Spring 2021

Long-Term Disability Following a Hamstring Injury

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LONG-TERM PERCEIVED DISABILITY FOLLOWING A

HAMSTRING INJURY

by

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(Under the Direction of Jessica Mutchler)

ABSTRACT

PURPOSE: Injuries to the hamstring complex are one of the most commonly seen lower extremity injuries in athletic populations. It is currently unknown how psychological or sociological factors affect an athlete after the recovery process has ended and if these factors play a role in re-injury rates relating to the hamstring. It is also unknown if athlete confidence level changes while in a fatigued state after an athlete returns to play from a hamstring injury. METHODS: Twenty-six physically active adults with and without a previous hamstring injury were recruited for this study. Participants completed a Qualtrics survey that included demographic questions for participant matching purposes, the Oslo Sport Trauma's Hamstring Outcome Score (HaOS), the Injury Psychological Readiness to Return to Sport (I-PRRS), and the Athletic Fear Avoidance Questionnaire (AFAQ). DATA ANALYSIS: Descriptive statistics were run to report means and standard deviations of questionnaire scores for the Hamstring (HS) and Control (Con) groups. Multiple one-way ANOVAs were used to compare the HaOS subscales and total score, I-PRRS scores, and AFAQ scores between previously-injured hamstring individuals and their healthy, matched control after splitting the SPSS data file between competitive (HS_Comp and Con_Comp) and non-competitive athletes (HS_Non-Comp and Con_Non-Comp). A paired-samples t-test was also run to determine differences between the I-PRRS scores within each group. RESULTS: There was a statistically significant difference in Pain, Function, and Total HaOS scores for the HS_Non-Comp compared to the Con_Non-Comp ($P<0.05$). There were also statistically significant differences in AFAQ scores between HS_Non-Comp and Con_Non-Comp groups ($p=0.05$) but not between the HS_Comp and Con_Comp groups ($P=0.09$). No other statistically significant differences were observed ($P > 0.05$).

CONCLUSION: Non-competitive athletes with a previous hamstring injury reported a greater degree of disability due to pain and function when compared to non-competitive athletes with no history of hamstring injury, but this was not observed in the competitive hamstring group. The results also suggest that fear of re-injury may exist after returning to activity following a hamstring injury, but confidence in performance may not change after returning to play. Future research should focus on the fear avoidance that may remain after injury and why non-competitive athletes had long-term reports of disability whereas competitive athletes did not.

INDEX WORDS: Hamstring, Injury, Long-term, Athlete, Perceived disability, Non-competitive, Competitive, Fatigue, Confidence, Fear.

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by

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B.S., Georgia Southern University, 2019

A Thesis Submitted to the Graduate Faculty of Georgia Southern University in Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

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Electronic Version Approved:
May 2021

DEDICATION

This thesis is dedicated to my wonderful, loving family. This journey was made possible by your strong, unwavering support for me and my education. Thank you for keeping me sane when things got tough, for keeping me driven through your daily encouragement, and for loving me undeniably. I will spend the rest of my life learning how to repay you all for everything that has been done in order to help me in my endeavors. This accomplishment is built on a foundation of accountability and support from everyone. I love you all.

To my hippie stepsister, Alexin Boyd, who passed away before being able to read this, I think of you and the drive that you had, and I spend each day trying to live my life the way you would want yours to be lived. Losing you in my Master's Program was one of the toughest things I've ever experienced, and it came at a time in my life where struggle was inevitable. I don't know how I managed through the grief of your loss; I'd like to think you're still here and giving me motivating words of encouragement. I pray every day that I grow to become half as strong, half as driven, as you were. I know that you're the brightest star I see in the sky every night, shining down and brightening everyone's world, just like you did when you were here. You'll forever be our family's guardian angel. I love you forever. See you soon.

ACKNOWLEDGMENTS

Thank you to all of my peers, family, and classmates for going through this journey with me, physically and spiritually. The support I've received has made me feel like the luckiest person in the world. Thank you to my professors for your endless support, guidance, and help when I've needed it the most. You have all gone out of your way to make sure I am successful and confident in my abilities. Despite me having difficult days, and sometimes difficult weeks, you all have stuck by me undeniably. I can only say thank you and hope that one day I will be able repay the favor.

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CHAPTER I

INTRODUCTION

Acute lower extremity (LE) injuries during sport are known as the most common injuries that occur in athletic populations, particularly injuries to the hamstring complex (Dalton et al., 2015; Ernlund & Vieira, 2017; Woods, 2004; Roussiez & Van Cant, 2004; Di Trani, 2017; Mutchler et al., 2015; Small et al., 2009; Sole et al., 2012; Coole & Gieck, 1987; Kujala, Orava, & Jarvinen, 1997; Schache et al., 2009; Hibbert et al., 2008). The hamstrings act as the primary movers and stabilizers of the hip and knee joints (Coole & Gieck, 1987), and this region is most likely to be found strained during non-contact, explosive, dynamic movements such as sprinting or jumping (Kujala, Orava, & Jarvinen, 1997; Taylor & Green, 2017; Woods, 2004; Schache et al., 2009; Hewett et al., 2005; Dalton et al, 2015). These injuries primarily occur during the eccentric portion of these quick, dynamic movements because the hamstrings are responsible for decelerating the lower extremity during these tasks (Hibbert et al., 2008; Mutchler et al., 2015; Ernlund & Vieira, 2017; Kujala, Orava, & Jarvinen, 1997; Begalle et al., 2012; Opar et al., 2013).

Rehabilitation is known as the traditional method of preventing re-injury after a hamstring injury occurs. Without it, the hamstring complex will weaken and may result in many possible neuromuscular compensations, such as sensory input impairments, weakened lumbar- pelvic neuromuscular control, and an increased rate of fatigue (Roussiez & Van Cant, 2019). Fatigue is a factor in the recovery process that must also be taken into consideration. If the physical rehabilitation strategy is not geared toward preventing fatigue of the muscle group, an athlete may be more susceptible for re-injury. Currently, we know that functional, sport-specific training can potentially prevent further hamstring injuries (Sole et al., 2012; Taylor and Green, 2017). Taylor & Green (2017) reported the after inducing muscular fatigue, EMG activity was significantly decreased, indicating potential benefits of training in a fatigued state. Research is trending towards the support of training while fatigued because of the possibility of improving injury prevention, a primary goal for an athlete when they have returned to play (Taylor &

Green, 2017; Sole et al., 2012; Roussiez & Van Cant, 2019; Katakura et al., 2011). Russell et al. (2019) examined fatigue through a different lens and found that mental fatigue, rather than physical, may have a negative impact on sporting performance, such as changes in technique, decision-making strategies, and skill execution. If an athlete is trained to withstand the effects of fatigue, they may be physically and mentally better prepared for gameplay.

Many different strategies can be utilized throughout a recovery process, but because rehabilitation is the traditional method of recovery, the role of psychological response to injury may be underestimated. As beneficial as the traditional strategy is, re-injury rates are still high and are not slowing down, according to the NCAA Injury Surveillance Program (ISP). This raises the question as to what other factors may be contributing to the recovery process and the rate of re-injury in athletes. It is quite plausible that there are psychological and sociological dynamics involved. Research has shown that if an athlete feels nervous, anxious, or untrustworthy towards their injured limb, they may reduce their athletic role on the team in order to maintain a state of positive self-image rather than challenging themselves to improve (Brewer et al., 2010; Smith et al. 1990). In the integrated model of response to sport injury, personal and situational factors directly influence cognitive appraisal of sport injuries. In turn, the psychosocial and physical elements of the recovery process may be hindered (Wiese-Bjornstal et al., 1998). Cognitive appraisal and emotional response are two components of the recovery process that must be examined further because currently, limited research surrounding perceptions about the cause of injury, recovery status, and the availability of social support exist.

This information is crucial to the recovery process because these self-perceptions, along with injury severity will directly affect the emotional and behavioral responses to an injury (Wiese- Bjornstal et al., 1998; Smith et al. 1990). Chan & Grossman (1988) studied the psychological effects of a 2-week recovery on runners and observed that those who were unable to run reported significantly worse scores in mood-disturbance and self-esteem than those who could run. It was discussed that these runners often felt psychologically dependent on running and used their running sessions as a stress-reliever. If two athletes have the same injury but one athlete is more concerned about returning, that athlete’s injury may manifest itself differently, resulting in more muscular compensations and a longer recovery time (Smith et al. 1990). Research suggests that roughly 88% of NCAA Division I athletes experienced a normal to mild depression range post- injury, supporting the idea that self-perception and self-worth have a role in the recovery process (Leddy, Lambert, & Ogles, 1994; Scott, Perry, & Sole, 2018).

Athlete confidence is another factor in the recovery process that may hinder the optimization of an athlete's performance (De la Vega et al., 2017). This lower confidence level, or perception of disability, may also be correlated with an athlete's loss of identity in their personal life (Scott, Perry, & Sole, 2017). Ross, Clifford, & Louw (2017) conducted a study on participants who sustained ACL reconstruction to determine what factors play a role after recovery, and it was found that some athletes felt fearful that their sport now imposed too much risk of re-injury to resume play immediately after being cleared. Some participants, who were listed as having no physical impairments, even stated that they refused to resume their previous level of performance strictly because of psychological factors (Ross, Clifford, & Louw, 2017). The extensive process of injury and recovery, along with the risk of re-injury, has been reported to elicit fear and decrease confidence in those who have sustained an injury, leading to a potential avoidance of activity (Ross, Clifford, & Louw, 2017; Truong et al., 2020). Conversely, Kunnen et al. (2019) discussed how an athlete's confidence in their body and physical abilities after rehabilitation is a key attribute of psychological readiness for returning to play. In their study, these researchers found that this population knew they were ready to return to play when they were confident in their physical abilities and no longer feared re-injury (Kunnen et al., 2019). Scott, Perry, & Sole (2017) reported that knee injuries can lower knee-related quality of life and suggests a broader rehabilitation strategy is needed to take into account psychosocial factors along with the physical recovery for athlete optimization.

