The Effectiveness of Rehabilitation in Prevention of Acute Hamstring Injuries in Collegiate Sprinters

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Abstract

Male collegiate sprinters were examined in order to determine the return to play timeline after suffering from an acute hamstring injury. Research reviewed included different types of rehabilitation and prevention as well as modality usage. Strict rehabilitation protocols combined with strengthening and modality usage were strong components of a healthy return to play for collegiate male sprinters. These findings suggest that multiple steps need to be taken in order to ensure fast recovery and minimal risk for reinjury.

Keywords: hamstring, collegiate sprinter, injuries, rehabilitation, prevention, stretching, strengthening, exercises, modalities

The hamstring is made up of three different muscles (see Appendix A). The biceps femoris is typically the most prominent and the most commonly injured (Dolman, Verrall, & Reid, 2014). The semimembranosus is medial to the biceps femoris, and the semitendinosus is lateral. These three muscles make up the entire section that athletes and athletic trainers would call the hamstring. Hamstring injuries can occur in football, soccer, volleyball, and many other sports. Most commonly, any sprinting exercise may cause damage to the hamstring, whether it is a full tear, or a muscle strain (Askling, Tengvar, & Thorstensson, 2013; Lui, Wan, Garrett, & Yu, 2017).

Injured athletes' concerns may be the extent of the injury and when they will be able to get back out to the sport that they love. Fortunately for them, if their school is equipped with a team of athletic trainers, research indicates that the student athlete will return to play quicker than if they did not work with an athletic trainer. When it comes to collegiate track, it is very easy to get caught up in competition and hard workouts and overwork the body before a big race. During the race, when student athletes are competing at their peak capacity, there is the possibility for the hamstring to become strained. If the athlete reports a hamstring injury the athletic trainer and medical professionals will determine the best route to allow the student to compete safely after their injury. Treatment of a hamstring injury depends on the severity of the injury and could be anything from icing, rest, modalities, rehabilitation exercises or surgery.

This review will examine whether a hamstring injury prevention program for college athletes will reduce initial or recurrent hamstring injuries. Examining past research of K-12 student athletes will help determine whether a prevention program was effective for K-12 athletes and whether a similar prevention program could be used with collegiate athletes to prevent hamstring injuries. The factors related to the hamstring injury: the prevention programs

used, the form the student athletes use, and the injury in relation to the sport will also be studied. The study will also examine exercise protocols that have the highest probability of being followed related to the ease of use and the availability of common treatment equipment found in an athletic training room. It will look at if male sprinters in college should have less hamstring injuries when following a rehabilitation and prevention protocol compared to those that do not follow any protocol. Finally, the research will look at male college athlete injuries and then try to find generalizable and applicable extensions for other researchers for other circumstances.

Statement of the Problem

The problem to be addressed is, how does rehabilitation and prevention play a role in the strength of a collegiate sprinter's hamstring? Is hamstring injury preventable and how?

Significance of the Study

It is important to study this information because of how common and serious hamstring injuries are in collegiate sprinters. In order to keep athletes doing what they love, athletic trainers need to be ready with rehabilitation and even a prevention plan if possible. This study will benefit those that have been injured and want to prevent another strain, those that are more likely to get injured, and those that are hoping in the return to play. According to Dalton, Kerr, & Dompier (2015), men's indoor track (15.70) had the highest number of hamstring injuries per 10,000 athlete-exposures over 5 seasons. The second highest sport was outdoor track (15.39), followed by soccer (14.69), and football (10.67). Hamstring strains are common in many sports, but the highest incidence in with track and field sprinters.

Purpose of the Study

The purpose of this study is to explore the new findings on stretching, strengthening, rehabilitation, and prevention programs that are used for collegiate sprinters to prevent or treat hamstring injuries. There has been a lot of research done for many different injuries to athletes,

particularly with the K-12 athletes. However, hamstring strains are not studied as much and can be difficult to rehabilitate back to previous health levels.

Definition of Terms

Hamstring: Either of two groups of tendons at the back of the human knee of any of three muscles at the back of the thigh that function to flex and rotate the leg and extend the thigh (Guex, Gojanovic, & Millet, 2012).

Strain: Injury to the hamstring muscle depending on severity (grade 1-3), location, mechanism of injury, level of pain, amount of strength lost, restriction of motion, and return to play time (Tyler, Schmitt, Nicholas, & McHugh, 2017).

Rehabilitation: Exercises done in order to strengthen weak or injured muscles. These can be done by anyone from professional athletes to the elderly (Horst, Hoef, Reurink, Huisstede, & Backx, 2016).

