Body Mass Index, Flexibility, and Playing Characteristics of Golfers with and without Low Back Pain

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INTRODUCTION: The etiology of low back pain is multifactorial making it difficult to identify a specific cause of pain. In golfers, the lumbar spine is the highest reported site of injury in the body. To investigate characteristics related to the prevalence of low back pain in golfers, the aim of this study was to compare Body Mass Index (BMI), hamstring flexibility, playing frequency, handicap, swing type and subject characteristics in golfers with and without low back pain. **METHODS:** This study utilized a descriptive cross-sectional design. The variables collected included the Oswestry Low Back Disability Index, age, sex, BMI, hamstring flexibility, playing frequency and swing type. Subjects included members of a golf or country club in the North East Region of the United States. Data was collected by means of a survey during a 2-week period. Descriptive statistics were calculated for all variables. Independent sample *t*-test and Fisher's Exact tests were used to compare variables between groups. **RESULTS:** A total of 40 subjects were included in this study (23 male, 17 female, 55.38 ± 12.18 years). Twenty-three subjects reported a prevalence of low back pain. No significance differences were demonstrated in any characteristics between the low back pain group and no low back pain group. **CONCLUSION:** These results, while not significant, suggest that low back pain is a widespread problem in golfers and its cause is multifactorial. This study may inform clinicians and golfers about the potential risk factors for low back pain.

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1.0 Introduction

Golf is a game that dates back to the fifteenth century. Being a game that is inclusive for all ages, genders and athletic abilities, the game is constantly growing in popularity. In 2019, the National Golf Foundation estimated 34.2 million Americans played golf. Of these Americans, 2.5 million were first time golfers.[1] With an increase in the number of Americans playing golf, there has also been an increase in golf courses across the country. In past 20 years, the number of golf coursed increased by 2,300 for an estimate of 16,300 golf courses.[1] This does not include the vast number of golf practice facilities such as simulators or Top Golf® locations.

Many see the golf swing as a simple activity. However, each individual swing is unique making it difficult to perfect. In the past, golfers had a very long, smooth golf swing. The backswing involved the pelvis and thorax rotating through equal ranges of motion (ROM). Traditionally, a golfer would lift the heel of their lead foot to create a greater rotation. After contact, the pelvis and thorax finished together in a relaxed, upright position.[2] The finished swing is characterized by an erect "I" finish.[3] As a result of research examining biomechanics of the golf swing, technology and equipment were enhanced to provide further performance benefits to the golfer.[2,4] These enhancements resulted in modern day golfers to evolve the long, classic golf swing to a quicker, more powerful swing, maximize the benefits of these improvements. While all stages of the swing have evolved, the backswing and downswing in particular have changed the most.

Understanding the components of the golf swing are important when considering risk factors associated with low back pain in golfers. Along with knowledge of the golf swing, understanding the potential effects of body composition, flexibility, and strength is also important.

If a relationship exists between the potential modifiable risk factors discussed below, golfers may see a need for change in their golf habits and lifestyle.

1.1 Low Back Pain Defined

Low back pain is an increasingly common condition worldwide. The prevalence of low back pain is higher in the middle- and lower-income countries.[5] This has shown to have a significant negative impact on the quality of life of those with low back pain. The reported lifetime prevalence of low back pain is as high as 84% with 23% of those suffering from chronic pain.[5] The etiology of low back pain is multifactorial. Frequent bending, torso twisting, prolonged static posture, somatization, and mental health such as anxiety and depression have all been linked to the development of pain.[6] In addition, many musculoskeletal risk factors have been noted as implication for low back pain. Proper identification of risk factors may offer a preventative strategy or treatment plan.

1.1.1 Epidemiology of Low Back Pain

Epidemiology can be defined as the study of the distribution of disease in the population and the application of this study to control health problems.[7] Specific to golf, epidemiology helps provide an understanding of the natural history of low back pain and the frequency of occurrence. It also helps provide a link between pain and factors associated. There are two concepts of epidemiology: incidence and prevalence. Incidence is often difficult to measure when discussing low back pain because individuals often cannot remember their first ever episode of pain.

Prevalence is a measure of the number of person in a specific population who have a disease or symptoms at a particular point in time.[7] Research shows a rising prevalence of low back pain, specifically chronic low back pain.[8] Those who seek medical care increases year to year. The increased prevalence may be due to the increased awareness of symptoms. An increase in knowledge from the media, medicalization, and the internet likely made back pain a more recognizable medical condition.[8] It is important to note that prevalence is not a measure of risk but rather a quantification of the burden a disease has in a population.

The epidemiology of low back pain, particularly prevalence, has been studied in great detail and identified as multifactorial. Physical, psychological, environmental, occupational and demographic factors are all identified potential factors that contribute to the development low back pain.[5,7,8] Low back pain continually shows to be a major problem throughout the world. The highest prevalence is among women and those aged 40-80.[8] Pain often peaks in the sixth decade or in the 50's age group. Eighty percent to ninety percent of reported attacks are short lived and resolved in six or less weeks.[7] Although it is not uncommon to experience low back pain at some point in a life time, only about 5%-10% of individuals develop persistent episodes and 15%-27% develop chronic low back pain.[7,8]

Clinicians often utilize disability indices and/or grading scales to assess the level of disability caused by low back pain. A common grading scale is one to four: Grade I quantifies low intensity – low disability low back pain, Grade II describes high intensity – low disability, Grade III and Grade IV describe high intensity – high disability. Based on this pain scale, almost 50% of those suffering low back pain experience Grade I disability, about 12% experience Grade II, and 11 % experience Grade III or IV.[8]

Low back pain in children and adolescents is far more common condition. Jones and Macfarlane conducted a review of the epidemiology of low back pain in population of children and adolescents. In their review, they found a one month prevalence of low back pain of 24%-26% in school children aged 11-14.[9] Although commonly reported, low back pain rarely prevents children from attending school or playing sports. Turner et al. reported a spondylolysis diagnosis in 13% of children complaining of low back pain.[9,10] When a child does not have a cause of pain, infection, tumors, and disc prolapse are often a concern. Turner et al. also found that 8%, 6% and 6% of reported youth back pain was due to infection, a tumor, or disc prolapse respectively.[10] Often low back pain in growing children and adolescents is associated with height or growth. There is however little evidence that supports a positive association.[9] Parents should be aware of a number of risk factors to low back pain in their children. Frequency of activity, particularly in sports such as weightlifting, gymnastics, rowing, golf and racquet sports, is often associated with high prevalence of low back pain.[9] Poor trunk muscle strength and decreased endurance is also a reported rick factor. On the contrary, sedentary activities like playing video games for more than two hours is also a risk factor of low back pain in this population. Early occurrence of low back pain is not directly associated with the development of pain later in life; however the reoccurrence rate of low back pain is high and likely to occur if youth have experienced a problem.

Identifying risk factors and the cause of low back pain in adults is laborious. Risk factors are variables correlated with an increased risk of disease development.[11] Epidemiologists studying low back pain attempt to analyze a number of factors. A multitude of occupational determinants such as heavy physical strain, frequent lifting, postural stress and vibration tend to be studied along with social demographic characteristics such as sex, age, race, height and weight.[7,8] There are a number of psychosocial factors associated as well. This includes stress, anxiety, depression, and pain behaviors.[8,11] Psychosocial work place factors have also shown a correlation with low back pain. Job dissatisfaction, monotonous tasks, a lack of social support and high demands are all psychosocial work place risk factors.[11] In addition to all these risks, comorbid factor such as diabetes and rheumatoid arthritis have also been found to be associated with low back pain.[8] Occupational, psychosocial, and comorbid are not the only risk factors. A vast number of musculoskeletal and sport related factors are associated, as well, and the developmental cause is multifactorial.