Sport psychologists have identified sociological aspects of the recovery process that also influence an athlete's psychological response to injury. Oftentimes, the recovery from an injury is cut short by external factors that an athlete wants to preserve, such as playing time, scholarship maintenance, or current fitness level (Wiese-Bjornstal et al., 1998; Truong et al., 2020; Mahood et al., 2020). Sports teams tend to hold an achievement mindset, creating a culture that values winning and success, and this culture may unintentionally have a negative impact on the psychological recovery of an athlete (Wiese-Bjornstal et al., 1998). In some cases, athletes will make the decision to return to activity without going through the proper treatment protocols to offset any negative perspectives from their peers, coaches, or fans (Wiese-Bjornstal et al. 1998; Messner 1992; Mahood et al., 2020). As a result, injuries may not fully heal, and a condensed recovery may result in a weaker limb, leading to a higher rate of re-injury.

Currently, it is known that the recovery process from an injury is extensive and involves the recovery of the physical damage. We also know that re-injury rates are remaining elevated, regardless of the benefits and improvements that are seen in rehabilitation. Research has found that psychological and sociological factors can impact player feelings, but we do not know the extent to which these feelings affect long-term perceptions of disability once they have returned to activity. More so, we do not know if athlete perception is a problem that relates to re-injury rates. Therefore, the purpose of this study was to explore long-term perceived disability in physically-active adults following a hamstring injury. For this study, the two main research questions were 1) Does long-term perceived disability and fear avoidance exist following a hamstring injury in athletes? And 2) Does confidence in performance differ in athletes with a history of hamstring injury compared to healthy controls, both with and without the participants thinking about fatigue? Based on previous research, we expected long-term perceived disability and fear avoidance to be present in athletes with a previous history of hamstring injury, and for confidence in ability to perform to be lower in athletes with a previous history of hamstring injury compared to healthy controls, regardless of the idea of fatigue.

CHAPTER II

METHODS

Participants

Physically active athletes aged 18 - 35 were recruited for this study. A G*Power analysis was run to determine the total number of participants required for this study. For this calculation, alpha was set a priori at 0.05, effect size was set to 0.5, and power was set to 0.8. We attempted to reach the recommended sample size of N >128 participants, 64 per hamstring and control group through recruitment by flyers, email notifications and word of mouth via athletic trainers and faculty at a university in southeast Georgia. The captured sample size was driven by the number of participants with a previous hamstring injury. From the 48 athletes with a history of a hamstring injury to complete the survey, 13 athletes with history of hamstring injury (8 males, 5 females; age = 20.9 $\pm$ 1.64) completed the survey and met all inclusion criteria. From the 278 athletes without a history of hamstring injury to compete the survey, 13 participants (8 males, 5 females; age = 21.1 $\pm$ 1.73) were selected based on matching criteria to the hamstring group that included sex, age, limb dominance, sport, and competitive or non-competitive sport participation.

The term "athlete" encompassed both Division I athletes and physically active adults and was defined as anyone participating in at least 20-minutes of vigorous aerobic activity at least three times per week and had for the past six months. Inclusion criteria consisted of any healthy athlete that had sustained a hamstring injury within the past three years and had since returned to full activity. The term "healthy" was defined as not having a current injury and no activity restrictions. A "competitive athlete" was defined as any athlete who engages in sports/activities with the purpose of competing against another team or player/s, while a "non-competitive athlete" was defined as any athlete who engages in physical activities that are not competitive in nature (i.e. recreational gym-goer). For this study, a hamstring injury was defined as loss of function/activity for more than one day with identified pain in the hamstrings. Exclusion criteria consisted of any athlete below the age of 18 years old, previous surgical intervention to repair hamstring injury, avulsion or complete hamstring muscle disruption as established by the classification of the National Athletic Injury Illness Reporting system, any lower extremity injury that results in time loss from activity, including hamstring injury, within the past four months, lower extremity orthopedic surgery, not including ACL- reconstruction, and lower extremity nerve entrapment.

Instrumentation

The Hamstring Outcome Score (HaOS) was created by the Oslo Sport Trauma Research Center and was used to assess levels of soreness, pain, and concerns surrounding an athlete's hamstring injury. The HaOS questionnaire is comprised of 19 bilateral questions that ask the individual to rate their answers on a 5-point scale from "Not at all" to "Very Much" or from "Never" to "Always" in order to determine statement agreeance. This survey has been utilized in several studies analyzing injury prevention strategies, re-injury strategies, and intrinsic factors that may affect the recovery process, and the HaOS has been discussed as a useful tool for hamstring research (Engebretsen et al., 2008; Engebretsen et al., 2010; De Vos et al., 2014). When implementing the HaOS, previous literature has reported statistically significant findings between those with a previous hamstring injury and those without a previous hamstring injury (Van dr Hoef et al., 2020; Zachazewski et al., 2019). In both studies, those with a previous hamstring injury scored significantly lower on the HaOS, illustrating the validity and accuracy of the HaOS. The HaOS questionnaire began by asking questions about soreness at different time points throughout the day, then transitioned into pain-specific questions geared towards movements that an individual would experience throughout the day, and the questionnaire ended by questioning the athlete on their perception of their quality of life as it relates to their hamstring injury. Physically-active adults and Athletic Trainers could benefit from using this survey because of the unilateral format of the questions being asked; the HaOS provided scales for the injured and uninjured limbs for each question, allowing the athlete to be as specific as possible with their answers.

The Injury Psychological Readiness to Return to Sport (I-PRRS) has been validated and found to be a reliable methodology when examining return to play confidence (Glazer, 2009; Conti et. Al., 2019).

This tool utilized a 10-point rating scale and asked a variety of confidence questions surrounding an athlete's injury and their return to play. Glazer (2019) recommends a score of 50/60 be reached prior to return to play, if using this scale as a tool for establishing return to play criteria. A score of zero implied no confidence, a score of five implied moderate confidence, and a score of 10 implied full confidence. Glazer (2009) reported low I-PRRS scores in athletes following an injury but found an increase in scores before practice, along with another increase in scores before and after competition. Conti et al. (2019) found evidence supporting Glazer (2009) with the I-PRRS showing a reliability score of .746 and cross-validation with the Sport Confidence Inventory screening (Vealey & Knight, 2002). This supports the usefulness of the I-PRRS and its helpfulness in determining an athlete's state of mind surrounding their injury.

The Athletic Fear Avoidance Questionnaire (AFAQ; Dover & Amar, 2015) assessed the athlete's feelings and thoughts around their pain from their injury. This has also been confirmed to be a valid measure of athlete injury-related fear avoidance when establishing a return to playing time (Dover & Amar, 2015). The AFAQ is a five-point scale that asks 10 questions regarding an athlete's thoughts and feeling while in pain as a result of their sport injury; a score of one implied they did not experience fear at all, a score of three implied they moderately felt fear, and a score of five implied they felt a great deal of fear surrounding their injury while in pain. The control was allotted an extra option of "N/A" to decrease confusion given they had no injury. All "N/A" selections were scored as a "1."

Procedure

Upon clicking on the designated survey link or QR code on the posted flyers, hamstring and control participants were directed to the informed consent. Once participants agreed to the informed consent, the survey began. The survey contained demographic questions pertaining to their hamstring injury history, HaOS, I-PRRS, AFAQ, and a second I-PRRS relating to a fatigued state. The control group's survey had an additional answer choice in the AFAQ that allowed them to choose "Not Applicable" in case no answer options applied to them. The I-PRRS was used twice in order to compare the confidence level of an athlete when they were fatigued compared to when they were in a normal state.

Completion of the survey took approximately 15 minutes. No identifying information was requested, and answers were anonymous. No follow-up were requested of the participants. The primary investigator extracted survey data and placed it into a Microsoft Excel spreadsheet for the calculations of composite scores, followed by SPSS 25.0 for statistical analysis.

Statistical Analysis

All data was analyzed using SPSS Statistics for Windows, version 25.0 (SPSS Inc., Chicago, Ill., USA). Differences were explored using the HaOS between competitive and non-competitive athletes, regardless of injury history, and a statistically significant difference was found in the QOL subscale ($p < 0.05$). As a result, the data file was split for the remainder of the analysis. Descriptive statistics were run for all questionnaires to report means and standard deviations for the hamstring and control groups, respectively. Multiple one-way ANOVAs were used to compare HaOS scores, AFAQ scores and I-PRRS scores between the hamstring and control groups. A paired-samples t-test was run to determine differences between the I-PRRS scores within each group. The alpha level was set to 0.05, and Cohen's *d* effect sizes were calculated to determine practical significance. A Cohen's *d* of zero meant that no effect size was present, a small effect size was defined as $d = 0.2$, a medium effect size was defined as $d = 0.5$, and a large effect size was defined as $d = .8$.