Modalities: Any and all machines and appliances that can be used in the healing of an athlete in the athletic training facility (Knoblauch, Laughlin, Vineyard, & Poe, 2017).

RTP: Most commonly used as "return to play" to get an athlete back to their pre-injury status of strength and flexibility (Creighton, Shrier, Schultz, Meeuwisse, & Matheson, 2010).

Delimitations of Research

This research was completed from 2017 to 2018. Many search terms were used including hamstring, collegiate sprinter, injuries, rehabilitation, prevention, stretching, and strengthening, exercises. PubMed was used as the main search tool as well as Google Scholar, National Library of Medicine, and the National Institutes of Health. The research was limited to peer-reviewed articles published within the last ten years. Not included in the review of research is the full tear of a hamstring or tendon. Surgery and repairs to hamstring injuries are not included in a majority

of the articles that were reviewed. The review of research focused solely on grade 1 to grade 2 hamstring strains.

Method of Approach

This literature review will study the mechanism of injury to strain a hamstring, what prevention strategies can work, how long it takes for the hamstring to return to health, what types of rehabilitation exercises are most beneficial, and how to prevent reinjury after the first injury occurs. Each of these topics are important to male collegiate sprinters and their athletic trainers to so athletes can get back to their sport as quickly as possible without risking reinjury.

Chapter Two: Review of Related Literature

Historical Treatment of Hamstring Injuries

Hamstring injuries are treated very differently depending on the part of the country, the nature of the injury, the competitive level of the athlete, the level of collaboration with the coaches, the training and experience of the athletic trainer, and the dedication and the persistence of the athlete. Previously, athletes with hamstring injuries would go to a medical doctor and were advised to rest until all swelling and pain subsided, using the injured leg as little as possible (Andrews, 1904). In the 1930s, the focus began to change from complete rest to gentle non-weight-bearing exercise. In 1936, a more comprehensive approach began to surface. "The year 1936 saw the clear articulation of the principle of approximating the torn ends of the muscle injury to enhance the healing process, and also the notion that premature disruption of this approximation may increase scarring" (Hamilton, 2012). The use of yoga, meditation, pilates, and core strengthening became more prevalent in the treatment of hamstring injuries. "Excessive lordosis of the lower back has been suggested as a risk for hamstring injury because it places the gluteal and hamstring muscles in a mechanically disadvantaged position… These athletes can then be given a specific core strengthening/stability programme to help improve posture" (Clark, 2008). In addition, researchers found that corticosteroids that were used for acute muscle injuries were having a negative impact on the regeneration of the muscle throughout the 1950s and 1960s. "Most failures experienced by practitioners can be attributed to faults in timing, technique, or inadequate supervision of the patient after injection" (Bass, 1966). The steps that must be taken in order to have a fully healed athlete are complex and may take more time than one thinks. "After the initial inflammatory phase resolves, initial goals are to restore range of motion and begin strengthening using open kinetic chain and non-weight bearing exercises

(Comfort, Green, & Matthews, 2009). With any injury, athletic trainers and doctors work together to create a plan for the athlete and make sure they are not returning to play sooner than they should be.

Incidence

Hamstring injuries make up a substantial percentage of acute musculoskeletal injuries depending on the sport. Typically, hamstring injuries range from 8-25% of all injuries (Liu, Garrett, Moorman, & Yu, 2012). There is research about which sprinting events (100m, 200m, 400m, etc.) cause the most amount of strain on the body and the hamstring. "High school boys and masters-level athletes are most likely to suffer a hamstring injury, and there is a higher risk in 400m events compared to 100m events (Opar, Drezner, Shield, Williams, Webner, Sennett, Kapur, R., Cohen, Ulager, Cafengiu, & Cronholm, 2014). There is not as much information about how to prevent this injury from occurring or the best way to recover properly. Like most professions, there will always be new information and new research coming forward about certain subjects and that is also true for hamstring strains.

Mechanism of Injury

What is most apparent when it comes to the hamstring injury, is how it occurs. Most strains occur when the athlete is performing high speed running or when combining running with lumbar flexion. "Hamstring tightness showed a moderate correlation with PT movement. This finding can be explained because it is thought that hamstring muscles draw the pelvis into posterior rotation" (Raftry & Marshall, 2012). Lumbar flexion is defined as the forward bending of the back and hips. The reason lumbar flexion is most likely to cause a hamstring injury is because as the hips and back go into flexion, the hamstring is being lengthened and at its weakest state. "Our data showed that hamstring extensibility significantly influences pelvis position

during maximal trunk flexion due to their attachment to the ischial tuberosity on the pelvis" (Lopez-Minarro & Alacid, 2010).