1.1.2 Prevalence of Low Back Pain in Golfers

One of the most commonly affected area of injury in elite athletes and the active population is the lower back.[12] For this reason, the prevalence of low back pain in the athletic population has been investigated in a number of studies. Trompeter et al. reported in a systematic review that the prevalence of low back pain varies widely depending on the sport.[13] A few examples of this can be found in the studies conducted by Lively et al.[14,15] Lively's study found that only 1% of soccer players have a lifetime prevalence of low back pain.[12,14] Ng et al. reported a 98% life time prevalence of low back pain in male rowers.[12,15] Sixty-five percent of male rowers reported point prevalence at the time of the study.[12,15]

Low back injuries are the most common musculoskeletal injury reported by recreational and professional golfers. The prevalence of pain is estimated to be between 15% and 35% in amateurs and as much as 55% in professional players.[2,16-19] Injury to the lumbar spine is often associated with a significant amount of time lost from play and practice. The magnitude of the prevalence of low back pain is often attributed to the mechanical demands of the game. The golf swing is a repetitive and asymmetrical motion.[19] Swinging a golf club is associated with high segmental angular velocities along with several loads applied to the spine. A combination of large magnitude spinal forces and high frequency swing repetitions can likely result in lower back injuries.[17] Although low back pain is not always persistent with many individuals, it can progress and lead to permanent disability.

1.2 Risk Factors for Low Back Pain

Due to the multifactorial cause of low back pain, predicting and identifying risk factors can often be challenging. Although research is difficult, it is clear there are a number of environmental and personal factors that influence the development of pain. The potential risks associated with low back pain includes non-modifiable and modifiable factors. Although there are countless risk factors for low back pain in all athletes, body composition, flexibility and playing variables lack a sufficient amount of research in the golfing population.

1.2.1 Non-Modifiable Risk Factors

A non-modifiable risk factor can be defined as an element that cannot be altered. A few examples include age, sex, family history, and race. For the purpose of this study, age and sex will be elaborated on as being non-modifiable risk factors for low back pain. In the United States, one third of the golfing population is age 50 or above.[3] With age comes degenerative changes to the body, especially the spine. Forces generated by the golf swing can predispose all golfers to injury. Biological changes to the body with age only increase a golfer's risk of injury.

Age is significantly associated with the prevalence of low back pain.[8,11,19] In a cross-sectional study conducted by Fett et al., there was a correlation found between an elite athlete's age and the prevalence of back pain in their lifetime. Between the ages of 13-18 years, the prevalence was 86%; ages 19-24 years, the prevalence was 87%; and from ages 25-30 years, the prevalence was 89%. The frequency of the prevalence of low back pain continues to increase to 98% in those older than 30 years and peaks between the ages of 55 and 64 years old.[12,20,21] Age, as a risk factor of low back pain, is likely because of many degrative conditions. Degenerative disc disease, degenerative facet disease, sacroiliac joint degeneration, and other pathologies are thought to be a result of 'wear and tear' from mechanical trauma and injuries throughout aging.[8]

Sex differences in the prevalence of low back pain may be influenced by a number of factors. Some studies report a significantly higher prevalence of low back pain in female athletes than males and they are more likely to develop chronic low back pain.[11,12] Through the years, this phenomenon has been frequently discussed. Women tend to mature earlier than males and they endure more hormonal changes during puberty.[20] On average, the bone density and muscle mass of women is lower than a men. This may result in degeneration of ligaments, bones or muscles of the body and therefore resulting in insufficient absorption of high loads.[12] The anatomical characteristics of a woman's body, such as the shape of the pelvis, Q angle of the femur and the lordotic curve of the lumbar spine, can also be noted as an contribution of low back pain. Other contributors to low back pain in women, unrelated to participation in athletics, includes menstrual related low back pain and pregnancy related back pain.[12]

1.2.2 Modifiable Risk Factors

Modifiable risk factors are habits or behaviors that can increase or decrease an individual's risk of cancer, heart disease, hypertension, and other morbidities. Low back pain has countless modifiable risk factors that if altered, can potentially reduce day to day pain and injury rate. The prevalence of low back pain is the highest injury occurrence in golfers due to the nature of the swing. As mentioned above, identifying risk factors in this population can aid in prevention and treatment for golfer suffering.

1.2.2.1 Rotation and X-Factor

Axial twisting of any kind has been identified as a risk factor for low back pain.[3,22,23] The difference in axial rotation between the torso and pelvis in the golf swing is known as the X-factor due to the "X" made along the axis of the shoulders and hips.[2,3,24,25] The yellow 'X' shown in *Figure 1* displays the X created from the line of the shoulders and the line of the hips. Increasing X-factor allows for a greater amount of torque and energy generated from the spine. The benefits include increased club head speed and increased driving distance of the ball. Axial rotation is limited by the annulus fibrosus anteriorly and the facet joints posteriorly in the lumbar spine.[26] Although it allows significant range of motion in the sagittal plane, the sagittal orientation of the facet joints limits axial rotation leaving it susceptible to rotational injury.[27]

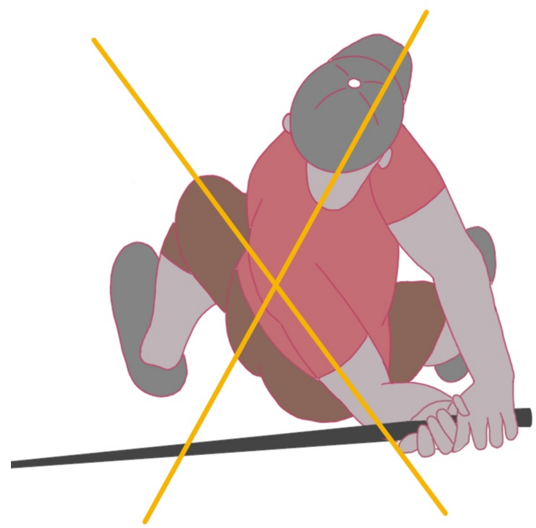

Figure 1. X-factor

Lindsay and Horton conducted a study of swing analysis' between golfers with and without low back pain. Their primary focus was to look for an association between X-factor and low back pain. The study found that golfers with low back pain exceeded trunk rotation beyond their physiologic range of flexibility.[28] Exceeding trunk rotation could elicit excessive strain on viscoelastic structures in the spine.[3]

In addition to axial rotation, the lumbar spine also endures compression, anterior-posterior shearing, torsion, and lateral bending forces during the golf swing. The consequence of maximizing X-factor and the other forces is an increased torsional stress on the spine. This is important to note when practicing and playing the game of golf. Often instructors emphasize loading the lumbar spine and torso which increases torque. Torqueing the torso is a result of a restriction of pelvic rotation relative to torso rotation.[2] Repetitive torqueing may lead to a decrease in the strength and integrity of stabilizing structures, such as the ligamentum flavum, anterior longitudinal ligament, and the posterior longitudinal ligament in the spine. These forces as mentioned above are all important components of the modern golf swing. One of the most common causes of disc herniation is lateral bending, compression, and torsion.[29] Increased repetition of these combined forces may predispose golfers to a number of low back injuries: muscle strains, herniated discs, stress fractures, spondylolisthesis, and facet arthropathy.[3,30]

Musculoskeletal dysfunction is a key factor to this risk factor of excessive spinal loading and decreased stability. Dysfunction of the lumbopelvic-hip complex specifically has demonstrated an increase in spinal loading and stability.[5] Altered core muscle recruitment patterns is a characteristic for low back pain, more specifically chronic low back pain.

