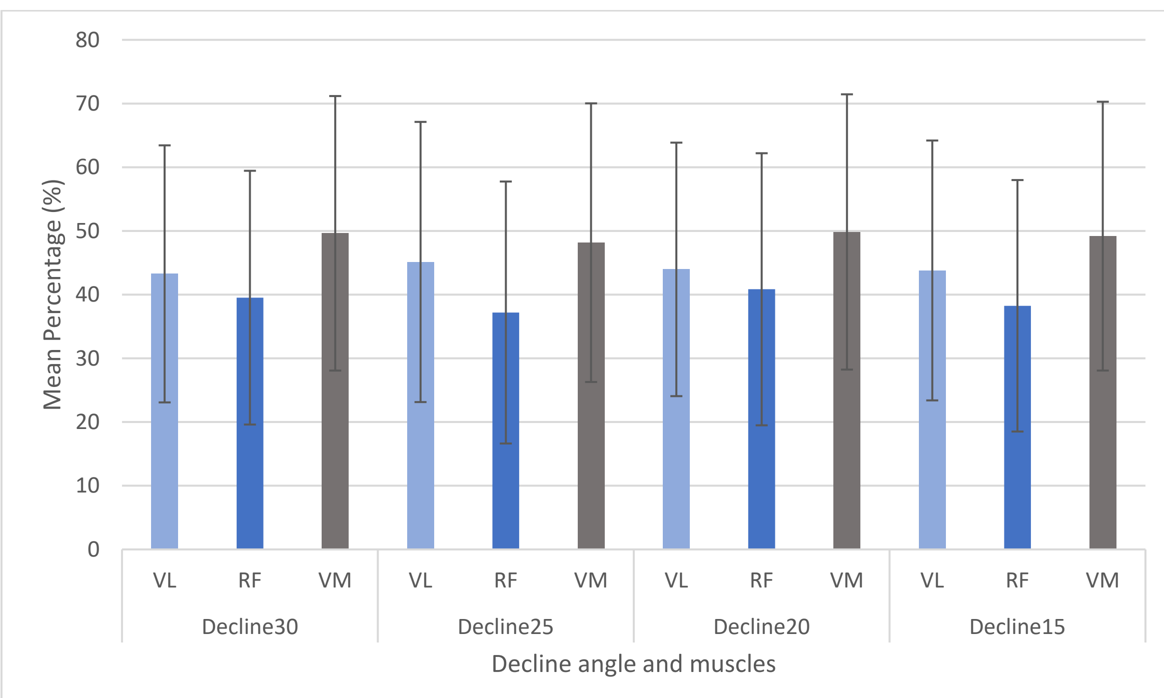


Figure 2

Mean muscle activation for select lower limb muscles during decline squat



CHAPTER 5

DISCUSSION

5.1 Decline angles and quadriceps activity

The purpose of this study was to compare the difference in muscle activation of the VL, RF, and VM. at decline angles of 15°, 20°, 25°, and 30° during decline squat. This study was conducted because there was less known about VL and VM muscle activation during EDS. Moreover, there are very few studies that have used a 30° decline squat angle and measured knee extensors muscles EMG activation. It was hypothesized that between the angles of 15°, 20°, 25°, and 30°, the 25°decline squat angle would produce the most EMG activation of knee extensors muscles (VL, RF, and VM). In contrast to the hypothesis, the results of this study indicate that all decline angles produce similar peak quadriceps EMG muscle activation. Additionally, the result of mean EMG muscle activation of the three examined quadriceps muscles showed no significant difference.

The squat exercise represents close kinetic chain exercise, which can promote joint stability through co-contraction of agonist and antagonist muscles (Lee, D., Lee, S., & Park, J., 2015). Tang et al. (2001) concluded that the VM/VL ratio in the squat exercise was higher than that in open kinetic chain exercise. In the patellofemoral joint, the VM muscle stabilizes the medial side of the patella, whereas VL stabilizes the lateral side of the patella. Lee et al. (2015) study applied squat exercises using a gym ball, a wedge, and an elastic band and measured VM and VL EMG activity and they found out no significant difference between VL and VM on the wedge. The results of VL and VM in the current study show no difference in muscle activation on all four decline angles.