Timmins, Bourne, Shield, Williams, & Opar (2015) found the next highest incidence of hamstring strains occur with acceleration into the sprint. "Most strains occurred during high speed running (24%) or when combining running with lumbar flexion (16.5%). A number of injuries occurred with acceleration (8.8%) and no specific mechanism was reported in 17.6% of cases". This kind of injury occurs because the hamstring is in the swing-stance transition moment which is crucial during acceleration. "The fact that both hip extensors concentric and knee flexor eccentric strength have been considered risk factors for hamstring strain in different prospective studies and activity are impaired after return to sport from a hamstring injury, support rationale that both hamstrings and glutei should be considered essential components of any training program for acceleration capabilities" (Morin, Gimenez, Eduard, Arnal, Jiménez-Reyes, Samozino, Brughelli, & Mendiguchia, 2015). Other hamstring injuries seem to have no specific mechanism or are perhaps a combination of smaller changes to the hamstring over time (Craddock & Buchholtz, 2018).

Hamstring injuries are generally classified into different categories depending on the severity of the injury (Paulus, Delvaux, Schwartz, & Croisier, 2016). "Grade I, in which there is minimal structural disruption and rapid return to normal function; grade II, in which there is a partial rupture with pain and some loss of function; and grade III, in which a complete tissue rupture is observed, with muscular retraction and functional disability" (Jarvinen, Kaariainen, Jarvinen, & Kalimo, 2000) (see Appendix B). For the purpose of this study, only grades I and II will be reviewed.

Knowledge of the mechanism of injury is important to the athletic trainer because the athletic trainer, coach and athlete may be able to study videotapes of the athlete's practice runs to determine if the probability of hamstring injury may be related to accelerating incorrectly or the athlete's entire running form that may be causing the athlete injury. The intent of studying the videotapes after a minor injury is to investigate the possible factors and try to eliminate further injury that would contribute to the athletes' inability to return to play in track and field events. Whether this injury was caused from acceleration or during the highest speed of their sprint, the athlete, their athletic trainer, and the doctor will need to determine how the athlete received the injury and what actions needs be taken to prevent future injury.

Prevention

Prevention studies examined whether hamstring injuries could be prevented and if so, what protocol or strategies were most effective. One study looked at introducing a flexibility program in order to reduce hamstring strain injuries (Amason, Anderson, Holme, Engebretsen, & Bahr, 2008). Another study tested whether inclusion of eccentric hamstring strength exercises would reduce a strain (Brooks, Fuller, Kemp, & Reddin, 2006). A longer-term study focused on different prevention programs and how they affected collegiate male sprinters who graduated from the same program over the course of 24 seasons. The first period was having the athlete focused only on strength training. The next period incorporated strength and agility into their protocol and the third was a combination of strength, agility, and added flexibility training as well. "The incidence of hamstring injuries in sprinters decreased as agility, further strength exercises, and flexibility were incorporated into a prevention program that already included strength training" (Sugiura, Sakuma, Sakuraba, & Sato, 2017). As agility and flexibility were added into the hamstring prevention protocol, athletes saw a significant decrease in injury rates.

This illustrated that athletes needed strength, agility and flexibility in order to be successful and not just the sprinting training.

Other studies looked at more factors that could be included in an injury prevention program such as; sleeping patterns, nutritional aspects, running form, level of play, use of supports (tape, etc.) or use of specialized blocks or other equipment. Each of these factors can impact player's overall health and wellness as well as their ability to recover from injuries. "Adequate sleep quality is important in the maintenance of high wellbeing scores and thus needs to be monitored by coaches and practitioners" (Woodhouse, 2015). A majority of the time, athletes are taught to be self-sufficient and should be able to take care of those aspects on their own, but sometimes they need to be reminded of the importance of sleep and nutrition. "Our results suggest that collegiate athletes can maintain sufficient status during the fall and spring but would benefit from supplementation during the winter to prevent seasonal decreases in vitamin D concentrations. Results further suggest that insufficient vitamin D status may increase risk for frequent illness" (Halliday, Peterson, Thomas, Kleppinger, Hollis, & Larson-Meyer, 2011).

Recommended nutritional review and advice for student athletes including the need for additional supplemental vitamins or minerals was also considered. "Over the past 20 years, researchers have documented the benefits of nutrition related to exercise performance. In a joint position statement, the American College of Sports Medicine, American Dietetic Association, and Dietitians of Canada reported "physical activity, athletic performance, and recovery from exercise are enhanced by optimal nutrition" (American College of Sports Medicine, 2009).