1.2.2.2 The Golf Swing

Contrary to the original, smooth golf swing, the modern golf swing emphasizes a large shoulder turn with restrictive pelvic rotation during the backswing.[2,3,19,31] The swing begins with a slow axial rotation of the trunk away from address. Unlike the classic golf swing, modern day golfers accomplish the restricted backswing by keeping their lead foot planted on the ground. This "quiets" the lower body, increases X-factor, and makes for a more controlled swing and consistent ball striking.[3] Once at the top of the backswing, the swing takes a quick burst downward where the club then makes contact with the ball and then finishes in an upright, hyperextended position.

A modern golf swing can be problematic due to the increased X-factor, increased lateral bending, and hyperextended follow-through. Lateral bending occurs alongside x-factor during the backswing. It can be measure through the "crunch factor". Morgan et al. developed this method to measure dynamic lateral bending during a swing.[32] Crunch factor can be defined as the product of the lumber lateral bending angle and axial rotation velocity.[3,19] Although it is important in the golf swing, golfers with increased lateral bending tend to exhibit low back pain.[3] The follow-through and end position of the modern golf swing is often referred to as a reverse C position. *Figure 2* displays the 'C' created by the spine and is shown with a yellow line. Its name comes from the shape of the spine after the follow through. The spine is in a hyperextended position resulting in maximal extensor muscle contractions. An excessive muscle contraction increases compressive and shearing forces on the spine. Repetitive hyperextension in addition to microtrauma has been shown in the etiology of spondylolysis.[3]

Figure 2. Reverse 'C' Position

Opposite of the modern golf swing, the classic golf swing highlights a reduced X-factor. By increasing hip turn and shortening the back swing, the magnitude of the hip-shoulder separation angle is reduced.[3] In addition to a reduced X-factor, the torque on the lumbar spine is less. A classic swing also accentuates a balanced upright follow-through and finish, almost completely eliminating the crunch factor.[30] Golfers with low back pain should consider altering their swing to fit a classic swing. By doing so, the anterior-posterior shearing force on the spine will be decreased.

1.2.2.3 Hamstring Flexibility

Similar to the dysfunction of muscles of the lumbopelvic-hip complex, abnormal lower limb function is a contributing factor to low back pain.[5] Abnormal muscle recruitment has an effect on spinal loading because the distal and proximal lower limb muscles are no longer properly absorbing the impact force. An example of proximal leg muscle dysfunction is tight hamstrings.[33,34] Tight hamstrings can result in a posteriorly rotated pelvis. Altered pelvis position increases the strain on pelvic muscles, such as the piriformis, which may cause compression of the sciatic nerve.[5] In addition, a posterior pelvic rotation increases stress on the intervertebral discs.[35,36] Tight hamstrings and a posterior pelvic rotation has also shown to reduce the lumbar lordosis of the spine.[37] Sacral slope and pelvic incidence are additional sagittal plane parameters that can influence the degree of lordosis.[5] The normal lordotic curve is imperative to weight bearing activities and load distribution. Prevalence of a decreased lumbar lordosis will alter the distribution of forces away from the hamstrings and towards the lumbar spine, thus increasing risk of developing low back pain.[5,37] Decreased lateral trunk flexion in the sagittal plane has also been noted as a risk factor for developing low back pain.

When assessing hamstring flexibility, an objective, numerical measurement is best. A tool such as a sit-and-reach box or a goniometer, are easy ways to estimate the flexibility of a subject.[38] The sit-and-reach tests measures hip flexion. Subject's flexibility is obtained by how far their fingertips reach towards their toes and is measured in centimeters. An unhealthy lumbar spine could alter the results of a true hamstring range of motion measurement. A sit-and-reach measurement should be obtained in healthy subjects to avoid skewed data. Goniometric measurements of hip flexion with the subject in a supine position is an additional assessment of hamstring mobility.

1.2.2.4 Body Mass Index

Increased body mass is often significantly associated with a number of short-term and long-term health conditions. This includes, but is not limited to, diabetes, heart disease, high blood pressure, gallstones and certain cancers. The assessment of body composition provides clinicians with both nutritional status and functional capacity of the human body.[39] Body mass can be assessed in a number of ways. The various methods are based on several different methods; compartment models and field methods are among the most common. The simplest of the compartment models if the two-compartment model. A few commonly used two-compartment models are hydro-densitometry, air displacement plethysmography, and hydrometry. All three are reliable methods of determining fat mass and fat-free mass.[39] Field methods include anthropometry, waist circumference, waist-hip ratio, skinfold measurements, bioelectrical impedance analysis.[39]

Body mass index (BMI) is an anthropometric measurement. Simple and inexpensive, BMI is widely used. Although BMI can be used to assess most men and women in the general population, it does have a few limitations. BMI may overestimate body fat in athletes and those who have increased lean muscles and underestimate body fat in the geriatric population and those who have lost muscle. It also cannot accurately differentiate between fat and lean mass.[39] Table 1, shown below, is an example of a chart used to correlate BMI to a category of body composition. To calculate BMI, the weight of an individual is divided by their height squared; BMI=kg/m^2.

Table 1. Body Mass Index[40]

Body Composition	**BMI**
Underweight	≥ 18.5
Normal	18.5 - 24.9
Overweight	25.0 - 29.9
Obese	30.0 ≤

Body mass index has been linked to low back pain particularly in the overweight and obese category.[8] Several studies have been linked to low back pain and people with a BMI categorized as overweight and obese.[8] Leboeuf-Yde reported in a systematic review, a weak, but significantly positive association between body weight and low back pain.[41] Another study showed a link between high body mass index and low back pain.[42] Although there is refuting evidence, large population-based studies indicate obesity with a high prevalence of low back pain.[8,43]

1.2.2.5 Playing Ability and Frequency of Play

Eighty-two point six percent of low back pain reported from golfers are a result of overuse injuries.[16] The frequency and duration of playing and practice is likely why low handicap players, or golfers with a handicap index below six, experience more pain. Although previous studies displayed no relationship between handicap and low back pain, there is conflicting findings regarding the relationship between frequency of play and the prevalence of low back pain.[19]

The number of rounds a golfer plays a week has a significant impact of the prevalence of low back pain. In a small study conducted by Gosherger et al., those who played four or more rounds a week had a higher prevalence of injury.[16] In addition, those who hit more than 200 golf balls on the practice range had a higher prevalence. As expected, professional and low handicap golfers spend more time on the golf course and driving range. Amateurs, or higher handicap players with a handicap index greater than ten, tend to play and practice less. Gosheger et al. also reported a significant relationship between a golfer regularly carrying their golf bag and experiencing low back pain.[16,19] This is especially true in professionals and/or lower handicap players compared to amateurs and higher handicap players. Although higher handicap players take less strokes in a single round of 18 holes of golf, they spend much more time practicing and tend to play golf more often, thus increasing the repetitions of their swing.

1.3 Definition of the Problem

Golf is a game that can be played throughout the lifetime. Low back pain has been a major health issue costing the United States over $50 billion each year.[3] To date, there have been many studies done on low back pain in all populations. There is, however, little research concerning body mass index, performance, hamstring flexibility, and subject characteristic that can relate to the prevalence of low back pain in golfers. Research is needed to identify correlations of low back pain in golfers.

1.4 Purpose of this Study

The purpose of this thesis was to investigate the body mass index, performance, estimated hamstring flexibility and subject characteristics of golfers who belong to a golf or country club with and without back pain then compare to these factors to identify correlates of low back pain. These factors were gathered with an anonymous survey.

1.5 Specific Aims

Specific Aim 1: By way of survey, investigate and compare body mass index, estimated hamstring flexibility, skill level and subject playing characteristics, in addition to demographics, in golfers with and without low back pain.