Previous researchers have stated that EDS targets knee extensors and patellar tendon, and that decline squat have been used as an exercise to target the knee extensors (Purdam et al., 2004; Jonsson and Alfredson, 2005; Zwerver et al., 2007; Richard et al.,2008; Richard et al.,2016). However, none of their study measured VM and VL muscle activity during EDS. Richard et al. (2008) and Richard et al. (2016) used EDS and measured lower body muscle activities; however, they included only RF muscle, not VM and VL. As a result, they found out that there is no significant difference between 16°- 24° (Richard et al.2008) and 15° – 20°, 15° – 25°, & 20°-25° (Richard et al. 2016) decline angle on RF muscle activation. Similar to these results, the results of our study showed that there is no effect of different decline squat angles (15°to 30°) on RF muscle activation. The result indicates that out of these four decline angles any of them can be used for rehabilitation exercise, because there is no significant difference in peak and mean muscle activation of quadriceps muscles. However, to select a proper angle for the patient, the therapist or trainer should consider the patient's other factors like age, recovery, and trained or untrained status. Numerous aspects should be taken into consideration when selecting exercise during the rehabilitation process.

Zwerver et al. (2007) was the only study to include a 30° decline squat angle and suggested that it can be used in the patellar tendinopathy exercise interventions. Our study also included a 30° decline squat angle, which shows no significant effect on quadriceps muscle activation across the three decline angles. Although a 30° decline angle can be recommended for exercise intervention due to no change in muscle activation, during this study we observed that even young and healthy participants tried to reach for supports to perform squats at a 30° decline angle. This study did not measure balance on decline angles, but it cannot be ignored that a 30° decline angle may become challenging for a clinical population to perform squats at this due to their condition and instability.

Purdam et al. (2004) and Young et al. (2005) included only 25° decline squat angle by assuming that it is the best angle to target the knee extensors and reduce pain. In contrast, our study result shows that there is no difference between 15°, 20°, 25° and 30° decline squat angles on quadriceps muscle activation in a healthy population.

5.2 Limitation

One limitation was that the participants were considered a healthy population, and it was assumed that the muscle activation of a healthy participant would be the same as an individual with patellar tendinopathy. Furthermore, there is always a risk of crosstalk from nearby muscles using surface EMG, which thereby would generate inaccurate measurements. Crosstalk interferes with the signal and can cause an incorrect reading of the signal information (Gerdle et al., 2005). Chowdhury et al. (2013) showed that several undesired signal sources (extrinsic factors, inherent noise in electronic equipment, motion artifacts, ambient noise) can affect surface EMG signals. Lastly, during the study, we noticed that trained and untrained participants may affect force production results of MVIC. According to Griffin and Cafarelli (2005) and Carroll et al. (2011) muscular training changes in force production due to neuromuscular adaptations related to learning optimal muscle activation patterns, like increases in motor unit firing rate and earlier motor unit recruitment. Also, the study by Vila-Cha et al. (2010) indicates that the specificity of training principles may play a role in training-related neuromuscular adaptations, namely single-motor-unit firing rate patterns. Lastly, EMG muscle activation can be varied between male and female participants, which may also affect the results of the study. Albert et al. (2006) showed a significant difference in muscular force production and fatigability between genders using EMG.

5.3 Suggestion for Future Study

Further studies with a larger sample size, specific to a population with patellar tendinopathy are required. Data from this study demonstrates that from 15° to 30° decline squat angles produce no difference in quadriceps muscle activation, therefore any decline squat angle might be useful in as exercise intervention for the patients with patellar tendinopathy. Future research examining the relationships between ultrasound imaging results and objective EDS outcome measures in the patellar tendinopathy participants are needed to study the structural change of the patellar tendon. A future recommendation would be to determine the optimum length of intervention, along with the dosage and frequency of the EDS protocol. Another potential research question could be to examine the effect of balance on decline board squat exercises, especially, on a 30° decline squat angle, because there is more risk of falling at a higher decline angle in a clinical population.