Several researchers mentioned proper running form as critical in the prevention of athletic injuries. "In several publications, barefoot runners exhibited a more anterior midfoot or forefoot striking pattern, thereby avoiding heel strike… Generally, with habituated barefoot

runners, stride length is shortened, stride frequency is increased, and the vertical displacement of the center of mass is reduced" (Goss & Gross, 2012). Specialized review and analysis of optimum running form for each track and field event compared to the student athlete's form was recommended to identify any potential flaws and then develop a plan to eliminate the issue with form by continued practice until muscle memory took effect. "Impact peak forces are hypothesized to contribute to some kinds of injury because they generate a shock wave that travels up the body, generating potentially high stresses and strains in skeletal tissues, which, in turn, generate high levels of elastic hysteresis that can contribute to injury over repeated cycles (Daoud, Geissler, Wang, Saretsky, Daoud, & Lieberman, 2012).). Revising the athlete's form was considered an integral part of the prevention of hamstring injuries. "Because there are very limited data based on controlled trials of runners, these conclusions explain only part of the complex variables that determine why some individuals can seemingly train for years at very high mileage without injury, while others develop repeat injuries even though they never reach mileage greater than 15-20 miles/week. This article expands upon the individual factors that have been implicated as possible triggers of running injury. These include anatomical variants in individual runners, biomechanical factors that affect running form, use of orthotics and shoes, training errors and total running mileage, strength training and muscle weakness, warm up, stretching, nutritional errors, and psychological factors" (Fields, Sykes, Walker, & Jackson, 2010).

Level of play was another factor to consider in hamstring injury prevention, particularly if the student athlete was competing at an elite level without yet having acquired the necessary skill set and maturity. "High school girls displayed lesser risk of Hamstring Injury (HSI) than high school boys, and masters athletes were more likely than high school and college level

athletes to suffer HSI" (Opar et al., 2014). Athletic trainers and coaches will be the ones to prepare athletes for the proper level of competition they are competing at. "Athletes competing in combined events and long-distance runs have the highest injury risk. Preventative interventions should focus on overuse injuries, hamstring strains, and adequate rehabilitation of previous injuries, and decreasing risk of transmission of infectious diseases, appropriate event scheduling and heat acclimatization" (Alonso, Edouard, Fischetto, Adams, Depiesse, & Mountjoy, 2012).

The use of taping, wrapping or medical devices is also considered as part of a prevention regimen by some researchers. "The tape is applied to the hamstring muscles in a stretched position so the athlete is flexed at the hip. Kinesiology tape is applied at the origin of the muscle with no tension in it. This provides a base to provide tension from in the lower part of the tape as it is applied. It is important to know where the hamstring muscles are located so the tape can follow the full length of the muscle" (Virtual Sports Injury Clinic, 2018). The use of specialized, track and field, National Track and Field Association, approved devices was also recommended as part of a comprehensive prevention plan. For example, specialized braces or compression wraps may help prevent or greatly reduce the severity of some hamstring injuries for some athletes. "Compression wrap or brace the injured part to allow for control of initial swelling and to decrease motion" (Foley, Vasily, Bradle, Rudio, & Calderhead, 2016).

Return to Play

Many different definitions are available for return to play. The athlete must reach pre-injury level, be able to preform full sport activities, have no pain, and show similar strength/flexibility in bilateral comparison of legs (Creighton, Shrier, Schultz, Meeuwisse, & Matheson, 2010).

The amount of time it takes an athlete to return to their sport can be hard to judge in the first few stages of the hamstring injury. “The diagnosis and prognosis of muscular injuries is normally mainly based on clinical findings, but radiological methods such as magnetic resonance imaging (MRI) or ultrasound (US) are commonly used as complimentary examinations in order to confirm a diagnosis and provide a prognosis of lay-off time… Furthermore, muscle injuries are a heterogeneous group of different injury types, locations, severities and sizes, and this makes prognoses about healing time and rehabilitation difficult” (Elkstrand, Hägglund, & Waldén, 2011). In track and field, there can be at least one meet at the end of every week. Fortunately, most athletes are able to recover after the meet during the first couple days of the next week. Unfortunately, a hamstring injury, particularly a serious one, can cause the athlete to not be able to recover quickly. The injury can cause the student athlete to be kept out of practice and competition for an extended period of time if the injury depending on the amount of rest or treatment needed and on the severity of the injury. In order to return an athlete to their sport, the athletic trainer needs to work with the athlete and medical professionals to determine when the athlete will be ready for competition.