Specific Aim 2: Explore a potential relationship between golfers swing characteristics and low back pain by comparing the proportion of golfers with classic swings and modern swings in golfers with and without low back pain.

1.6 Study Significance

This study will contribute to golfers' existing knowledge of the golf swing and low back pain, and more specifically, which characteristics can contribute to pain. Additionally, this study will add to the body of knowledge for clinicians as well. Current literature has already identified a few risk factors that contribute to low back pain in golfers including subject characteristics and flexibility. However, there is a need for further research in these risk factors as well as body mass index and playing characteristics. The outcome of this study will be important for the design of future research studies that will contribute to a more comprehensive understanding of the risk factors for low back pain in golfers.

2.0 Methods

2.1 Experimental Design

This study utilized a descriptive cross-sectional survey design. The purpose of this study was to explore the relationship between each exploratory specific aim with the prevalence of low back pain in golfers. An online survey was sent to golfers belonging to a golf or country club across the North East region of the United States of America to address these specific aims.

2.1.1 Variables

The variable for this study that determined the subject classification was the score of the Oswestry Low Back Pain[44] questionnaire; the final ten questions of the Qualtics survey. This score was utilized to measure the level of back pain experienced and place subjects into categories: minimal disability, moderate disability, or severe disability.

2.1.2 Covariables

The covariables for this study included, age, sex, body mass index (BMI), handicap index (low handicap, mid handicap, high handicap), type of golf swing and estimated hamstring flexibility. These variables were assessed in a survey.

2.2 Subject Recruitment

Subjects were acquired from several golf and country clubs around the North East region of the United States. This region included the states of Pennsylvania, Maryland, Delaware, New Jersey, New York, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire and Maine. Each club golf professional was contacted directly through a phone call with information regarding the study. Those willing to assist in recruitment were asked to forward an email with information regarding this research and a hyperlink web address of the survey, to the golfing members of the club. Recruited subjects included avid golfers who play at least one 18-hole round of golf a week and the golf professionals at the club. Participation in the survey was completely voluntary and all subjects were free to withdraw from the study at any time. Approval was obtained from the Institutional Review Board (IRB) at the University of Pittsburgh.

2.3 Subject Characteristics

2.3.1 Inclusion Criteria

Subjects were included in the study if they were at least 18 years of age. All subjects must also play at least one 18-hole round of golf a week during the months of May through August and have a Golf Handicap and Information Network (GHIN) or United States Golf Association (USGA) handicap index. The significance of a handicap index is to ensure the player is an avid and committed player. Those who update their handicap likely play often rather than a few times a year.

2.3.2 Exclusion Criteria

Subjects were excluded from the study if they underwent a previous surgery to the spine and/or had a musculoskeletal injury to the upper or lower extremity with in the last six months that limited their golfing ability for greater than one week. If a survey question was incomplete, data was excluded. Subjects who score above a 30% in the low back pain disability section of the survey were also excluded as these subject's pain falls into the severe disability category and likely affects their daily living.

2.3.3 Power Analysis

To date, there have been no studies that utilize a survey to gather variables recorded in this study. The goal sample size for this study was 128 subjects to achieve an actual power of 80.1% power to detect an intraclass correlation of 0.8. To determine sample size, an *F* test ANOVA fixed effects omnibus was conducted with a significance level of 0.05.

2.4 Instrumentation

2.4.1 Qualtrics Online Survey System

Qualtrics Online Survey System is a survey platform utilized by the University of Pittsburgh to create and disperse survey questions. In this study, golfers were asked to answer 24 questions pertaining to their demographics, body composition, golfing ability, flexibility and prevalence of low back pain. The first set of questions regarded the subject's demographics. Two questions concerned the subject's body composition. Next, subjects were asked to answer five questions pertaining to golf followed by two questions about their fitness and flexibility. The last 13 questions evaluated the prevalence of low back pain by utilizing the Oswestry Disability Index Questionaire.[44] Anonymity of golfers and their responses was maintained through the use of Qualtrics Software. Survey data was collected during a two-week period of the month of February 2021.

2.4.2 Hamstring Flexibility Grading Scale

The hamstring grading scale was created by the investigator's knowledge of hamstring flexibility and previous research regarding the modified sit-and-reach test and fingertips to floor test.[38,45] The investigator graded subjects based on their response to which statement regarding hamstring flexibility was selected in their survey. Subjects with great flexibility could stand up straight, bend at their waist with knees straight and place their hands flat on the floor. Subjects with good flexibility could stand up straight, bend at their waist with knees straight and touch the floor with their fingertips. Subjects with fair flexibility could stand up straight, bend at their waist with knees straight and reach their ankles with their fingertips but not the floor. Lastly, subjects with poor flexibility could stand up straight, bend at their waist with knees straight and could not reach their ankles with their fingertips. This grading was created because of the need to collect data via an online survey. The ideal way to measure flexibility is with an objective measurement such as a sit-and-reach box or goniometric measurements.

Extensive research has been conducted on the procedures, validity and normality of the sit-and-reach test.[38,45-47] Due to the anatomical placement of the posterior trunk muscles and the hamstrings, the integrity of the lower back could play a role in the sit-and-reach measurement. However, the sit-and-reach test has been shown to successfully measure hamstring flexibility in healthy subjects.[45] When measuring hamstring flexibility with a modified sit-and-reach, the zero mark is adjusted to each subject and placed at their toes. A negative measurement is recorded when the subject sit, with their knees straight, and cannot reach their fingertips past the zero mark.[48] Negative results have been categorized as fair and poor.

2.4.3 Oswestry Disability Index

Figure 3 bellow is an example of a pain scale from the Oswestry Disability Index.[44,49] The questions and answers for the final 10 questions of the survey were derived from this reference and formatted in Qualtrics so that the primary investigator could calculate each subject's low back pain disability and place into the appropriate low back pain group of this study. Each question was answered with a scale of 0-5, with zero being no pain or disability and five being severe pain or disability. All subjects were asked to complete this section of the survey with their current scale of pain or disability. Subjects were classified as having or not having low back pain based on the total score was calculated as follows: [x(total score)/50(total possible score)]*100 = % of low back pain disability. The category of subjects without low back pain were subjects with a 0%-9% score and had minimal disability. The category of subjects with low back pain were subjects with a 10%-30% score and had moderate disability. Any subject with a score of 31%+ was excluded from the study as their level of disability was severe. This grading scale was modified from five to three categories of the Oswestry Disability Index.

Instructions: Please circle the **ONE NUMBER** in each section which most closely describes your problem.

Section 1 – Pain Intensity
0. The pain comes and goes and is very mild.
1. The pain is mild and does not vary much.
2. The pain comes and goes and is moderate.
3. The pain is moderate and does not vary much.
4. The pain comes and goes and is severe.
5. The pain is severe and does not vary much.

Section 2 – Personal Care (Washing, Dressing, etc.)
0. I would not have to change my way of washing or dressing in order to avoid pain.
1. I do not normally change my way of washing or dressing even though it causes some pain.
2. Washing and dressing increase the pain but I manage not to change my way of doing it.
3. Washing and dressing increase the pain and I find it necessary to change my way of doing it.
4. Because of the pain I am unable to do some washing and dressing without help.
5. Because of the pain I am unable to do any washing and dressing without help.

Section 3 – Lifting
0. I can lift heavy weights without extra pain.
1. I can lift heavy weights but it gives extra pain.
2. Pain prevents me lifting heavy weights off the floor.
3. Pain prevents me lifting heavy weights off the floor, but I can manage if they are conveniently positioned, e.g., on a table.
4. Pain prevents me lifting heavy weights but I can manage light to medium weights if they are conveniently positioned.
5. I can only lift very light weights at most.