CHAPTER III

RESULTS

HaOS

Descriptive injury statistics reported on the HaOS for all hamstring group participants can be viewed in Table 1. Means, standard deviations and effect sizes can be viewed for all between group and within group comparisons in Table 2. There was a statistically significant difference ($p = 0.03$) in the Quality of Life (QOL) subscale of the HaOS between competitive and non-competitive athletes, so these groups were split for analysis.

There was a statistically significant difference in Pain score for the Non-competitive hamstring group (HS_Non-Comp) compared to the Non-competitive control group (Con_Non- Comp) (HS_Non-Comp: 80.71 ± 8.5, Con_Non-Comp: 98.57±1.96; $p < .001$; $d = 2.89$). A statistically significant difference was also found in Function score (HS_Non-Comp: 87.86±11.85, Con_Non-Comp: 99.28±1.89; $p = 0.027$; $d = 1.34$), and Total HaOS score (HS_Non-Comp: 81.9±7.22, Con_Non-Comp: 92.85±2.21; $p = .002$; $d = 2.05$). No statistically significant differences were observed between HS_Non-Comp compared to Con_Non-Comp participants in the categories of Soreness (HS_Non-Comp: 87.86±9.51, Con_Non-Comp: 91.43±11.8; $p = 0.54$; $d = 0.33$) or QOL (HS_Non-Comp: 88.33±3.07, Con_Non-Comp: 88.57±15.73; $p = 0.974$; $d = 0.02$). No statistically significant differences were seen in the Competitive hamstring group (HS_Comp) compared to the Competitive control group (Con_Comp) in any HaOS categories ($P > 0.05$).

Table 1: Self-Reported Injury Statistics

Injury Type	# of Injuries	Time Loss from Injury	Time Loss from Injury N	Percent of HS Injury Players Time Lost (%)	Summary % of Injury Time Lost
Total Injuries Reported	36	1-3 Days	0	0.00	23.08
		4-7 Days	3	23.08	
Unilateral	8	1-4 Weeks	8	61.54	76.92
Bilateral	5	>4 Weeks	2	15.38	

Table 2. Means and Standard Deviations of HaOS for Non- Competitive vs. Competitive Athletes based on Injury History

Group	HaOS Category	No Injury History		History of Injury			
		Mean	SD	Mean	SD	*p*-value	Cohen's *d*
Non-Competitive	Soreness	91.43	11.8	87.86	9.51	0.545	0.33
	Pain	98.57	1.96	80.71	8.5	**< .001**	2.89
	Function	99.29	1.89	87.86	11.85	**0.027**	1.34
	QOL	88.57	15.7	88.33	7.52	0.974	0.02
	Total	92.85	2.21	81.9	7.22	**0.002**	2.05
Competitive	Soreness	86.36	10.26	80.45	15.07	0.295	0.46
	Pain	93.18	8.44	85.45	12.68	0.108	0.72
	Function	96.82	5.6	93.64	9.51	0.35	0.41
	QOL	92.85	7.56	82.5	15.81	0.139	0.84
	Total	88.28	6.89	82.93	9.15	0.137	0.66

I-PRRS

Means, standard deviations and effect sizes can be viewed for all between group and within group comparisons of the I-PRRS and I-PRRS_Fatigue in Table 3. There were no statistically significant differences in confidence scores between or within hamstring and control groups, regardless of competition type ($P > 0.05$).

Table 3. Means and Standard Deviations of I-PRRS and I-PRRS Fatigue for Non- Competitive vs. Competitive Athletes based on Injury History							
		No Injury History		History of Injury			
Group	Survey	Mean	SD	Mean	SD	*p*-value	Cohen's d
Non-Competitive	I-PRRS	53.83	9.8	42.33	20.13	0.237	0.73
	I-PRRS Fatigue	55.83	6.46	40.83	20.37	0.116	0.99
Competitive	I-PRRS	56.13	5.3	51	13.08	0.322	0.51
	I-PRRS Fatigue	54.38	7.48	49.63	15.74	0.454	0.38

AFAQ

Means, standard deviations and effect sizes for the AFAQ can be viewed for all between group comparisons in Table 4. Statistically significant differences were seen in the AFAQ between HS_Non-Comp compared to Con_Non-Comp groups (HS_Non-Comp: 23±11.14, Con_Non-Comp: 11.4±3.13; p = 0.05; d = 1.41). There was not a statistically significant difference found between the HS_Comp and the Con_Comp groups (HS_Comp: 18.5±12.96, Con_Comp: 10.13±0.35; p = 0.09; d = 0.91).

Table 4. Means and Standard Deviations of AFAQ for Non-Competitive vs. Competitive Athletes based on Injury History						
	No Injury History		History of Injury			
Group	Mean	SD	Mean	SD	p-value	Cohen's *d*
Non-Competitive	11.4	3.13	23	11.14	**0.05**	1.41
Competitive	10.13	0.35	18.5	12.96	**0.09**	0.91

CHAPTER IV

DISCUSSION

The purpose of this study was to determine if long-term perceived disability exists following return to activity after a hamstring injury. Based on previous research, our first hypothesis stated that perceived disability and fear avoidance would exist in athletes who have had a previous hamstring injury, and have returned to full activity. To test this hypothesis we compared the group to a control group and expected the Hamstring group (HS) would report a higher degree of perceived disability and fear avoidance than the healthy Control group. The results of this study supported the research hypothesis with the HS group having reported significantly higher perceived disability and fear avoidance than their healthy counterparts. The second hypothesis of this study stated that confidence in performance would be lower in athletes with a history of hamstring injury compared to healthy controls both with and without the participants thinking about fatigue. We further hypothesized that confidence level for the hamstring group would be lower when thinking about fatigue as compared to confidence in performance without fatigue. Based on the results of this study, both parts of the second research hypothesis were rejected.

The results of this study suggest that non-competitive athletes with a previous hamstring injury may perceive a significantly greater degree of disability when compared to non-competitive athletes with no history of injury. There was a difference in QOL subscale of the HaOS for competitive compared to non-competitive athletes, therefore, the sample was split. Once split, the comparisons showed the non-competitive athletes with a history of injury reported a higher degree of disability on the Pain subscale, Function subscale and Total score of the HaOS compared to non-competitive athletes in the control group. The difference was not observed in the competitive hamstring group compared to the competitive control group. These results are similar to other research findings that illustrate hamstring injury recurrence and perception of disability following a hamstring injury (Zachazewski et al., 2019; Van de Hoef et al., 2020; Engebretsen et al., 2010; De Vos et al., 2014). These results suggest that some athletes can experience perceived disability following their hamstring injury, regardless of perceived disability during the recovery process.

In regard to the AFAQ questionnaire, the results of this study observed that non-competitive and competitive athletes both experience a statistically significant degree of fear avoidance following a hamstring injury. While the AFAQ questionnaire is not specific to long-term fear avoidance, this survey was given to athletes that had already returned to activity and at least four months had passed since their most recent injury. As a result, the greater than four month timespan was deemed long-term for this study. Factors such as fear of re-injury, perceived need to protect the previously injured limb, and overall perceived disability have been explored following injury in general, but not specifically to explore if these factors persist following return to play after a hamstring injury (Dover & Amar, 2015; Mahood et al., 2020; Leddy, Lambert, & Ogles, 1994; Scott, Perry, & Sole, 2018). Previous literature supports that the psychological response to sport injury may be affected by external factors such as playing time, negative perspectives of peers, or overall fitness level (Wiese-Bjornstal et al., 1998; Mahood et al., 2020). This study suggests that these factors may exist for an extended period of time beyond that of return to activity.

The current study also assessed athlete confidence through the I-PRRS questionnaire by utilizing its original format along with a secondary format that explored confidence while an athlete is thinking about performance while fatigued. Fatigue is an important element to consider following a hamstring injury because most injuries sustained to the posterior thigh occur in the second half of games or matches when the athlete is most likely to be fatigued, which indicates the need for training in a fatigued state to withstand potential compensatory responses (Dalton et al., 2015; Woods et al., 2004; Anderson, Wasserman, & Shultz, 2019). In regard to athlete confidence, previous studies support the statement that confidence levels are significantly reduced following a hamstring injury (Glazer, 2009; Conti et al., 2019; Kunnen et al., 2019). However, there is little research surrounding long-term confidence levels in a fatigued athlete. The current study explored confidence in performance through the I-PRRS both when thinking about exercising in fatigued state and without the idea of fatigue. Confidence levels for all participants did not significantly change between mindsets, and no differences between groups were observed. As a result, confidence may not be affected after the return to play process has ended. This is somewhat contrasting to previous studies that analyzed confidence throughout the return to play process

(Conti et al., 2019; Glazer et al., 2019). Previous literature recommends an athlete score at least a 50 out of 60 total points prior to returning to play if this questionnaire is being utilized as a recovery tool (Glazer, 2019). This information gave us a better insight to our non-competitive groups, whose average scores were both less than the recommended score of 50, although the results were not statistically significant. More research needs to be performed to investigate why non-competitive athletes reported lower confidence levels than the competitive athletes. The standard deviations of the HS groups in Table 3 should be emphasized due to the large variability reported, which may have affected our study findings. Having standard deviations of that magnitude may have resulted in this study not seeing statistically significant differences as it relates to confidence levels. Nonetheless, it perfectly illustrates the variability of hamstring injuries and their subjectivity to the individual. There is currently a lack of research on the topic of long-term confidence after athletes return to play following a hamstring injury, particularly when an athlete is in a fatigued state. Future research should further explore confidence levels in athletes with a previous history of hamstring injury while actually in a fatigued state and needing to continue the exercise.