Rehabilitation

Previously, athletes with hamstring injuries would be put on crutches and not given any exercises at all until all pain subsided. “In 1906, management of muscle tears was typically conservative involving ‘holding the limb under a cold water tap as long as you can bear it, and as often as is possible’ (Andrews, 1904), plaster immobilization ‘in the direction of the fibres of the muscle’ (Wilbur, 1906), complete rest for 3 to 6 days, followed by ‘active work’ (Wilbur 1906) and the use of ‘embrocations’ (Andrews, 1904; Hamilton, 2012; Thurber, 1936).

Recent studies have proved that this rehabilitation protocol is not effective and takes much longer than it should for the athlete to recover. “The year 1936 saw the clear articulation of the principle of approximating the torn ends of the muscle injury to enhance the healing process, and also the notion that premature disruption of this approximation may increase scarring” (Hamilton, 2012). The next big discovery cam after Dr. Roger Bannister broke the 4-minute mile when doctors realized different muscle injuries would require different treatment (Delarue, 1954). “The imperative of controlling hemorrhage and inflammation to minimize scar tissue remains unchanged 60 years on. The theme of scar tissue minimization has been resurrected in recent years, with the identification of numerous medications that may potentially assist in this task” (Bedair, Karthikeyan, Quintero, Li, & Huard 2008). More recent research has found better and more efficient ways to care for the hamstring strain. “Blood injections have been recognized as potentially therapeutic in sports medicine for over 60 years, and refinement of this in the form of autologous plasma preparations (platelet-rich plasma) has recently been popularized for muscle strain injuries” (Karli, 2010). Athletes are now instructed to be on crutches with an ACE wrap on their hamstring area for no more than one day. “These stages include mobilization and stretching, to avoid loss of extensibility, improve range of motion, and help reduce formation of scar tissue; avoidance of atrophy and regaining o stretch; and advanced stretch and conditioning that is sport specific to appropriately prepare the athlete for their return to sport” (Comfort, Green, Matthews, 2009). Once swelling has gone down, generally within one or two days, the athlete can incorporate gentle flexion and extension of the knee under the supervision of the athletic trainer or physical therapist/medical professional. “To regain the lost flexibility and prevent further injury and inflammation, the performance of concurrent pain free stretching and strengthening exercises, beginning with isometric and progressing to dynamic exercises, is

essential" (Comfort et al., 2009). Researchers noted that incorporating easy exercises made for a better transition to the more difficult movements that were required in full-scale rehabilitation (Kilcoyne, Dickens, Keblish, Rue, & Chronister, 2011).

Another study looked specifically at the angle of knee flexion during exercises and whether or not it was helpful in the rehabilitation process. These rehabilitation exercises were all eccentric strengthening and concluded that a lengthened hamstring during exercises would result in less injuries (Tyler, Schmitt, Nicholas, & McHugh, 2017).

Rehabilitation can and often does include the use of magnetic resonance imaging (MRI), cryotherapy, nonsteroidal anti-inflammatory drugs, electrotherapy, modalities, and pain free stretching and strengthening exercises (Comfort, et al., 2009). Extensive research has been conducted on the use of RICE for hamstring injuries. "Starting the application of rest, ice, compression and elevation (RICE) immediately after injury should be both essential combined therapy and regularly recommended" (Croisier, 2004). It may be particularly difficult for full-time students to be immobile or elevate their leg when they are in classes. Even though this may be difficult, athletes should focus on school and keep up with class work even with an ongoing injury. "Physical injury can trigger depression as well as other problematic responses. In a retrospective study of Division I football players, 33% of injured athletes reported high levels of depressive symptoms, using the Center for Epidemiological Studies Depression scale, compared with 27% of non-injured athletes" (Brewer & Petrie, 1995). Researchers suggested that athletic trainers, team physicians as well as athletes, coaches, and administrators must understand there can be emotional and problematic reactions to these injuries and the problematic responses such as excessive anger or rage, frequent emotional outbursts, and substance abuse are what needs to be addressed (Putukian, 2016).

More extensive rehabilitation may need to be considered for grade II hamstring injuries but can also have good outcomes, particularly is the student athlete is consistent in following the rehabilitation guidelines and exercise protocol. Whether an athlete is suffering from their first injury, or coming back from a reinjury, they need to stay consistent with rehabilitation and they will have a better outcome. “Fear of reinjury after a sports injury can lead to poor rehabilitation outcomes. Incorporating principles of psychologically informed practice into sports injury rehabilitation could improve rehabilitation outcomes for athletes with high fear of reinjury” (Hsu, Meierbachtol, George, & Chmielewski, 2017).