Section 4 – Walking
0. I have no pain on walking.
1. I have some pain on walking but it does not increase with distance.
2. I cannot walk more than 1 mile without increasing pain.
3. I cannot walk more than ½ mile without increasing pain.
4. I cannot walk more than ¼ mile without increasing pain.
5. I cannot walk at all without increasing pain.

Section 5 – Sitting
0. I can sit in any chair as long as I like.
1. I can sit only in my favorite chair as long as I like.
2. Pain prevents me from sitting more than 1 hour.
3. Pain prevents me from sitting more than ½ hour.
4. Pain prevents me from sitting more than 10 minutes.
5. I avoid sitting because it increases pain immediately.

Section 6 – Standing
0. I can stand as long as I want without pain.
1. I have some pain on standing but it does not increase with time.
2. I cannot stand for longer than 1 hour without increasing pain.
3. I cannot stand for longer than ½ hour without increasing pain.
4. I cannot stand for longer than 10 minutes without increasing pain.
5. I avoid standing because it increases the pain immediately.

Section 7 – Sleeping
0. I get no pain in bed.
1. I get pain in bed but it does not prevent me from sleeping well.
2. Because of pain my normal nights sleep is reduced by less than one-quarter.
3. Because of pain my normal nights sleep is reduced by less than one-half.
4. Because of pain my normal nights sleep is reduced by less than three-quarters.
5. Pain prevents me from sleeping at all.

Section 8 – Social Life
0. My social life is normal and gives me no pain.
1. My social life is normal but it increases the degree of pain.
2. Pain has no significant effect on my social life apart from limiting my more energetic interests, e.g., dancing, etc.
3. Pain has restricted my social life and I do not go out very often.
4. Pain has restricted my social life to my home.
5. I have hardly any social life because of the pain.

Section 9 – Traveling
0. I get no pain when traveling.
1. I get some pain when traveling but none of my usual forms of travel make it any worse.
2. I get extra pain while traveling but it does not compel me to seek alternate forms of travel.
3. I get extra pain while traveling which compels to seek alternative forms of travel.
4. Pain restricts me to short necessary journeys under ½ hour.
5. Pain restricts all forms of travel.

Section 10 – Changing Degree of Pain
0. My pain is rapidly getting better.
1. My pain fluctuates but is definitely getting better.
2. My pain seems to be getting better but improvement is slow.
3. My pain is neither getting better or worse.
4. My pain is gradually worsening.
5. My pain is rapidly worsening.

Figure 3. Oswestry Low Back Pain Scale Questions

2.4.4 Methodological Considerations

The choice of a survey designed study was based on the COVID-19 pandemic restrictions in place by the University of Pittsburgh and to ensure the safety of researchers and subjects. All questions asked in the survey reflect the objectives and specific aims of this study. The primary aim of this survey was to answer research questions in the study's target population. All questions were developed to focus on ‘need to know’ information and carefully written to be clearly stated.[50] To enhance response rate, the survey was constructed to be short, relevant and easy to complete. The literature in a good survey is constructed at a reading level of eight grade.[50] Close-ended questions have been shown to be optimal for online surveys due to the provided standardized responses and take less time to complete, therefore the questions are thought out to reflect this standard when appropriate. Pilot testing will be utilized to provide a sense of survey flow and to ensure the survey is ready to launch to subjects.

2.5 Testing Procedures

2.5.1 Data Collection

Study participants were sent an email invitation with a brief description of the research study purpose and a link to the online survey. The data collection period was two weeks. Subject participation was voluntary, individuals could withdraw at any timepoint. Survey responses remained anonymous. Any information that may have revealed the identity of a subject were filtered and omitted from the overall results. The survey consisted of 24 questions and took approximately five to ten minutes to complete. Data was collected and recorded in Qualtrics. Following the collection period, the primary investigator reviewed the data.

2.6 Data Reduction

Responses to the survey were reviewed in Qualtrics. Incomplete survey responses were excluded from the study. Information contained in a response that may have revealed the identity of a subject were omitted prior to analysis. Subjects' degree of low back pain disability was interpreted based off the Oswestry Disability Index.[44,51] For each section of low back pain portion of the survey the total possible score was 5. If the first statement was marked, the section score is zero. If the last statemen was marked, the score is five. As long as all ten sections of the end of the survey was completed the score was calculated as follows: [x(total score)/50(total possible score)]*100 = % of low back pain disability. Body mass index was calculated using the formula $BMI=m/h^2$: m=mass in kilograms and h=height in meters.

2.7 Data Analysis

Survey data was obtained using Qualtrics Core XM Online Survey System (Qualtrics XM, Provo UT, USA). Descriptive statistics were calculated for all variables (mean, standard deviation, median, interquartile range, proportion/percent). Normality was assessed using Shapiro-Wilk test. Continuous covariables variables were compared between golfers with and without low back pain using independent sample T-test or Mann-Whitney U-test, as appropriate. Categorial covariables variables were compared between the two groups using Fisher's Exact Tests.

Statistical analysis was conducted using SPSS Statistics Version 26 (IBM Corporation, Armonk NY, USA). Statistical significance was decided *a priori* at alpha=0.05, two-sided.

3.0 Results

3.1 Subject Characteristics

The survey for this study was published and emailed to potential participants on February 4th, 2021. The survey was open for two weeks and closed on February 18th, 2021 at midnight eastern time. A total of seventy-four (74) subjects from the North Eastern Region of the United States of America enrolled in this study by working through the survey. Forty (40) subjects' surveys were completed to their entirety and corresponding data was included in the study. Thirty-four (34) subjects answered a survey question that excluded them from the study. Of the 40 included subjects, twenty-three (23) were male and seventeen (17) were female. Age of included subjects ranged from 18-73. Subject characteristics data for golfer with and without low back pain are shown in *Table 2* below. Characteristics of subjects without low back pain and characteristics of subjects with low back pain are displayed in *Table 3*.

Table 2. Subject Demographics and BMI

	N	Mean ± Standard Deviation	Minimum	Maximum
Age (yrs.)	40	55.38 ± 12.18	18.00	73.00
Height (m)	40	1.74 ± 0.50	1.55	1.98
Weight (kg)	40	79.19 ± 15.81	48.53	113.40
BMI (kg/m^2)	40	26.00 ± 3.90	19.56	34.36

3.2 Age, Height, Weight and BMI

In order to determine whether or not subjects with and without low back pain can be analyzed as one group, independent samples *t*-tests or Mann Whitney U tests were performed to compare age, height, weight and BMI between subjects with and without low back pain.

For all four continuous variables, age, height, weight, and BMI, we failed to reject the null hypothesis for the Levene's Test for Equality of Variances. Independent samples *t*-tests were performed to compare the means of the two groups: subjects with low back pain and subjects without low back pain, in order to determine if there is statistical evidence that their means are significantly different.