Based on the current study, non-competitive athletes may experience a higher degree of perceived disability and fear avoidance following a hamstring injury compared to competitive athletes. Although the competitive athletes in this study did report long-term fearfulness surrounding their previous injury, they did not perceive any long-term disability or confidence deficits. This may be a testament to the quality of resources provided by athletic departments for their competitive athletes. Another possibility could be attributed to the lack of resources available for non-competitive athletes. Most athletic departments provide athletes with a full medical staff consisting of a team physician, athletic trainers, strength and conditioning coaches, sport psychologists, and a nutritionist, in some cases (Haff & Triplett, 2016). Other competitive athletes within a college setting include those who participate in intramural sports, and these athletes are commonly provided with an athletic trainer who is responsible for covering the respective team and/or is stationed within the university’s recreational center. Non-competitive athletes may not have direct access to, or may not utilize, these extensive resources, which could be the reason that these athletes reported more perceived disability and greater fear avoidance. They have less direct resources than competitive athletes, therefore, they have less immediate and/or daily aid when an injury is sustained. Consequently, improved access to healthcare, or greater advertisement of the current healthcare in place, could reduce the amount perceived disability seen in this population. Future research should focus on the fear avoidance that remains after injury for all athletes, and why non-competitive athletes also have long-term reports of disability.

A few limitations were present in this study. We assumed that all participants read each question carefully and answered each question honestly and accurately. A convenience sample was used in this study, so caution should be taken when generalizing the results to other populations. The small sample size also has the possibility of resulting in decreased statistical power. Future studies should expand the sample size to at least 64 participants or greater for HS and Control groups to allow for greater statistical power, as recommended by the G*Power calculation.

CHAPTER V

CONCLUSION

The purpose of this study was to analyze perceived disability, fear avoidance and confidence deficits following a hamstring injury. The results of this study suggest that non-competitive athletes perceive a greater degree of disability due to pain and function following a hamstring injury, whereas competitive athletes reported no perceived disability. No deficits in confidence were reported, but fear avoidance existed in both non-competitive and competitive athletes. Furthermore, non-competitive athletes reported the existence of perceived disability related to pain and function that was not reported by competitive athletes. It is possible that this can be attributed to the lack of medical resources that non-competitive athletes have access to, or utilize, as competitive athletes are provided a full medical staff upon joining a sports team. Lacking or underutilizing these medical resources may result in non-competitive athletes feeling a greater sense of perceived disability after sustaining an injury to the posterior thigh. Regardless of competitiveness, the athletes that reported a previous hamstring injury also reported a substantially greater degree of fear avoidance. Future research should focus on the fear avoidance that remains after injury for all athletes, and why non-competitive athletes also have long-term reports of disability.

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APPENDIX A

EXTENDED INTRODUCTION

Statement of the Problem: Society is currently aware of the extensive requirements that the injury recovery process entails, often including many weeks of rehabilitation. Despite the advancements in rehabilitation strategies over the past decade, re-injury rates are continuing to remain elevated. Research has recently discovered that psychological and sociological factors may play into the recovery process, but minimal research has been performed to determine if athlete perception of injury is a problem that relates to re-injury rates.

Aim of Research (Purpose): The purpose of this study is to explore long-term perceived disability in collegiate and recreational athletes with a history of hamstring injury.

Research Questions:

RQ1: Does long-term perceived disability and fear avoidance exist following a hamstring injury in collegiate athletes?

RQ2: Does confidence in performance differ in athletes with a history of hamstring injury compared to healthy controls, both with and without the participants thinking about fatigue?

Research Hypotheses:

H0 (null): Long-term perceived disability and fear avoidance will not exist in any athletes with a previous history of hamstring injury.

a. Long-term perceived disability and fear avoidance will not exist in collegiate or recreational athletes after a hamstring injury.

b. No difference in long-term perceived disability and fear avoidance will be seen between the hamstring group and control group

H1: Athletes with a history of hamstring injury will show higher scores of perceived disability and fear avoidance compared to health controls.

$H0_2$ (null): Confidence in performance will not be lower in athletes with a history of hamstring injury compared to healthy controls with or without the participants thinking about fatigue.

H2: Confidence in performance will be lower in injured athletes with a history of hamstring injury compared to healthy controls both with and without the participants thinking about fatigue.

Independent Variables:

1. Hamstring group
2. Control group

Dependent Variables*:*

1. Hamstring Outcome Score
2. Injury Psychological Readiness to Return to Sport
3. Athlete Fear Avoidance Questionnaire
4. Injury Psychological Readiness to Return to Sport (as it relates to fatigue)

Inclusion Criteria*:*

1. Individuals between 18-35 years old
2. Physically active individuals that participate in at least 20-minutes of vigorous aerobic intensity activity at least 3 times per week and has for the past 6 months
3. History of hamstring injury within the past 3 years; returned to full activity
4. Healthy individuals with no history of hamstring injury

Exclusion Criteria:

1. Any athlete below the age of 18
2. Surgical intervention to repair hamstring injury
3. Avulsion or complete hamstring muscle disruption as established by the classification of the National Athletic Injury Illness Reporting system
4. Any lower extremity injury that results in time loss from activity, including hamstring injury, within the past 4 months

5. Lower extremity orthopedic surgery, not including ACL-reconstruction
6. Lower extremity nerve entrapment

Limitations:

1. All answers were subjective to the individual and therefore may not be interpreted the same for all athletes.
2. Participants may not have read questions thoroughly
3. The time since injury varied between athletes

Delimitations*:*

1. Questions will be specific, clear, and comprehensible
2. All injuries will have occurred in the past 3 years; anything prior will be excluded

Assumptions:

1. Participants accurately reported their hamstring injury history
2. Each participant gave his/her best effort throughout the questionnaires
3. Subject accurately read and answered each question correctly
4. Student-athletes were truthful in answering all survey questions.

Operational Definitions*:*

1. Hamstring Injury - Self identified loss of function/activity for more than one day with identified pain in the hamstrings
2. Limb dominance - The leg the participant would use to kick a ball the farthest
3. Healthy - No loss of time from practice and/or game; no restriction of activity
4. Injury - Any loss of time from practice and/or games for one day or longer
5. Athlete - Anyone who participates in vigorous intensity aerobic activity for a minimum of 20 min on three days per week.
6. Fatigue - Self-perceived exhaustion from physical activity
7. Competitive – Any athlete who engages in sports/activities with the purpose of competing against another team or player/s.

8. Non-competitive – Any athlete who engages in physical activities that are not competitive in nature (i.e. recreational gym-goer)

APPENDIX B

LITERATURE REVIEW

Epidemiology of the Hamstring Complex

Injuries to the lower extremity (LE) during sport are some of the most common injuries that occur in athletic populations (Dalton et al., 2015; Ernlund & Vieira, 2017; Woods, 2004; Roussiez & Van Cant, 2004; Di Trani, 2017; Mutchler et al., 2015; Small et al., 2009; Sole et al., 2012; Coole & Gieck, 1987; Kujala, Orava, & Jarvinen, 1997; Schache et al., 2009; Hibbert et al., 2008). According to the NCAA Injury Surveillance Program (ISP), the prevalence and rate of LE injuries remaining elevated. The most prominent non-contact hamstring (HS) injury occurrence has been found to take place during preseason, during game play, and in male rather than female sports, particularly in men's football, men's soccer, and women's soccer (Dalton et al, 2015; Ernlund & Vieira, 2017). Of the 1,143 HS injuries reported by the NCAA ISP, 68.2% of HS strains occurred during practices while 52.9% of HS strains occurred during the regular season (Dalton et al., 2015).

The hamstring complex acts as the primary movers and stabilizers of the hip and knee joints (Coole & Gieck, 1987), and this region is most likely to be found strained during non-contact, explosive, dynamic movements such as sprinting and running (Kujala, Orava, & Jarvinen, 1997; Taylor & Green, 2017; Woods, 2004; Schache et al., 2009; Hewett et al., 2005; Dalton et al, 2015). These injuries often occur primarily during the eccentric portion of these quick, dynamic movements because the hamstrings are responsible for decelerating the lower extremity (Hibbert et al., 2008; Mutchler et al., 2015; Ernlund & Vieira, 2017; Kujala, Orava, & Jarvinen, 1997; Begalle et al., 2012; Opar et al., 2013). The hamstring muscles have been found to be the most biomechanically exposed during the terminal swing phase of gait. Terminal swing lengthens the biceps femoris (BF) more so than either semitendinosus or semimembranosus, which means the BF will be under the greatest tension of the hamstring complex, leading to the BF undergoing the most frequent amount of strains (Hibbert et al., 2008; Coole & Gieck, 1987; Schache et al., 2009; Woods, 2004; Roussiez & Van Cant, 2004; Marshall et al., 2014)**.** Sole et al. (2012) examined injuries across two full seasons in professional soccer players and found that, in total, 12% of all injuries reported in this study were hamstring related. This totaled to 796 hamstring injuries, being the most prominent injury seen across both seasons (Sole et al., 2012). When analyzing muscle fiber distribution, an increase in muscle fiber cross sectional area decreases the stress on a muscle, which is why the biceps femoris is often strained more than other hamstring muscles.