Risk of Reinjury

More than half of athletes who strain their hamstring will reinjure it within the first month of returning to their sport (Horst, Hoef, Reurink, Huisstede, & Backx, 2016). This probability is not in favor of the athlete or the athletic trainer. In order to prevent the hamstring injury from reoccurring, strengthening the muscle, decreasing the pain, and getting the athlete back to pre-injury flexibility is the key to a successful return to play. “The literature states that the greatest risk factor for a hamstring strain is a previous hamstring strain. The high rate of recurrence could be due to ineffective rehabilitation programmes, returning to sport too soon, or a combination of these and various other modifiable and non-modifiable risk factors” (Craddock & Buchholtz, 2018).

Researchers recommend anti-inflammatories to help reduce pain. “Non-steroidal anti-inflammatory drugs (NSAIDs) were first mentioned in the routine management of muscle strain injuries in the late 1960s and their use has persisted in sports medicine” (Hamilton, 2012). Anti-inflammatories, muscle relaxers, painkillers, and other medications can be prescribed but their use and potential misuse must be carefully monitored. “While they may have a role in limited

situations (eg, reducing the incidence of myositis ossificans following muscle contusion injuries), increasing in vitro evidence suggests that NSAIDs may impede regeneration and increase fibrosis during muscle healing, and hence should be considered relatively contraindicated in muscle strain injuries" (Hamilton, 2012). Research on muscle relaxers found they are mostly used with fractures that cause increased spasticity. "In addition they can help relieve muscle guarding which can interfere with therapy. It should be kept in mind, however, that these medications have an additive effect with narcotics in terms of sedation, and close attention is required to make sure that patients do not get too sedated" (Baldwin, Donegan, & Keenan, 2018). Track and field professionals were cautioned on the use of pain medication, particularly with track and field athletes because numbing the pain could cause the athlete to not immediately feel that they were reinjuring their hamstring and could thus result in more severe injury. "The high use of medication and NSAIDs in particular is not limited to international football. Similar use of medication has been reported during the Sydney Olympics in 2000,in top-level track and field athletes, triathletes, and also in collegiate athletes. An unpublished review of articles published between 2003 and 2010 found that power/sprint disciplines show a similar 'substance profile' as ball sports" (Tscholl, Vaso, Weber, & Dvorak, 2015)

A key component of effective rehabilitation is the patient- student athlete. Not showing up to rehabilitation sessions or doing exercises not approved by the athletic trainer, can put the student athlete at a higher risk of re-injury and a longer time away from the track.

Summary

By examining different elements of the hamstring strain, researchers can conclude what type of prevention methods would work best for student athletes in a collegiate sprinter setting. The prevention and rehabilitation protocol is the most important part of any hamstring injury and

should continue to be researched in order to find the best results for the largest number of collegiate sprinters.

When looking at the research provided, it is clear the method that a hamstring becomes injured. Athletes do not have equal strength in both legs, are over training, or even have incorrect form when it comes to sprinting. All of these characteristics combined make a recipe for a hamstring strain. Many different doctors have many different return-to-play protocols when it comes to an injured hamstring. It might be noted that a majority of the research now has athletes jogging within the first 48 hours instead of on crutches until pain free. “Immediately after injury, compression, ice, and non-painful movements are encouraged, because an early mobilization foments scar healing” (Valle, Tol, Hamilton, Rodas, Malliaras, Malliaropoulos, & Jardi, 2015).).

Recommendations made by this research might be helpful in preventing future hamstring injuries or reinjuries. Athletic trainers will always want to do what is best for the athlete and that changes when more and more research comes out.

Chapter Three: Conclusions and Recommendations

In summary, hamstrings are one of the most commonly injured muscles (Liu, Garrett, Moorman, & Yu, 2012). This can happen frequently in sprinting sports such as track and field or soccer. With the popularity of this injury, prevention and rehabilitation for it have been researched extensively. There is no plan that has a 100% guarantee but incorporating movement early, performing eccentric rehabilitation and taking into account the athlete's mental state might end in a more positive return-to-play.