Table 3. Demographics and BMI among Golfers with and with Low Back Pain

	Subjects with Low Back Pain			Subjects without Low Back Pain			
	N	**Mean ± SD**	**Median**	**N**	**Mean ± SD**	**Median**	***p* -value**
Age (yrs.)	17	53.9 ± 11.9	5.1	23	56.4 ± 12.6	57.0	0.529
Height (m)	17	1.7 ± 0.1	1.8	23	1.7 ± 0.1	1.7	0.779
Weight (kg)	17	79.2 ± 15.2	81.6	23	79.2 ± 16.6	77.1	0.998
BMI (kg/m^2)	17	25.9 ± 3.8	25.1	23	26.1 ± 4.1	25.7	0.915

Table 4. Height and Weight by Sex and Low Back Pain Status

	Men without Low Back Pain			Men with Low Back Pain			
	N	**Mean ± SD**	**Median**	**N**	**Mean ± SD**	**Median**	***p*-value**
Height (m)	14	1.7 ± 0.1	1.8	9	1.8 ± 0.1	1.8	0.101
Weight (kg)	14	87.5 ± 12.9	87.1	9	87.7 ± 13.56	86.2	0.159
	Women without Low Back Pain			**Women with Low Back Pain**			
	N	**Mean ± SD**	**Median**	**N**	**Mean ± SD**	**Median**	***p*-value**
Height (m)	9	1.7 ± 0.1	1.7	8	1.6 ± 0.1	1.6	0.772
Weight (kg)	9	66.2 ± 13.3	61.2	8	69.6 ± 10.7	68.0	0.574

An independent samples *t*-test was calculated comparing the mean score of subjects who identified as not experiencing low back pain to the mean score of those subjects who identified as experiencing low back pain. No significant difference for age, height, weight and BMI was found as displayed in *Table 3*. The means of subjects without low back pain were not significantly different from the means of subject with low back pain.

An independent samples *t*-test was calculated comparing the mean score of male subjects who identified as not experiencing low back pain to the mean score of those male subjects who identified as experiencing low back pain. No significant difference for height and weight was found. Additionally, an independent samples *t*-test was calculated comparing the mean score of female subjects who identified as not experiencing low back pain to the mean score of those female subjects who identified as experiencing low back pain. No significant difference for height and weight was found. These results are all displayed in *Table 4*.

3.3 Categorical Variables

For the categorical data collected in this study, a Fisher's exact test, from the chi-square test of independence, was used due to the small sample size. The Fisher's exact test was utilized to determine if there was an association between prevalence of low back pain, and age, sex, BMI, playing ability and golf swing type.

Table 5. Proportions of Subjects with and without Low Back Pain by Sex, BMI and Estimated Hamstring Flexibility Category

		Subjects with Low Back Pain	Subjects without Low Back Pain	*p*-value
Sex	**Male**	9/17=52.9%	14/23=60.9%	0.749
	Female	8/17=47.1%	9/23=39.1%	
BMI	**Normal**	8/17=47.1%	10/23=43.5%	0.842
	Overweight	5/17=29.4%	9/23=39.1%	
	Obese	4/17=23.5%	4/23=17.4%	
Hamstring Flexibility	**Great Flexibility**	4/17=23.5%	5/23=21.7%	0.967
	Good Flexibility	6/17=35.3%	8/23=34.8%	
	Fair Flexibility	6/17=35.3%	7/23=30.4%	
	Poor Flexibility	1/17=5.9%	3/23=13.0%	

A Fisher's exact test of independence was calculated comparing the results of the prevalence of low back pain in male and female subjects (sex), normal, overweight, and obese subjects (BMI) and subjects with great, good, fair and poor flexibility (hamstring flexibility). No significant relationship was found. Sex, BMI and hamstring flexibility appear to be independent. These results are displayed in *Table 5*.

Table 6. Proportion of Subjects with and without Low Back Pain by Golf Skill Characteristics Category

		Subjects with Low Back Pain	Subjects without Low Back Pain	*p*-value
Skill Level	**Low Handicap**	6/17=35.3%	4/23=17.4%	0.184
	Mid Handicap	4/17=23.5%	12/23=52.2%	
	High Handicap	7/17=41%	7/23=30.4%	
Swing Type	**Classic**	15/17=88.2%	14/23=60.9%	0.079
	Modern	2/17=11.8%	9/23=39.1%	

A Fisher's exact test of independence was calculated comparing the results of the prevalence of low back pain in low, mid and high handicap subjects (skill level) and subjects who display a classic and modern swing (swing type). No significant relationship was found, and results can be seen in *Table 6*.

Table 7. Proportion of Subjects with and without Low Back Pain by Frequency of Playing Categories

		Subjects with Low Back Pain	Subjects without Low Back Pain	*p*-value
	0 times a week	0/17=0.0%	2/23=8.7%	
	1 time a week	0/17=0.0%	2/23=8.7%	
Plays Golf per Week	2-3 times a week	14/17=82.4%	14/23=60.9%	0.530
	4-5 times a week	3/17=17.6%	4/23=17.4%	
	6+ times a week	0/17=0.0%	1/23=4.3%	
	0 times a week	0/17=0.0%	1/23=4.3%	
	1 time a week	9/17=52.9%	12/23=52.2%	
Walks	2-3 times a week	5/17=29.4%	7/23=30.4%	0.944
	4-5 times a week	2/17=11.8%	1/23=4.3%	
	6+ times a week	1/17=5.9%	2/23=8.7%	
	0 times a week	1/17=5.9%	2/23=8.7%	
	1 time a week	3/17=17.6%	5/23=21.7%	
Rides a Cart	2-3 times a week	11/17=64.7%	13/23=56.5%	1.000
	4-5 times a week	2/17=11.8%	2/23=8.7%	
	6+ times a week	0/17=0.0%	1/23=4.3%	
	0 times a week	16/17=94.1%	19/23=82.6%	
	1 time a week	1/17=5.9%	4/23=17.4%	
Uses a Push/Pull Cart	2-3 times a week	0/17=0.0%	0/23=0.0%	0.373
	4-5 times a week	0/17=0.0%	0/23=0.0%	
	6+ times a week	0/17=0.0%	0/23=0.0%	

A Fisher's exact test of independence was calculated comparing the results of the prevalence of low back pain in subject's frequency of play. No significant relationship was found. These results are displayed in *Table 7*.

4.0 Discussion

The primary aim of this study was to explore a potential relationship between golfers' BMI, estimated hamstring flexibility and golfing characteristics, in addition to age, weight, height and sex, with their prevalence of low back pain.

Information found in this study will contribute to golfers existing knowledge of low back pain and its prevalence associated with demographics, BMI, hamstring flexibility and playing characteristics. Along with golfers, clinician's knowledge will be enhanced as well. Current literature has identified many of risk factors associated with developing low back pain in golfers. Variables such as age, sex, weight and flexibility have been studied in great detail. However, the results of this study suggest that low back pain remains prevalent in the golfing population. Further research is needed to better identify variables associated with the prevalence of low back pain in the golfing population.

4.1 Subject Demographics, Characteristics and BMI

The results of this study showed no statistical differences between age, sex, height, weight and BMI in golfers with and without low back pain. Although these results are contrary to research that previous research that studied subject demographics, characteristics and BMI associated with low back pain, it is important to remember that the results of this study account for an extremely small sample size for a very large population. Subject age range in this study was vast ranging from 18 to 73. The majority of subjects were above the age of 30 and inside the peak range of ages

(30-60 years of age) where the prevalence of low back pain is at the highest.[12,20,21] However, the large range of 55 years could have negatively affected the outcome of this study. Results may have varied had a narrower age been utilized. Younger subjects have a lower prevalence of low back pain as opposed to middle aged and geriatric subjects. A number of previous studies have demonstrated a relationship between advanced age and low back pain. [8,11,19] Specifically, Fett et al. conducted a study and found a positive correlation between an increase in age and prevalence of low back pain.[12]

Previous literature has shown that the prevalence of low back pain among the sexes is influenced by a vast number of factors. Factors such as height and weight differences, hormone levels, menstruation and ligament laxity have been previously identified as potential variables associated with low back pain.[20] Additionally, a woman's major life changes like the menstrual cycle, pregnancy and menopause, are also risk for developing low back pain. While this study did not show that a significantly different proportion of women exhibited low back pain compared to men, previous research has shown a higher prevalence of low back pain in women who are athletes than men.[11,12] To date, there are few studies that study a woman's risk of developing low back pain. This is due to the multifactorial cause of low back pain; researches have had difficulty identifying specific variables in women.