Injury Susceptibility and Potential Compensations

Lower extremity (LE) injuries during sports and recreational activity is not an uncommon occurrence, regardless of the activity being performed. While exploring LE injuries and their causes, it is important to expand to both acute and chronic. If an athlete or individuals has asymmetries throughout their lower body, compensations may arise leading to injury susceptibility (Hewit, Cronin, & Hume, 2012). For example, patello-femoral pain syndrome (PFP) can be a result of weakened patella stabilizers, the vastus medialis and vastus lateralis (Worrell, Crisp, & LaRosa, 1998). Additionally, weak gluteal function often results in lower extremity dysfunction such as PFP, IT band syndrome, and anterior cruciate ligament (ACL) sprains/tears (Destefano et al., 2009; Roussiez & Van Cant, 2004). If a HS strain occurs, then the gluteal muscles are responsible for compensating for the weakened hamstring muscle. In turn, their firing rate will increase. The most common LE injuries that occur today include hamstring strains and knee injuries, specifically ACL tears (Hewett et al., 2005). ACL injuries are often a result of a weak hamstring complex, which causes the quadriceps and gluteus maximus to compensate and work harder in lower extremity movement. Walsh et al. (2012) reported a significant correlation between large quadricep activity and low knee-flexion angles. A lower knee-flexion angle often results in larger impact forces at the knee joint, leading to larger forces being placed on the ACL. This in turn results in excessive anterior tibial translation, a primary cause of ACL tears (Kaeding, Leger-St-Jean, & Magnussen, 2017; Hewett et al., 2005; Walsh et al., 2012; Destefano et al., 2009). Knee valgus and excessive internal rotation of the hip and tibia during explosive, high-stress movements are also supplementary causes of non-contact ACL injuries (Kaeding, Leger-St-Jean, & Magnussen, 2017). ACL tears can result in a 16% shorted stance time during gait, leading to asymmetries and an increased risk for further injury elsewhere (Hewett et al., 2005). Nationally, over 120,000 non-contact ACL injuries occur every year in high school and college athletes, leading to ACL injuries and rehab for female athletes averaging approximately one billion dollars annually (Hewett et al., 2005). This is a cost heavy injury that often results in the player being sidelined for the rest of the season.

Neuromuscular Adaptations

Current research has established that after a muscle strain occurs, compensations and neuromuscular adaptations may become evident. Mutchler et al. (2017) suggested that a decrease in muscle activity of an agonist after a hamstring strain may be a result of protective neuromuscular adaptations, which would decrease the demand of the injured muscle (Mutchler et al., 2017; Roussiez & Van Cant, 2019). Roussiez & Van Cant (2019) reported common symptoms often seen after a hamstring strain injury: sensory input impairments, adverse neural tension, weakened lumbar-pelvic neuromuscular control, and neuromuscular fatigue. They, along with Di Trani (2017), reported a significant increase of perceived tightness in their subject's previously injured limb. Di Traini (2017) suggests this perceived tightness stems from mechanoreceptor damage and cortical remodeling after a hamstring strain (Roussiez & Van Cant, 2019; Di Trani, 2017). When looking at neuromuscular impairments of the lumbar-pelvic region, imbalances may occur with anterior pelvic tilt, which lengthens the bicep femoris and inhibits activity of the gluteus maximus. The increased stress being placed on the bicep femoris due to potential anterior pelvic tilt will increase its susceptibility for strains to occur (Panayi, 2009; Dalton et al, 2015). Neuromuscular fatigue is also a common result of a muscle strain. In regards to hamstring strains, neuromuscular fatigue will decrease the amount of eccentric contraction that the hamstrings are capable of producing during dynamic movements, which creates an imbalance of muscle activity when these movements occur, an example being in the terminal swing phase of running/sprinting. If the body is unable to produce enough deceleration force, then the LE will be forced into excessive anterior tibial translation, which has previously been discussed to lead directly towards injury risk of the knee joint (Marshall et al., 2014; Roussiez & Van Cant, 2019; Walsh et al., 2012; Destefano et al., 2009).

Muscle compensations may arise from neuromuscular adaptations, and because of these potential adaptations from an injury, muscle activity during an injury may be constrained (Dalton et al, 2015; Opar et al., 2013). While immediate neuromuscular changes are often not seen, Henrikson et al. (2011) found that hamstring strains result in an 11% reduction in hip extensor moment and internal knee flexor moment and a three percent reduction in lateral knee rotator moment while Lessi & Serrao (2017) reported similar findings in peak trunk flexion and hip extension (Henrikson et al., 2011; Lessi & Serrao, 2017). At the onset of injury, the healthy limb experiences a substantial increase in ground reaction forces due to the compensations from the immediate deceleration of the injured limb and significantly less strength output across all conditions. This results in a substantial decrease in maximal peak hip flexion (Schache et al., 2009; Opar et al., 2013). A decrease in hip flexion is often problematic because individuals have a tendency to keep their balance during unilateral movements by utilizing a trunk flexion strategy to ensure that their center of mass is over their base of support (Begalle et al., 2012).

Rehabilitation Strategies

Rehabilitation settings often employ a strategy of neuromuscular training when dealing with hamstring strains, and this includes implementing exercises that focus on eccentric movements. The biceps femoris (BF), for example, is recommended to be strengthened through eccentric work because EMG activity during eccentric movements has shown to be significantly lower in previously injured hamstring individuals. Eccentric strength should be prioritized after a hamstring injury to prevent reoccurrence, which is why a single-leg exercises may be a successful rehab addition to examine lower extremity functionality (Hibbert et al., 2008; Ernlund & Vieira, 2017; Opar et al., 2013; Begalle et al., 2012; Small et al., 2009). When implementing a fatigue protocol for a strained hamstring, Samaan et al. (2017) recommends using a compound protocol rather than an isolated protocol because isolated hamstring fatigue protocols have a history of causing excess anterior tibial translation, reducing muscular force output. This ideology was used elsewhere to look at EMG of ACL-reconstruction patients before and after a dynamic fatigue protocol, and evidence showed greater EMG activity in the BF, vastus lateralis, and G_{max} muscles, suggesting a positive impact from a compound fatigue protocol for ACL injuries (Lessi & Serrao, 2017). When performing a side-step cutting task after another compound fatigue protocol, it was reported that the muscle activity was significantly altered and joint stability was weakened due to the fatigued hamstring (Samaan et al., 2017). This is indicative of a need for training in a fatigued state in order to counteract the effects of fatigue during competition. As a result of competition fatigue, most hamstring injuries occur at the end of the first half and throughout the second half of games, which is why there is a need for fatigued, sport-specific training (Dalton et al, 2015; Woods et al., 2004; Anderson, Wasserman, & Shultz, 2019; Marshall et al., 2014; Small et al., 2009). Depending on the perception of the athlete and their perceived disability after their injury, it may be helpful to gear rehabilitation strategies towards their concerns in conjunction with the overarching goal of returning to play. Adding additional exercises into an athlete's rehabilitation program may improve their confidence level as well as decrease their level of perceived disability after their injury, which will aid in their return to play as well as improve their perception during their eventual gameplay.

Consequences of Fatigue

While recovery from an injury is vital prior to returning to play, an athlete must also be prepared to face the element of fatigue when they return. If an athlete is approved to return to play without the preparation of fatiguing from rehabilitation, they will be more susceptible for re-injury. Currently, we know that functional, sport-specific training can potentially prevent further hamstring injuries (Sole et al., 2012; Taylor & Green, 2017), and females often are more fatigable compared to their respective counterparts due to their muscle fiber distribution. A faster rate of motor unit recruitment is indicative of an increase in EMG activity of an agonist muscle, which may be indicative of a fatigue response; however, Enoka & Duchateau (2008) reported that muscles acting synergistically often are more easily fatigued (Enoka & Duchateau, 2008). When comparing agonist and antagonist EMG activity during an MVIC fatigue protocol of the tibialis anterior and the soleus, Patikas et al. (2002) found that both tibialis anterior and soleus EMG activity decreased; however, only the soleus decrease was significant. This suggests that the agonist muscle was more affected compared to the antagonist due to the need for more motor unit recruitment (Patikas et al., 2002).

According to two studies by Katakura et al. (2011) and Taylor et al. (2017), mean peak torque significantly decreases at the end of a given fatigue task. Post 10-minutes, however, it may increase again to a torque higher than that of even the pre-fatigue value. The reliability of lengthened protocols has been researched for the LE by Bosquet et al. (2010), and they found that an increased length of a protocol further increases its reliability as well as significantly improved knee extensor peak torque (Bosquet et al., 2010). Taylor et al. (2017) also noted that hamstring EMG activity was significantly decreased after muscular fatigue, which indicates potential positive results of training in a fatigued state. Root mean square (RMS) EMG amplitudes were significantly increased after their fatigue protocol, again higher than that of the pre-fatigue peak torque. Interestingly, this was found to not be related to an increase in muscle firing rate, but instead, it was more than likely due to the type II fibers being compromised as a result of the fatigue (Katakura et al., 2011). These findings support the idea that training in a fatigued state will improve the likelihood of injury prevention, which the goal if an athlete is returning to play. If rehabilitation strategies are geared towards building muscular endurance to properly withstand the effects of fatigue, an athlete will be better prepared for gameplay.