5.4 Clinical Relevance

The decline squat has been used as an exercise to target the knee extensors (Khan et al., 1998; Purdam et al., 2004; Young et al., 2005). The principles behind this logic were fundamentally correct; however, the optimal decline angle for patellar tendinopathy rehabilitation had not been identified. Our study provides a piece of information for therapists when beginning the decision-making process for using double-limb squats. The decline squat enables the knee to be flexed, which may be useful if the ankle has a poor range of motion due to immobilization, and, therefore, should be given as an effective knee extensor exercise without moving the ankle into a dorsiflexed position (Richard et al.,2016; Zwerver et al.,2007). If the clinical reasoning for the test is to target the knee extensors muscles, then the data presented suggest that the four decline angles included in this study have an equal effect on the knee extensors activation. However, a decline angle of 15°, 20°, and 25° may be justified if the aim of programming is rehabilitation. This rationale is due to the researcher's subjective observations of balance difficulties in a healthy population on a 30° decline angle.

CHAPTER 6

CONCLUSION

Researchers have shown that the use of eccentric squat exercises has a significant effect on performance (Purdam et al., 2004; Jonsson and Alfredson, 2005; Zwerver et al., 2007; Richard et al.,2008; Richard et al.,2016); however, little was known about the optimal decline angle for rehabilitation. This study increased understanding that decline angles 15°, 20°, 25°, and 30° produce non-significant differences in VL, RF, and VM muscle contraction during the squat. Any of these four angles can be used for rehabilitation of patellar tendinopathy, however; 30° decline angle needs further investigation of balance during squat. Additionally, further studies are needed to include patellar tendinopathy patients and need to measure recovery of the patellar tendon using EDS and ultrasonography.

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APPENDIX -A

Consent Form for Participation in Research Project

Indiana State University

THE EFFECT OF VARIOUS DECLINE SQUAT ANGLE ON KNEE EXTENSORS ACTIVATION

You are being invited to participate in a research study. This study aims to find out the effect of 15°, 20°, 25°, and 30° decline squat angles on knee extensors muscle activation using Electromyography (EMG) in healthy subjects when 60° knee flexion is achieved.. This document will help you decide if you want to participate in this research by providing you information about the study and what you will be asked to do. You will be asked to perform squats on a decline board at 4 different angles.

Some reasons you might want to participate in this research are that you will learn about your: knee extensor muscle activation, thigh skinfold measurement, the maximum amount of force your knee extensor muscles can produce. Additionally, you will be helping exercise specialist better understand how different angles of decline squats can be used to strengthen knee extensor muscles and patellar tendon.

Some reasons you might not want to participate in this research are that performing squats on decline board requires balance, and a base of physical ability. If you are not a healthy, physically active individual the exercise may increase your risk of falling. . Participation in this study requires multiple squat repetitions which may be consider challenging to some individuals. You may not want to participate in study because it may require you to shave your thighs, for EMG electrode placement. Additionally, this study will require 2 hours of your time.

This study asks you to: fill out two questionnaires, perform a dominant leg test, perform a squat test, perform a maximal knee extension against resistance, to do a warmup on stationary bicycle and to preform multiple squats on decline board**.** You have been asked to participate in this research because you are between ages of 18 to 30.

Description of Procedures

This study will take place at Indiana State University (ISU), it involves 1 visit (approximately 2- hours). This is what will happen during the study:

You will be instructed to avoid any kind of lower body exercise for 48 hours prior to your first visit.. You will be asked to dress in the following attire: T-shirt, running shorts, socks, and running shoes.

At the first visit the informed consent document will be discussed and signed. You will then complete two health and fitness history questionnaire, to see if you qualify for the study.

If you have a history of serious orthopedic hip, knee and ankle condition or injury such as any arthritis, frequent sprains, strains, and other soft tissue injury at hip, knee or /and ankle joint, you will be excluded from the study. You will also be excluded if you have a history of any kind hip, knee and/or ankle surgery. Additionally, the measurements of thigh fat will be taken using skinfold caliper. If you have a thigh skinfold result of ≥ 21mm you will be excluded from the study. Moreover, dominant leg test (includes kicking soccer ball) and squat test (includes to perform squat)will be taken and data will be collected.