Body mass index was used as the method of estimating subject's body composition. Ideally, a body fat percentage measurement would be a more accurate interpretation of each subject's body mass distribution. For the purpose of this study, BMI was the best available method to categorize subjects into the correct body composition. Although there was no significant difference in BMI between low back pain groups, previous systematic reviews have shown a positive association between BMI and low back pain.[41,42] High BMI is often associated with low back pain due to the increased load that the spine, which serves as the support system of the body, has to carry. The lumbar spine, specifically, is under extreme stress when an individual has extra mass in the abdominal region of the body and in the overweight category for BMI.[52]

Lastly, no significant differences in estimated hamstring flexibility were revealed between back pain groups. Previous research has suggested a relationship between hamstring flexibility and low back pain.[33,34] Specifically, a tight hamstring muscle can posteriorly tilt the pelvis. Altered pelvic position reduces the lumbar lordosis of the spine increases stress on the intervertebral discs.[35-37] A decreased lumbar lordotic curve alters the distribution of forces away from the large muscle groups, like the hamstrings, to the smaller muscles surrounding the spine, thus increasing risk of low back pain.[5,37] Hamstring flexibility is nearly impossible to measure from a survey because the answer is measured subjectively. Additionally, hamstring flexibility could have been affected by the range of motion of a subject's lower trunk. Had an objective measurement been collected, results may have varied.

4.2 Golf Skill and Swing Type

The lumbar spine is one of the most commonly affected area of injury in athletes of all kind.[12] Due to the high prevalence of low back pain in the general population, the low back pain in athletes has been studied in great detail and had varying results depending on the nature of each sport.[13] Amongst the golfing population, previous research as reported the low back as the area of greatest injury in professional and amateur players, with professionals having a higher frequency.[2,17,18,24] All subjects in this study were amateur golfers, which are more commonly referred to as recreational players. For this reason, players were categorized based on their handicap index number to classify their skill level. While in this study there was no significant difference in a golfer's skill level between subjects with and without the prevalence of low back pain, previous literature has suggested that a lower handicap player, or a golfer with better skill, would have a higher likely hood of developing low back pain. Of the 17 subjects who experienced low back pain, 35.3% of them were in the lower handicap group as shown in *Table 6*. The higher occurrence rate in this group is likely is due to the biomechanical makeup and demands of the golf swing. A golf swing is a repetitive and asymmetrical motion.[19] The motion of a golf swing is associated with high segmental angular velocities and spinal loading. Like professional golfers, lower handicap players or better skilled golfers, tend to spend more time practicing, playing and perfecting the mechanics of their swings. A combination of high frequency swing repetitions and spinal force is likely the reason for lower back injuries.

Table 6 also displays the results of the association between swing type, classic or modern, and the prevalence of low back pain. Although no significance difference was demonstrated in swing type between back pain groups, the results of swing type were opposite the what the investigator expected. A notably high frequency of players which low back pain displayed a classic swing. Of the 17 subjects with low back pain, 15, or 88.2%, of them play golf with the classic golf swing. The modern swing is more likely to have a significant association with low back pain due to the increased X-factor, lateral bending and hyperextension of the spine. An increase in axial twisting is a risk factor for low back pain.[3,22,23] X-factor is measured from the axial rotation between the torso and pelvis, making the modern golf swing problematic.

4.3 Playing Frequency

In this study, the majority of subjects played golf two to three times a week during the months of May to August (*Table 7*). Although none of the playing variables were significant in this study, this frequency of play per week was the highest reported frequency among both low back pain groups. Previous research has demonstrated that a slightly higher frequency of play per week was associated with low back pain. Gosherger et al. showed that players who play four or more rounds a week or hit 200+ golf balls in a week had a higher prevalence of low back pain.[16] It was also expected that those who walk while playing golf would have a higher prevalence of low back pain than those who rode in a cart because of the weight of the golf bag. The average golf bag weighs 30 pounds. That load, in addition to the loads applied to the lumbar spine while swinging a golf club, is additional stress added to the low back. Of the 40 subjects included in this study, there was a higher proportion of golfers who walked without low back pain compared to golfers with low back pain. It is thought that those with low back pain prefer to drive as walking and carrying their golf bag aggravates their low back pain.[16,19]

4.4 Limitations

There are several limitations of this study that should be recognized. The first is the small sample size. Out of the hundreds of survey invitations sent by golf club professionals, only 74 surveys were completed. Thirty-four subject responses were excluded due to exclusion factors in response to the survey, equating to a 54% inclusion rate. Although the survey reached several hundred golfers, the survey data was collected during the non-traditional or off-season for golfers in the North Eastern Region of the United States. It is assumed that if data had been collected during the summer months, May through August, participants may have been more inclined to answer the survey. The data collection time could have also been a reason for the low participation rate. Being the 'off-season' for golfers in this region, many may check their emails from their golf or country clubs as often as the traditional golfing season.

Another limitation that may explain the results of this study was the subject recruitment method. The primary investigator 'cold-called' club professionals around the United States. The majority of golf and country club golf professionals were uninterested and unwilling to assist in recruiting subjects by forwarding an email with the attached survey link. Several professional stated that their club would not allow for the survey to be sent to the membership. Of the few golf professionals that sent the survey link, each had a personal interest in low back pain and the aim of this study, which suggests that motivated participants are more likely to answer and participate.[50] Additionally, the email invitation requested that avid golfers with no current musculoskeletal injury and previous spinal surgery complete the survey. It is possible that survey was forwarded to non-golfing members of the club. Due to this, there is no way to ascertain if the survey reached the maximum intended study participants.

Lastly, as with any survey, participants may be subject to recall bias and self-report bias and the researcher may be subject to researcher bias. Recall bias refers to the inability to adequately recall past events. Self-report bias refers to the tendency for individuals to downplay negative attributes of themselves. In the last section of the survey participants answered questions related to their low back pain scale. For some, low back pain could have been a negative attribute they saw in themselves. If this was the case for some, these subjects may not have scaled their low back pain truthfully and rated it at a lesser degree. Researcher bias can affect the way questions are asked. The survey questions were designed carefully, but data collected by means of a survey can have many limitations within itself. This study's survey utilized 21 close-ended questions. The disadvantage of close-ended questions is that they can be difficult to write.[50,53] The difficulty is due to the need for exhaustive response options. Also, too many questions can result in incomplete survey. Data from Survey Monkey reported that subjects will spend an average of five to ten minutes to answer ten to twenty-five questions.[50] Survey participants may be more likely to abandon the survey if it takes them longer than expected. Finally, all survey measures, qualitative or quantitative, are subject to error.[50]

4.5 Future Research

Future research should be aimed at identifying prospective risk factors for incidence of low back pain in the golfing population. Previous literature has shown that individuals with a high BMI, who are middle aged or older, and who are female have an increased risk of developing low back pain. While the current study did not yield significant findings, utilizing these potential risk factors in a large cohort, prospective study might give further insight to risk factors for low back pain in golfers. Additionally, future research should include physical variables, such as goniometric range of motion in the trunk, hips, knee, ankles, shoulder and wrists, strength variables in those joints, and body composition utilizing a validated laboratory measure. Performance metrics, like driving distance, club head speed and swing mechanics can also be assessed in future research. Ideally, research should be conducted during the prime golf season which falls between the months of May and August in the North East Region of the United States.