Athlete Perception Post-Injury

It is well known that rehabilitation is crucial in the return to play process in order for an athlete to recover from the physical damages caused by the injury. In a study examining the perceived need for physical therapy after lower-extremity trauma, it was found that, of those who chose to receive no physical therapy, 23-46% felt they needed it after their first follow-up, and over 68% felt they needed it by two years (Castillo et al., 2005). This represents the importance of receiving the proper care after a traumatic injury, especially in athletes who must return to play. If an athlete has low confidence when returning to play, it may be advantageous to continue rehabilitation to build up their confidence prior to returning to sport. Other factors can also affect the recovery process, specifically the mental state of the injured athlete. According to the integrated model of response to sport injury, cognitive appraisal of sport injuries is directly affected by personal and situational factors. These self-perceptions and injury severity of the athlete directly affect the emotional and behavioral responses to an injury (Wiese-Bjornstal et al., 1998; Smith et al. 1990). When a hamstring injury occurs, it is important that an athlete’s Athletic Trainer not only take into account his or her injury severity, but it is also crucial to an athlete’s overall health to also consider their confidence level and mentality throughout the recovery process.

Wiese-Bjornstal et al. (1998) discussed other sociological factors that might also influence an athlete's mindset during the recovery process; external factors must not be forgotten, such as a team's achievement mindset, scholarship maintenance, playing time, or a desire to maintain a current fitness level. In some cases, athletes will make the decision to return to activity without going through the proper treatment protocols to offset any negative perspectives from their peers, coaches, or fans (Wiese-Bjornstal et al. 1998; Messner 1992). Oftentimes, athletes will be approved to return to play without psychological considerations, and those athletes may be at a disadvantage compared to their healthy teammates due to their perception of their previously-injured limb. Brewer et al. (2010) discovered that some athletes may even reduce their role or responsibilities on their team in order to maintain a positive self-image for themselves rather than further challenge themselves or risk a re-injury. As a result, these athletes cannot reach their previous potential or may not contribute to their sport solely to preserve their confidence level, which could lead them to being more susceptible for re-injury. In conclusion, the integrated model of response to sport injury outlines the importance of mental health throughout the injury and recovery process (Wiese-Bjornstal et al. 1998). Rehabilitation is one of the most useful tools to utilize when an athlete is injured, but society does not currently utilize the integrated model of response to sport injury as extensively as the primary method. This could potentially answer the question as to why re-injury rates are remaining elevated despite rehabilitation advancements, but current research on this theory is limited.

APPENDIX C

QUALTRICS SURVEY

Welcome to the research study!

Participant Informed Consent:

My name is Savannah McLain, and I am a current Kinesiology Graduate Student at Georgia Southern University. I currently work in the Biomechanics lab where I coordinate with Athletic Trainers and interact with student-athletes on a daily basis to perform concussion testing and other projects. I have developed a curiosity for injuries and injury prevention as a result, and I hope that this project will further enhance my knowledge surrounding our athletes.

The purpose of this study is to explore long-term perceived disability in collegiate and recreational athletes with a history of hamstring injury to determine if self-reported limitations exist after return to full activity.

Participation in this research will include a completion of an online survey - administered via Qualtrics sent either to your Georgia Southern email address, posted by a professor, or via the link provided in the QR code flyers. You will only be asked to complete the survey once.

There is little to no risk involved in partaking in the questionnaire, no greater than the risk that you experience in your daily life. The questionnaires involved in this study are meant to question your perception of your injury, and there is potential for it to bring you emotional discomfort and/or stress. If this study does begin to produce stress or discomfort, understand you have the right to terminate participation and have access to your Team Athletic Trainer as well as the Georgia Crisis & Access Line at 1-800-715-4225.

You shall receive no direct benefit for participating in this study, however, it will aid in the growing body of literature surrounding athlete perception post-injury.

The survey should take you approximately 15 minutes to complete, and should you choose to participate, you will only be asked to complete it once.

A link to the Qualtrics survey may be sent to your Georgia Southern email address, and that will be the extent of your identification. The survey is completely anonymous and does not require you to enter any demographic information that could lead to your identification. You will not be identified by name in any data set or any reports using information obtained from this study. Surveys will be administered via Qualtrics online, so there is also a slight risk of cybersecurity. Individual responses will not be shared with your coaches or Athletic Trainers as a result of the survey's anonymity. Data will be stored on a password protected computer in the custody of Dr. Jessica Mutchler.

Subsequent uses of records and data will be subject to standard data use policies which protect the anonymity of individuals and institutions. You will not be identified by name in any data set or reports using information from this study.

Participants have the right to ask questions and have those questions answered. If you have questions about this study, please contact the researcher named above or the researcher's faculty advisor, whose contact information is located at the end of the informed consent. For questions concerning your rights as a research participant, contact Georgia Southern University Institutional Review Board at 912-478-5465.

You will not receive any compensation for your participation in this study.

You understand that you do not have to participate in this survey and your decision to participate is purely voluntary. At any time, you may choose to withdraw your participation with no consequences by informing the primary investigator, Savannah McLain.

You understand that you may terminate participation in this study at any time without prejudice or penalty.

You understand that there is no deception involved in this project.

All information will be treated confidentially. There is one exception to confidentiality that we need to make you aware of. In certain research studies, it is our ethical responsibility to report situations of child or elder abuse, child or elder neglect, or any life-threatening situation to appropriate authorities. However, we are not seeking this type of information in our study nor will you be asked questions about these issues.

You must be 18 years of age or older to consent to participate in this research study. If you consent to participate in this research study and to the terms above, please sign your name and indicate the date below.

You will be given a copy of this consent form to keep for your records. This project has been reviewed and approved by the GSU Institutional Review Board under tracking number H21185.

Title of Project: Long-term Perceived Disability Following a Hamstring Injury.

Principal Investigator: Savannah McLain, (770)-845-1517, sm09149@georgiasouthern.edu

Other Investigator(s):

Jessica Mutchler, Ph.D., LAT, ATC, jmutchler@georgiasouthern.edu

Samuel J. Wilson, Ph.D, sjwilson@georgiasouthern.edu

Megan Byrd, Ph.D, CMPC, mmbyrd@georgiasouthern.edu
Research Advisor: Jessica Mutchler, Ph.D, ATC, jmutchler@georgiasouthern.edu

Please read and answer questions carefully and as honestly as possible. Please note that the survey will be best displayed on a laptop of desktop computer. Some features may be less compatible for a mobile device.

- ○ I consent - Begin the study (1)
- ○ I do not consent (2)

Skip To: End of Survey If Welcome to the research study! Participant Informed Consent: My name is Savannah McLain, and I... = I do not consent

Q80 Have you experienced any of the following conditions? Check all that apply.

- ☐ Surgical intervention to repair hamstring injury (1)
- ☐ Avulsion or complete hamstring muscle disruption as established by the classification of the National Athletic Injury Illness Reporting system (2)
- ☐ Any lower extremity injury that results in time loss from activity, including hamstring strain, within the past 4 months (3)
- ☐ Lower extremity orthopedic surgery, not including ACL-reconstruction (4)
- ☐ Lower extremity nerve entrapment (5)
- ☐ None (6)

Skip To: End of Survey If Have you experienced any of the following conditions? Check all that apply. != None

Q84 Have you ever sustained a hamstring injury?

- ◯ Yes (1)
- ◯ No (2)

Q1 Sex (biological):

- ◯ Male (1)
- ◯ Female (2)

Q2 Age? (Ex: 22)

____

Skip To: End of Survey If Condition: Age? (Ex: 22) Is Less Than 18. Skip To: End of Survey.

Q3 Are you a current collegiate athlete or recreational athlete?

- ◯ Collegiate Athlete (1)
- ◯ Recreational Athlete (Intramurals, club sports, gym, etc.) (2)

Q4 If you are a collegiate athlete, what sports team are you a member of?

- ◯ Football (1)
- ◯ Basketball (2)
- ◯ Baseball (3)
- ◯ Softball (4)
- ◯ Golf (5)
- ◯ Soccer (6)
- ◯ Tennis (7)
- ◯ Volleyball (8)
- ◯ Swim/Dive (9)
- ◯ Track/Cross-country (10)
- ◯ Rifle (11)
- ◯ I am not a collegiate athlete (12)

Q5 If you are a recreational athlete, please describe your level (competitive/non-competitive) and type of physical activity (cycling, weight training, group fitness, etc.).

____

Q6 Have you ever sustained an injury or repair to your anterior cruciate ligament (ACL)?

- ◯ Yes (1)
- ◯ No (2)

Q83 Which leg would you prefer to kick a ball with in order to kick it the farthest?

- ◯ Left (1)
- ◯ Right (2)

Q8 How many days/weeks/months were missed because of your injury? (# days / # months / # years).

If you have never sustained a hamstring injury, you may answer "0 days"

____

Q9 For the following questions, please answer in regard to your LEFT leg:

Number of previous acute hamstring strains:

- ◯ 0 (1)
- ◯ 1 (2)
- ◯ 2 (3)
- ◯ 3 (4)
- ◯ 4 (5)
- ◯ 5 (6)
- ◯ >5 (7)

Skip To: Q13 If For the following questions, please answer in regard to your LEFT leg: Number of previous acute h... = 0

Q10 Time since most recent injury:

- 0-6 months (1)
- 6-12 months (2)
- 1-2 years (3)
- >2 years (4)

Q11 For how long were you unable to fully play/train?