After meeting all criteria, the EMG electrodes will be placed on your thigh and electronic goniometer will be placed at knee joint of your dominate leg. Then, you will perform a warm-up on a stationary bicycle for 5 minutes. After the bike you will perform 5 standard double leg squats on a flat surface and 5 double leg squats on each of the four chosen angles on the decline board (4 sets x 5 reps).

After warm-up your maximum thigh muscle activation will be measured. You will sit in chair, and a strap will be placed to your ankle, the length of the strap will be adjusted so that your knee angle is 60 degrees. You will be asked to push against the strap as if you are trying to straighten your leg. We will record the maximum amount of force produced.

You will be completing a double leg squat trial on each of the four different decline board angles (15°, 20°, 25°, and 30°) with 1-minute rest between each decline set. In other word, 4 sets of 3 squat reps with one-minute rest. The order of the decline board angles will be random, not be told to you. You will be asked to bend your knee joint at least 60° while squatting. Cueing and proper posture as instructions will be given during warm-up while performing squat to prevent any kind of pain at knee and lower back.

Voluntary Participation

The choice to participate or not is yours; participation is entirely voluntary. You can decline to perform squats on the decline board or withdraw at any time. If you wish to leave during a visit, tell the principal investigator that you want to stop. If you uncomfortable during the study, you let the principal investigator know that you wish to stop. You do not have to be in this study if you do not want to. If you agree to be in the study, but later change your mind, you may drop out at any time. If you want to stop being a subject before research experiment, you can contact the principal investigator by email cpatel3@sycamores.indstate.edu or phone (317)480-6765.In addition, you can contact the faculty sponsor by email Heather.Abbott@indstate.edu, by phone (812)-237-2810 or by mail Indiana State University, Kinesiology, Recreation, and Sport, 401 North Fourth St., Terre Haute, IN 47809.

There are no penalties or consequences of any kind if you decide that you do not want to participate. Your participation in this study may be terminated at any time by the investigators if they believe that it is in your best interest to do so or if you fail to follow the study procedures.

Confidentiality

Every effort will be made to protect your confidentiality by keeping all data in coded subject files in the exercise physiology lab's locked office. We will treat all data and results with strict confidentiality to the extent allowed by law. We will keep electronic records on the primary investigator's computer, which is password protected and in a locked office. Subject records may be kept indefinitely. We will use subject codes for statistical analyses or when we produce experimental feedback sheets for you. We will not use your name in any presentation of the data or results from the study. You should also know that the ISU Institutional Review Board may inspect study records as part of its auditing program, but these reviews will only focus on the researchers and not on your responses or involvement. The Institutional Review Board is a group of people that reviews research studies to make sure they are safe for participants.

Risks and Inconveniences

There are some potential risks and inconveniences to this study. These include, you maybe be asked to shave your thighs prior to the experiment session. You will be asked to perform squats repetitively. These could be viewed as inconveniences. Not being able to exercise 48 hours prior to a visit could be troublesome. Additionally, you will be required to give your 2 hours of time for this study. Performing squats on decline board could be challenging.

Benefits

It is unlikely that you will benefit directly by participating in this study, but the research results may help exercise specialist better understand how useful decline squats are to strengthen quadriceps muscles and patellar tendon.

In Case of Injury

We will give you emergency medical care if you are injured during the study. The research team and ISU are not obligated for the cost of that treatment. Thus, you are responsible for any medical costs.

Questions

If you have any questions regarding the study, please contact Chandani Patel by email cpate3@sycamores.indstate.edu, by phone number (317) 480-6765, or by mail at Indiana State University, Kinesiology, Recreation, and Sport, 401 North Fourth St., Terre Haute, IN 47809. The faculty sponsor, Dr. Heather Abbott, can also be contacted by email Heather.Abbott@indstate.edu or by phone (812) 237-2810.

If you have any questions about your rights as a research subject or if you feel you have been placed at risk, you may contact the Indiana State University Institutional Review Board (IRB) by mail at Indiana State University, Office of Sponsored Programs, Terre Haute, IN 47809, by phone at (812) 237-3088 or by email at irb@indstate.edu.

Authorization

I understand the processes described above. My questions have been answered to my approval, and I agree to participate in this study. I will participate in the project described above. The overall purposes, details of involvement, and possible risks and inconveniences have been explained to my approval. My signature also shows that I have received a copy of this consent form.