4.6 Conclusion

Although no significant differences were demonstrated in the covariables of this study between low back pain groups, this study suggested that low back pain is a widespread problem in golfers and its cause is multifactorial. It also demonstrated that continued research is needed to better understand the potential cause of low back pain. This study is the first step in evaluating all these factors in golfer with and without low back pain. Although this study's aim was not to identify risk factors, it did aim to compare variables between golfers with and without low back pain as a guide for future research. Overall, there is a great need for continued research and education regarding low back pain in the golfing population. Advising golfers of risk factors that lead to the development of low back pain may potentially serve to prevent the development of pain and aid in the therapy options to modify these risks. Increased knowledge and understanding of this topic will help improve the health and well-being of golfers as well as optimize clinical practice of medical professionals providing healthcare services to golfers.

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Appendix A

University of Pittsburgh

You are invited to participate in a research study titled "A Comparison of BMI, Flexibility and Subject Characteristics in Golfers with and without Low Back Pain". The purpose of this study is to investigate the body mass index, hamstring flexibility, playing frequency and ability and subject characteristics of golfers with and without low back pain then compare these factors to identify correlates of low back pain.

Survey participation is voluntary, you are free to withdraw or stop at any time with no penalty or loss of benefits. The survey requires approximately 5-10 minutes to complete. Submission of your survey indicates consent to participate in the study.

Please answer all of the following questions honestly and to the best of your ability. All survey responses will remain anonymous. Information contained in a response that may disclose the your identity will be filtered and omitted from the results.

University of Pittsburgh

What is your age?

What is your sex?

Male

Female

What is your height in inches?

What is your weight in pounds?

Do you record a GHIN or USGA handicap?

- Yes
- No

What is your handicap index?

- 5 and under
- 6-10
- 11-15
- 16-20
- 21 and over

Are you a certified golf professional or professional golfer?

- Yes, a PGA certified golf professional
- Yes, a professional golfer
- No, I am no either of the above options

Do you exhibit a classic or modern golf swing?

- Classic- I swing similar to Arnold Palmer, Jack Nicklaus, Ben Hogan, Sam Sneed and Betsy King.
- Modern- I swing similar to Rory McIlroy, Justin Thomas, Dustin Johnson, Adam Scott and Annika Sorenstam.

Please select the number of days a week do you do the following during the months of May to August...

	0 times a week	1 day a week	2-3 times a week	3-4 times a week	6+ times a week
I play 18 holes of golf...	○	○	○	○	○
I walk and carry my bag for 18 holes of golf...	○	○	○	○	○
I ride in a cart for 18 holes of golf...	○	○	○	○	○
I use a pull/push cart for 18 holes of golf...	○	○	○	○	○

What region of the United States do you play golf during the months of May to August?

- North East (PA, MD, DE, NJ, NY, CT, RI, MA, VT, NH, ME)
- South East (WV, VA, KY, TN, NC, SC, GA, FL, AL, MS, LA, AR)
- West (CA, OR, WA, AL, NV, ID, UT, MT, WY, CO)
- Midwest (ND, SD, NE, KS, MN, IA, MO, IL, IN, OH, MI, WI)
- South West (AR, NM, TX OK)

University of Pittsburgh

Which of the following describes your hamstring flexibility?

- I can stand up straight, bend at my waist with my knees straight, and place my hands flat on the floor.
- I can stand up straight, bend at my waist with my knees straight, and touch the floor with my fingertips.
- I can stand up straight, bend at my waist with my knees straight, and reach my ankles with my hands but not the floor.
- I can stand up straight, bend at my waist with my knees straight, but can not reach my ankles.

Have you ever been diagnosed with an injury to your lumbar spine/low back?

Yes

No

Have you undergone any of the following surgical procedures to your spine: Spinal Fusion, Nucleoplasty (disc decompression), Discectomy, Vertebroplasty, Spinal Decompression, Foraminotomy, or Artificial Disc Replacement?

Yes

No

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Do you currently have or have had a musculoskeletal injury in the last 6 months that limited your ability to play golf for longer than 1 week?

- Yes
- No

Please select the most accurate statement that closely describes your level of low back pain.

Low Back Pain Intensity

- 0- I have no low back pain.
- 1- Low back pain comes and goes and is very mild.
- 2- Low back pain comes and goes and is moderate.
- 3- Low back pain is moderate and constant
- 4- Low back pain comes and goes and is severe
- 5- Low back pain is severe and constant

Personal Care (Washing Dressing, etc.)

0- I would not have to change my way of person care in order to avoid low back pain.

1- I do not normally change my way of personal care even though it causes low back pain.

2- Personal care increases low back pain, but I manage not to change my way of doing it.

3- Personal care increases low back pain and I find it necessary to change my way of doing it.

4- Because of low back pain, I am unable to do some person care without help.

5- Because of low back pain, I am unable to do any personal care.

Lifting

0- I can lift heavy weight without any low back pain.

1- I can lift heavy weight, but it gives extra low back pain.

2- Low back pain prevents me from lifting heavy weight off the floor, but I can manage light to medium weight.

3- Low back pain prevents me from lifting heavy weight off the floor, but I can manage if the weight is conveniently position, e.g. on a table.

4- Low back pain prevents me from lifting heavy weight, but I can manage to lift light to medium weight if they are conveniently positioned.

5- I can only lift very light weights.

Walking

0- I have no low back pain walking

1- I have some low back pain walking, but it does not increase with distance.

2- I cannot walk more than 1 mile without increasing low back pain.

3- I cannot walk more than 1/2 mile without increasing low back pain.

4- I cannot walk more than 1/4 mile without increasing low back pain.

5- I cannot walk at all without increasing low back pain.

Sitting

0- I can sit in any chair for as long as I like with no low back pain.

1- I can sit in only my favorite chair for as long as I like.

2- Low back pain prevents me from sitting for more than 1 hour.

3- Low back pain prevents me from sitting for more than 1/2 hour.

4- Low back pain prevents me from sitting for more than 10 minutes.

5- I avoid sitting because it increases low back pain immediately.

Standing

0- I can stand for as long as I want without low back pain.

1- I have some low back pain on standing but it does not increase with time.

2- I cannot stand for longer than 1 hour without increasing low back pain.

3- I cannot stand for longer than 1/2 hour without increasing low back pain.

4- I cannot stand for longer than 10 minutes without increasing low back pain.

5- I avoid standing because it increases low back pain immediately.

Sleeping

0- I have no low back pain while in bed.

1- I have low back pain while in bed, but it does not prevent me from sleeping well.

2- Because of my low back pain, my normal nights sleep is reduced by less than one-quarter.

3- Because of my low back pain, my normal nights sleep is reduced by less than one-half.

4- Because of my low back pain, my normal nights sleep is reduced by less than three-quarters

5- Low back pain prevents me from sleeping at all.

Social Life

0- My social life is normal and gives me no low back pain.

1- My social life is normal, but it increases the degree of low back pain.

2- Low back pain has no significant effect on my social life apart from limiting my more energetic interests e.g. dancing, etc.

3- Low back pain has restricted my social life and I do not fo out very often.

4- Low back pain has restricted my social life to my home.

5- I have hardly any social life because of low back pain.

Traveling

0- I have no low back pain when traveling.

1- I have some low back pain when traveling but none of my usual forms of travel make it any worse.

2- I have extra low back pain while traveling but it does not compel me to seek alternative forms of travel.

3- I have extra low back pain while traveling which compels me to seek alternative forms of travel.

4-Low back pain restricts me to short necessary journeys.

5- Low back pain restricts me from all forms of travel.

Changing Degrees of Low Back Pain

0- I have no low back pain, or my pain is rapidly getting better.

1- My low back pain fluctuates but is gradually getting better.

2- My low back pain seems to be getting better, but improvement is slow.

3- My low back pain is neither getting better or worse.

4- My low back pain is gradually worsening.

5- My low back pain is rapidly worsening.