Based on the existing literature, the following conclusions were drawn. Hamstring rehabilitation methods have changed over time. As the years have gone on and more research has been done, rehabilitation has gotten more progressive. Athletes are getting faster which means the athletic trainers need to keep up with the latest technology and research in order to prevent injury (Hamilton, 2012). Some sprinting events are more likely to cause hamstring injury than others (Opar et al., 2014) and that is because of the hamstring tightness within the muscles (Raftry & Marshall, 2012). These injuries can be grouped into three different types depending on the severity or tear of the hamstring muscle (Paulus, Delvaux, Schwartz, & Croisier, 2016). With severity, athletic trainers and doctors need to know just how the muscle was injured so they can create the specialized rehabilitation program.

Prevention is key to hamstring injuries because it is easier to prevent than to fix the injured muscle. Flexibility (Amason, Anderson, Holme, Engebretsen, & Bahr, 2008), eccentric strength exercises (Brooks, Fuller, Kemp, & Reddin, 2006), a higher level of strength training (Sugiura, Sakuma, Sakuraba, & Sato, 2017), and proper warm-up/cool-down (Fields, Sykes, Walker, & Jackson, 2010 and (Heiderscheit, Sherry, Silder, Chumanov, & Thelen, 2010). are all needed to prevent a hamstring from being strained. Smaller aspects looked at included sleeping

patterns, nutritional facts, running form, level of play, use of supports or other equipment when it came to prevention (Halliday et al., 2011).

Not only did research look at the methodology and prevention of a hamstring, but Opar, et al., (2014) discovered that high school girls were less likely to injure their hamstring as compared to high school boys. This could be because of the genetic make-up of boys or because they develop slower than girls typically do. Either way, this information can be taken into account when looking at male collegiate sprinters because they have a higher chance of having a previous history of hamstring injuries before even entering college.

When returning to play, an athlete must obtain several checks off a list to get back onto the track. The athlete must reach pre-injury level, be able to preform full sport activities, have zero pain, and show similar strength and flexibility to the bilateral leg (Creighton, Shrier, Schultz, Meeuwisse, & Matheson, 2010). It can be hard to determine if a hamstring strain is a grade 1 or 2. Athletic trainers and doctors now use MRIs as a way to determine how much time off is needed for the hamstring to heal itself (with help from rehabilitation) (Elkstrand, Hägglund, & Waldén, 2011).

Athletes are no longer put on crutches for days before preforming rehabilitation (Comfort, et al., 2009). Research now says that movement is crucial to preventing scar tissue build-up (Valle et al., 2015). Track athletes will begin to incorporate flexion of the knee as soon as swelling goes down (Comfort, et al., 2009). Recently, Tyler, Schmitt, Nicholas, & McHugh (2017) discovered that a lengthened hamstring during rehabilitation exercises would result in less injuries. A lengthened muscle would help with the eccentric movements that were mentioned throughout different research and also prepare the muscle for the load it is about to take on during sprinting.

Rehabilitation also includes magnetic resonance imaging (MRI), cryotherapy, nonsteroidal anti-inflammatory drugs, electrotherapy, modalities, and pain free stretching and strengthening exercises (Comfort, Green, & Matthews, 2009). All of these aspects combined might help provide the safest and most effective return-to-play for an injured track hamstring.

More than half of athletes who strain their hamstring will reinjure it within the first month of returning to their sport (Horst, Hoef, Reurink, Huisstede, & Backx, 2016). By returning the athlete back to the track too soon, the athletic trainer is putting them at risk of reinjury (Craddock & Buchholtz, 2018; Malliaropoulos, Isinkaye, Tsitas, K & Maffulli, 2010; Malliaropoulos, Papacostas, Kiritsi, Papalada, Gougoulias, & Maffulli, 2010).

Drugs can become a problem if the athlete lets it. Non-steroidal ani-inflammatory drugs were first used for management of a hamstring strain around the late 1960s (Hamilton, 2012). Since then, athletes at all levels have used them in order to get by. The athlete may believe that they are helping themselves because they feel less pain after taking the NSAIDs, but in reality, they are only doing more damage to the injured portion of their body (Baldwin, Donegan, & Keenan, 2018). In this case, the hamstring muscle will continue to be torn up while the athlete continues sprinting instead of doing the rehabilitation it would take to help the injured muscle.