PRINTED NAME: ____

SIGNATURE: ____

Date: ____

APPENDIX -B

Modified Exercise Pre-participation Health Screening Questionnaire by Riebe and Magal (2016)

Step 1 **SYMPTOMS** **Do you experience**: __ chest discomfort with exertion __ unreasonable breathlessness __ dizziness, fainting, blackouts __ ankle swelling __ unpleasant awareness of a forceful, rapid or irregular heart rate __ burning or cramping sensations in your lower legs when walking short distance If you **did** mark any of the statements under the symptoms, **STOP**, you should seek medical clearance before engaging in or resuming exercise. You may need to use a facility with a **medically qualified staff. You will be exempted from this study, unless medical clearance from your physician can be provided.** If you **did not** mark any symptoms, continue to step 2 and 3
Step 2 **CURRENT ACTIVITY** Do you currently perform planned, structured physical activity at least 30 min at moderate intensity on at least 3 days per week for at least the last 3 months? ☐ Yes ☐ No Continue to Step 3
Step 3 **MEDICAL CONDITIONS** **Have you had or do currently have:** __ heart attack

__ heart surgery, cardiac catheterization, or coronary angioplasty
__ pacemaker/implantable cardiac defibrillator/rhythm disturbance

__ heart valve disease
__ heart failure
__ heart transplantation
__ congenital heart disease
__ diabetes
__ renal disease

Evaluating Steps 2 and 3:

- If you **did not mark any of the statements in Step 3**, medical clearance is not necessary.
- If you marked Step 2 "**yes**" and **marked any of the statements in Step 3**, you may continue to exercise at light to moderate intensity without medical clearance. Medical clearance recommended before engaging in vigorous exercise.
- If you marked Step 2 "**no**" and **marked any of the statements in Step 3,** medical clearance is recommended. You may need to use a facility with a **medically qualified staff, and you will not be able to participate in this study without medical clearance from your physician.**

APPENDIX -C

Research Criteria Questionnaire

Participant's Age ____________________________ (18-30 years)
Height ______________ **Weight______________**

1.Do you experience any pain during squatting? Or when bending your knees?
☐ Yes ☐ No

2.Did you ever have surgery in hip, knee, and ankle joint?
☐ Yes ☐ No

3. Have you had any knee injuries in past 6 month?
☐ Yes ☐ No

4. Have you had any ankle injuries in past 6 months?
☐ Yes ☐ No

5. Have you had any hip injuries in past 6 months?
☐ Yes ☐ No

6. have you had any history of pain in knee, ankle, and/or hip joints in past 3 months?
☐ Yes ☐ No

7. Do have currently have pain in your lower extremities?
☐ Yes ☐ No

8. Are you currently undergoing any knee joint, ankle joint, hip joint and/or lower back treatment?
☐ Yes ☐ No

Pretesting results (Please do not fill out any information below. This portion of the questionnaire is for the research only.)

1.Squat test (approximately 60-degree knee flexion)
☐ Yes ☐ No

2. Dominant leg test

☐ Right ☐ left

3.Thigh skin fold measurement (Should be ≤ 21 mm)

☐ Yes ☐ No

APPENDIX -D

Volunteers Needed for Research Study

Participants:

We are looking for adults (age 18-30) to participate in a research study looking at the effect of various decline angles on knee extensors activation.

Study includes 1 visit (approximately 2 hours)

This visit will include

- Signing inform consent and filling 2 questionnaires
- .... Performing warm-up on stationary bicycle
- .... Performing decline (slant board) board squats
- .... Measurement of muscle electric activity using electromyography equipment
- .... Measurement of knee movement activity
- .... Measurement of thigh fat

Study Location:

Exercise Lab (New Arena building), Indiana State University.

Interested?

Participation is voluntary and confidentiality will be ensured. If interested please contact primary investigator Chandani Patel by email- cpatel3@sycamores.indstate.edu and by phone 317-480-6765 or faculty Dr. Heather Abbott, PhD. at Heather.Abbott@instate.edu or 812-237-2810 .

Research Study –
Decline squat
cpatel3@sycamores.indstate

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APPENDIX -E

Power Analysis