- 1-3 days (1)
- 4-7 days (2)
- 1-4 weeks (3)
- >4 weeks (4)

Q13 For the following questions, please answer in regard to your RIGHT leg:

Number of previous acute hamstring strains:

- 0 (1)
- 1 (2)
- 2 (3)
- 3 (4)
- 4 (5)
- 5 (6)
- >5 (7)

Skip To: Q17 If For the following questions, please answer in regard to your RIGHT leg: Number of previous acute... = 0

Q14 Time since most recent injury:

- ◯ 0-6 months (1)
- ◯ 6-12 months (2)
- ◯ 1-2 years (3)
- ◯ >2 years (4)

Q15 For how long were you unable to fully play/train?

- ◯ 1-3 days (1)
- ◯ 4-7 days (2)
- ◯ 1-4 weeks (3)
- ◯ >4 weeks (4)

Q16 Have you missed a training/match during the previous season due to symptoms from your hamstrings?

- ◯ No- never (1)
- ◯ Yes- Rarely (2)
- ◯ Yes- Sometimes (3)
- ◯ Yes- Often (4)

Q17 In the last week, have you experienced soreness/stiffness/had complaints from your LEFT posterior thigh/hamstrings?

○ Never (1)

○ Rarely (2)

○ Sometimes (3)

○ Often (4)

○ Always (5)

Q18 In the last week, have you experienced soreness/stiffness/had complaints from your RIGHT posterior thigh/hamstrings?

○ Never (1)

○ Rarely (2)

○ Sometimes (3)

○ Often (4)

○ Always (5)

Q19 The following questions cover soreness in the posterior thigh region. Report the degree of soreness that you have experienced from your posterior thigh/hamstrings during a typical week.
How sore is your LEFT posterior thigh **after** training?

○ Nothing at all (1)

○ A little (2)

○ Moderate (3)

○ A lot (4)

○ Very much (5)

Q20 How sore is your RIGHT posterior thigh **after** training?

- Nothing at all (1)
- A little (2)
- Moderate (3)
- A lot (4)
- Very much (5)

Q21 How sore is your LEFT posterior thigh **during** training?

- Nothing at all (1)
- A little (2)
- Moderate (3)
- A lot (4)
- Very much (5)

Q22 How sore is your RIGHT posterior thigh **during** training?

- Nothing at all (1)
- A little (2)
- Moderate (3)
- A lot (4)
- Very much (5)

Q23 How sore is your LEFT posterior thigh when you wake up in the morning?

- ◯ Nothing at all (1)
- ◯ A little (2)
- ◯ Moderate (3)
- ◯ A lot (4)
- ◯ Very much (5)

Q24 How sore is your RIGHT posterior thigh when you wake up in the morning?

- ◯ Nothing at all (1)
- ◯ A little (2)
- ◯ Moderate (3)
- ◯ A lot (4)
- ◯ Very much (5)

Q25 How sore is your LEFT posterior thigh if you have been sitting still for a while during the day?

- ◯ Nothing at all (1)
- ◯ A little (2)
- ◯ Moderate (3)
- ◯ A lot (4)
- ◯ Very much (5)

Q26 How sore is your RIGHT posterior thigh if you have been sitting still for a while during the day?

- Nothing at all (1)
- A little (2)
- Moderate (3)
- A lot (4)
- Very much (5)

Q27 The following questions ask you about your pain level surrounding your hamstring injury.

How often do you experience pain from your LEFT posterior thigh?

- Never (1)
- Rarely (2)
- Sometimes (3)
- Often (4)
- Always (5)

Q28 How often do you experience pain from your RIGHT posterior thigh?

- Never (1)
- Rarely (2)
- Sometimes (3)
- Often (4)
- Always (5)

Q29 Do you often sustain small strains in your LEFT posterior thigh that resolve quickly?

- Never (1)
- Rarely (2)
- Sometimes (3)
- Often (4)
- Always (5)

Q30 Do you often sustain small strains in your RIGHT posterior thigh that resolve quickly?

- Never (1)
- Rarely (2)
- Sometimes (3)
- Often (4)
- Always (5)

Q33
Report the degree of pain that you have felt from your posterior thigh/hamstrings during the last week when performing the following activities:

Stretching the LEFT posterior thigh/hamstring

- No pain (1)
- A little (2)
- Moderate (3)
- Considerable (4)
- Very painful (5)

Q34 Stretching the RIGHT posterior thigh/hamstring

- ◯ No pain (1)
- ◯ A little (2)
- ◯ Moderate (3)
- ◯ Considerable (4)
- ◯ Very painful (5)

Q35 Walking up a ladder/stairs (double steps): LEFT

- ◯ No pain (1)
- ◯ A little (2)
- ◯ Moderate (3)
- ◯ Considerable (4)
- ◯ Very painful (5)

Q36 Walking up a ladder/stairs (double steps): RIGHT

- ◯ No pain (1)
- ◯ A little (2)
- ◯ Moderate (3)
- ◯ Considerable (4)
- ◯ Very painful (5)

Q37 Jogging (LEFT)

- ○ No pain (1)
- ○ A little (2)
- ○ Moderate (3)
- ○ Considerable (4)
- ○ Very painful (5)

Q38 Jogging (RIGHT)

- ○ No pain (1)
- ○ A little (2)
- ○ Moderate (3)
- ○ Considerable (4)
- ○ Very painful (5)

Q39 Changing direction while running (LEFT)

- ○ No pain (1)
- ○ A little (2)
- ○ Moderate (3)
- ○ Considerable (4)
- ○ Very painful (5)

Q40 Changing direction while running (RIGHT)

- No pain (1)
- A little (2)
- Moderate (3)
- Considerable (4)
- Very painful (5)

Q41 Accelerating (LEFT)

- No pain (1)
- A little (2)
- Moderate (3)
- Considerable (4)
- Very painful (5)

Q42 Accelerating (RIGHT)

- No pain (1)
- A little (2)
- Moderate (3)
- Considerable (4)
- Very painful (5)

Q43 Braking speed after sprinting (LEFT)

- No pain (1)
- A little (2)
- Moderate (3)
- Considerable (4)
- Very painful (5)

Q44 Braking speed after sprinting (RIGHT)

- No pain (1)
- A little (2)
- Moderate (3)
- Considerable (4)
- Very painful (5)

Q45 The following questions concern your physical function. For each of the following activities, please indicate the degree of difficulty you have experienced in the last week due to your posterior thigh/hamstrings.

Running (LEFT)

- Nothing at all (1)
- A little (2)
- Moderate (3)
- A lot (4)
- Very much (5)

Q46 Running (RIGHT)

- ○ Nothing at all (1)
- ○ A little (2)
- ○ Moderate (3)
- ○ A lot (4)
- ○ Very much (5)

Q47 Jumping (LEFT)

- ○ Nothing at all (1)
- ○ A little (2)
- ○ Moderate (3)
- ○ A lot (4)
- ○ Very much (5)

Q48 Jumping (RIGHT)

- ○ Nothing at all (1)
- ○ A little (2)
- ○ Moderate (3)
- ○ A lot (4)
- ○ Very much (5)

Q49 Accelerating (LEFT)

- ○ Nothing at all (1)
- ○ A little (2)
- ○ Moderate (3)
- ○ A lot (4)
- ○ Very much (5)

Q50 Accelerating (RIGHT)

- ○ Nothing at all (1)
- ○ A little (2)
- ○ Moderate (3)
- ○ A lot (4)
- ○ Very much (5)

Q51 Braking speed after sprinting (LEFT)

- ○ Nothing at all (1)
- ○ A little (2)
- ○ Moderate (3)
- ○ A lot (4)
- ○ Very much (5)

Q52 Braking speed after sprinting (RIGHT)

- Nothing at all (1)
- A little (2)
- Moderate (3)
- A lot (4)
- Very much (5)

Q53 The following questions concern how problems from your hamstrings restrain you during physical activity. Report the degree of difficulty you have experienced during the last week due to your posterior thigh/hamstrings.

In what degree do you trust your LEFT hamstrings during physical activity?

- Totally (1)
- A lot (2)
- Moderate (3)
- To some degree (4)
- Not at all (5)

Q54 In what degree do you trust your RIGHT hamstrings during physical activity?

- Totally (1)
- A lot (2)
- Moderate (3)
- To some degree (4)
- Not at all (5)

Q55 Do you sometimes keep from performing 100% due to concerns of sustaining a LEFT hamstring strain?

- ○ Totally (1)
- ○ A lot (2)
- ○ Moderate (3)
- ○ To some degree (4)
- ○ Not at all (5)

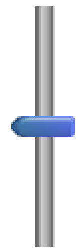
Q56 Do you sometimes keep from performing 100% due to concerns of sustaining a RIGHT hamstring strain?

- ○ Totally (1)
- ○ A lot (2)
- ○ Moderate (3)
- ○ To some degree (4)
- ○ Not at all (5)

Q57
Please rate your confidence level to participate in your sport/activity on a scale from 0 to 10 as it relates to the integrity of your hamstring.