Based on these conclusions, it is recommended that researchers continue to do work on hamstring injuries in sprinting events. In these cases, would weight lifting or plyometrics have helped in preventing the injury? Researchers can also look at trends in professional track and field or soccer athletes, as both have sprinting within them. By looking at these elite athletes, researchers can give recommendations to collegiate athletes on pre-season workouts to prevent injuries and even warm-up activities to do during the season to prevent a hamstring strain. How willing are collegiate athletes to do these preventative measures? Sometimes, collegiate athletes

have a full load class schedule that can prevent them from getting to the athletic training room to do their rehabilitation. In this case, researchers can look into what else collegiate athletes can be doing because of the added struggle of class and homework. Another aspect that researchers can delve into would be the relationship and attitude that a coach has toward an athletic trainer's interactions with their athletes. As more research comes out, do coaches prepare themselves and their athletes properly? Do coaches ask enough questions to their athletes and athletic trainers when it comes to rehabilitation so that they can stay involved? All of these topics are related to hamstring strains in male collegiate sprinters and could use some digging into in order to find more answer out about why hamstrings are injured so often and what can be done to get the athlete back to their sport as quickly and safely as possible.

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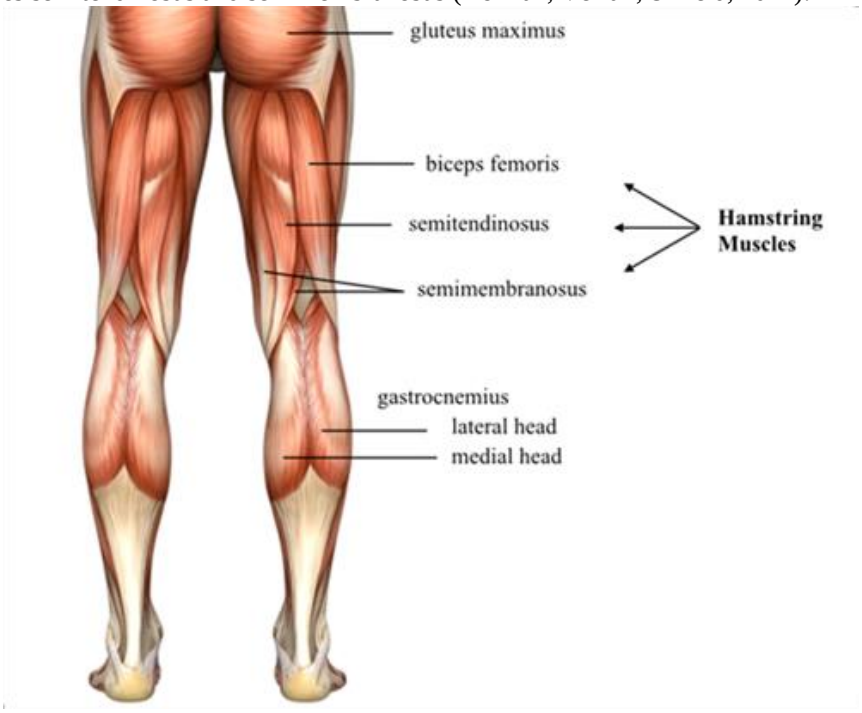
Appendix A
Hamstring Muscle

The hamstring muscle is made up of three separate muscles. These muscles include the larger biceps femoris, and two smaller muscles semitendinosus and semimembranosus (Dolman, Verrall, & Reid, 2014).

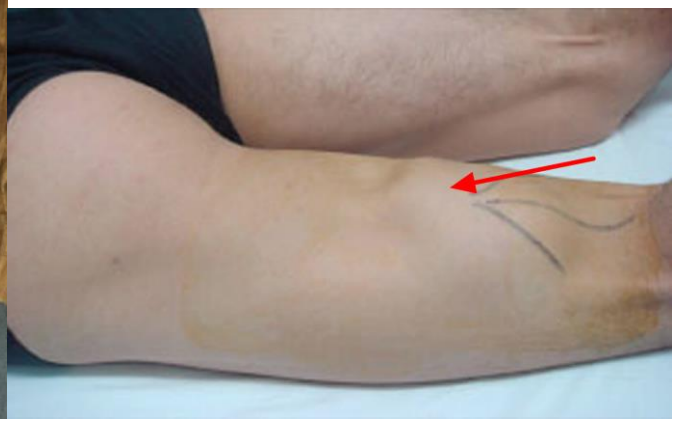


Appendix B
Hamstring Strain

A hamstring strain is classified by three different grades, 1 being the least amount of trauma, and 3 being a complete tear (Jarvinen, Kaariainen, Jarvinen, & Kalimo, 2000). Most of these studies focused on tears graded 1 and 2 because 3 would typically require surgery over rehabilitation.

A grade 1 hamstring will only be classified as a "strain" where grade 2 is a partial tear of the muscle and results in a lot of bruising. A grade 3 hamstring will usually show a lump where the muscle has gathered after a tear (Tyler, Schmitt, Nicholas, & McHugh, 2017)..

Grade 2



Grade 3