0 = no confidence at all
5 = moderate confidence
10 = complete confidence

My overall confidence to play is:



0 (0)

1 (1)

2 (2)

3 (3)

4 (4)

5 (5)

6 (6)

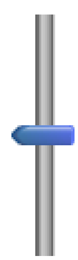
7 (7)

8 (8)

9 (9)

10 (10)

Q58 My confidence to play without pain is:



0 (0)

1 (1)

2 (2)

3 (3)

4 (4)

5 (5)

6 (6)

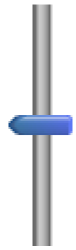
7 (7)

8 (8)

9 (9)

10 (10)

Q59 My confidence to give 100% effort is:



0 (0)

1 (1)

2 (2)

3 (3)

4 (4)

5 (5)

6 (6)

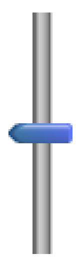
7 (7)

8 (8)

9 (9)

10 (10)

Q60 My confidence to not concentrate on my injury is:



0 (0)

1 (1)

2 (2)

3 (3)

4 (4)

5 (5)

6 (6)

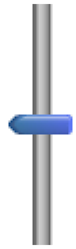
7 (7)

8 (8)

9 (9)

10 (10)

Q61 My confidence in the injured body part to handle demands of the situation is:



0 (0)

1 (1)

2 (2)

3 (3)

4 (4)

5 (5)

6 (6)

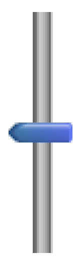
7 (7)

8 (8)

9 (9)

10 (10)

Q62 My confidence in my skill level/ability is:



0 (0)

1 (1)

2 (2)

3 (3)

4 (4)

5 (5)

6 (6)

7 (7)

8 (8)

9 (9)

10 (10)

Q63 We are interested in your feelings or thoughts when in pain as a result of a sports injury. Using the following scale, please indicate the degree to which you have these thoughts and feelings when you are in pain due to your previous hamstring injury. If you have never sustained a hamstring injury, you may choose the "Not Applicable" answer choice.

1 = Not at all
2 = To a slight degree
3 = To a moderate degree
4 = To a great degree
5 = Completely agree
N/A = Not applicable

I will never be able to play as I did before my injury

- ◯ 1 (1)
- ◯ 2 (2)
- ◯ 3 (3)
- ◯ 4 (4)
- ◯ 5 (5)
- ◯ N/A (7)

Q64
I am worried about my role with the team changing

1 = Not at all
2 = To a slight degree
3 = To a moderate degree
4 = To a great degree
5 = Completely agree

N/A = Not applicable

- ◯ 1 (1)

- 2 (2)
- 3 (3)
- 4 (4)
- 5 (5)
- N/A (7)

Q65 I am worried about what other people will think of me if I don't perform at the same level

1 = Not at all
2 = To a slight degree
3 = To a moderate degree
4 = To a great degree
5 = Completely agree

N/A = Not applicable

- 1 (1)
- 2 (2)
- 3 (3)
- 4 (4)
- 5 (5)
- N/A (7)

Q66 I am not sure what my injury is/was

1 = Not at all
2 = To a slight degree
3 = To a moderate degree
4 = To a great degree
5 = Completely agree

N/A = Not applicable

- ○ 1 (1)
- ○ 2 (2)
- ○ 3 (3)
- ○ 4 (4)
- ○ 5 (5)
- ○ N/A (7)

Q67 I believe that my current/previous injury has jeopardized my future athletic abilities

1 = Not at all
2 = To a slight degree
3 = To a moderate degree
4 = To a great degree
5 = Completely agree

N/A = Not applicable

- ○ 1 (1)

- 2 (2)
- 3 (3)
- 4 (4)
- 5 (5)
- N/A (7)

Q68 I am not comfortable going back to play until I am 100%

1 = Not at all
2 = To a slight degree
3 = To a moderate degree
4 = To a great degree
5 = Completely agree

N/A = Not applicable

- 1 (1)
- 2 (2)
- 3 (3)
- 4 (4)
- 5 (5)
- N/A (7)

Q69 People don't understand how serious my injury is/was

1 = Not at all
2 = To a slight degree
3 = To a moderate degree
4 = To a great degree
5 = Completely agree

N/A = Not applicable

○ 1 (1)

○ 2 (2)

○ 3 (3)

○ 4 (4)

○ 5 (5)

○ N/A (7)

Q70 I don't know if I am ready to play

1 = Not at all
2 = To a slight degree
3 = To a moderate degree
4 = To a great degree
5 = Completely agree

N/A = Not applicable

- 1 (1)
- 2 (2)
- 3 (3)
- 4 (4)
- 5 (5)
- N/A (7)

Q71 I worry if I go back to play too soon I will make my injury worse

1 = Not at all
2 = To a slight degree
3 = To a moderate degree
4 = To a great degree
5 = Completely agree

N/A = Not applicable

- 1 (1)
- 2 (2)
- 3 (3)
- 4 (4)
- 5 (5)
- N/A (7)

Q72 When my pain is intense, I worry that my injury is a very serious one

1 = Not at all
2 = To a slight degree
3 = To a moderate degree
4 = To a great degree
5 = Completely agree

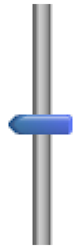
N/A = Not applicable

- ○ 1 (1)
- ○ 2 (2)
- ○ 3 (3)
- ○ 4 (4)
- ○ 5 (5)
- ○ N/A (7)

Q73 Please rate your confidence level to participate in your sport/activity on a scale from 0 to 10 as it relates to the integrity of your hamstring. For this section, we are interested in how confident you are while thinking of performing physical activity in a fatigued state.

0 = No confidence at all
5 = Moderate confidence
10 = Complete confidence

My overall confidence to play is:



0 (0)

1 (1)

2 (2)

3 (3)

4 (4)

5 (5)

6 (6)

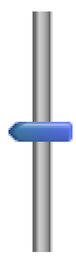
7 (7)

8 (8)

9 (9)

10 (10)

Q74 My confidence to play without pain is:



0 (0)

1 (1)

2 (2)

3 (3)

4 (4)

5 (5)

6 (6)

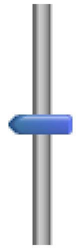
7 (7)

8 (8)

9 (9)

10 (10)

Q75 My confidence to give 100% effort is:



0 (0)

1 (1)

2 (2)

3 (3)

4 (4)

5 (5)

6 (6)

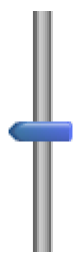
7 (7)

8 (8)

9 (9)

10 (10)

Q76 My confidence to not concentrate on the injury is:



0 (0)

1 (1)

2 (2)

3 (3)

4 (4)

5 (5)

6 (6)

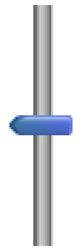
7 (7)

8 (8)

9 (9)

10 (10)

Q77 My confidence in the injured body part to handle demands of the situation is:



0 (0)

1 (1)

2 (2)

3 (3)

4 (4)

5 (5)

6 (6)

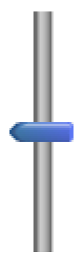
7 (7)

8 (8)

9 (9)

10 (10)

Q78 My confidence in my skill/ability is:



0 (0)

1 (1)

2 (2)

3 (3)

4 (4)

5 (5)

6 (6)

7 (7)

8 (8)

9 (9)

10 (10)

End of Block: Default Question Block

APPENDIX D

IRB APPROVAL DOCUMENT

GEORGIA SOUTHERN UNIVERSITY

RESEARCH INTEGRITY

Institutional Review Board (IRB)
Veazey Hall 3000
PO Box 8005 • STATESBORO, GA 30460
Phone: 912-478-5465
Fax: 912-478-0719
IRB@GeorgiaSouthern.edu

To:	McLain, Savannah Mutchler, Jessica; Wilson, Samuel; Byrd, Megan
From:	Eleanor Haynes, Director, Research Integrity
Approval Date:	December 22, 2020
Subject:	Institutional Review Board Exemption Determination - Limited Review

Your proposed research project numbered **H21185**, and titled **"Long-term perceived disability following a hamstring injury."** involves activities that do not require full approval by the Institutional Review Board (IRB) according to federal guidelines.

According to the Code of Federal Regulations Title 45 Part 46, your research protocol is determined to be exempt from full review under the following exemption category(s):

Exemption 2 Research involving only the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, if: Information obtained is recorded in such a manner that human participants cannot be identified, directly or through identifiers linked to them. Please visit our FAQ's for more information on anonymous survey platforms; Any disclosure of the human participant's responses outside the research could not reasonably place the participant at risk of criminal or civil liability or be damaging to the participant's financial standing, employ-ability or reputation; Survey or interview research does not involve children; The research project does not include any form of intervention.

The IRB has approved your safety plan for in person research for this protocol. You may proceed with the research as described in the above protocol as long as you continue to follow the submitted safety plan and local conditions remain manageable by that plan. Any changes to the protocol and/or safety plan must be approved by the IRB before the changes are initiated. It is the researcher's responsibility to maintain awareness of the current COVID Phase (as defined by the CDC) in the community where the research is taking place and to follow applicable safety precautions for that phase. The research must also remain aware of any changes to the University's COVID policies as it relates to research.

Any alteration in the terms or conditions of your involvement may alter this approval. *Therefore, as authorized in the Federal Policy for the Protection of Human Subjects, I am pleased to notify you that your research, as submitted, is exempt from IRB Review. No further action or IRB oversight is required, as long as the project remains the same. If you alter the project, it is your responsibility to notify the IRB and acquire a new determination of exemption. Because this project was determined to be exempt from further IRB oversight, this project does not require an expiration date.*