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The Evaluation of Core Strength, Endurance, Flexibility, Body Composition, and Physical Activity on the Prevalence of Low Back Pain in College-Aged Individuals

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THE EVALUATION OF CORE STRENGTH, ENDURANCE, FLEXIBILITY, BODY COMPOSITION, AND PHYSICAL ACTIVITY ON THE PREVALENCE OF LOW BACK PAIN IN COLLEGE-AGED INDIVIDUALS

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Title: The Evaluation of Core Strength, Endurance, Flexibility, Body Composition, and Physical Activity on the Prevalence of Low Back Pain in College-Aged Individuals

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PURPOSE: Evaluate the impact of core strength, endurance, flexibility, body composition, and physical activity on the reported prevalence of low back pain (LBP) in college-aged individuals.

METHODS: Twenty-six subjects (11 males;15 females) between 18-25 years old volunteered to participate. Subjects completed all necessary paperwork and questionnaires before being familiarized with the protocol during the orientation session. During the exercise session, all the objective data was collected as the subject's core strength, endurance and flexibility were assessed using established protocols. Several physiological measurements were recorded during both sessions. The results of the questionnaires determined the subjects LBP categorization.

RESULTS: A t-test revealed a significant body fat percentage (%) difference between females with Little/No LBP and Moderate LBP ($p = 0.029$) as assessed by the Roland-Morris Disability Questionnaire (RMDQ). Significant correlations existed between body fat % and core strength ($p = 0.016$) and between body fat % and core endurance ($p = 0.001$). Significant correlations existed between core strength and endurance ($p = 0.000$) and between core strength and flexibility ($p= 0.004$). The RMDQ and the Revised Oswestry Disability Questionnaire were significantly correlated ($p = 0.001$).

CONCLUSION: College-aged females with Little/No LBP will likely display a lower body fat % compared to females with Moderate LBP. As body fat % increases core strength

decreases or the inverse. As body fat % increases core endurance decreases or the inverse. As core strength increases core endurance increases or the inverse. As core strength increases flexibility increases or the inverse.

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CHAPTER I

INTRODUCTION

Low back pain (LBP) is a health issue many individuals face, as it affects activities of daily living, as well as their occupational and recreational activities. LBP is a very vague and complex condition, as in most cases there is no singular cause or event, but rather combinations of several factors (Brennan, 2007). LBP is the leading cause of activity limitation and work absence throughout much of the world, imposing a high economic burden on individuals, families, communities, industry, and governments (World Health Organization, 2013). It has become a significant health issue here in the United States (U.S.A) reportedly affecting between 70% and 85% of the population, while between 49% and 70% of individuals living in other industrialized nations, such as Canada and Japan, report experiencing LBP throughout their lives. Annually in the U.S.A., the cost associated with LBP increased by 91% from 1996 to 2011, now totaling approximately $253 billion annually (American College of Sports Medicine, 2018). Much of the current research in the field has been conducted with middle-aged to elderly individuals, as historically LBP has been thought to be a condition of these populations, but the prevalence continues to rise across most populations, including college-aged individuals. Current evidence suggests that persons with LBP tend to avoid physical activity participation, so therefore tend to lead a more sedentary lifestyle compared to individuals not experiencing LBP. LBP.

One contributing factor to LBP is thought to be weak muscles of the core, which include the muscles of the abdomen and lower back, such as the rectus abdominis, transverse abdominis, erector spinae, and external/internal obliques, all help maintain posture and spinal stability. Strengthening and improving the endurance of these muscles, among other muscles located in the area is essential. According to Fitzgerald (2010), improving an individual's core strength and endurance should help minimize or eliminate LBP. Core strength is associated with LBP, as low core strength can lead to lumbar instability, which reduces the flexibility of the spine (Lee, 2016). Although the relationship between core muscular strength and LBP is still unclear, as according to the American College of Sports Medicine Guidelines for Exercise Testing and Prescription (2018), the tenth edition, individuals with LBP often have deficits in core and trunk muscular strength, along with neuromuscular imbalances. According to Lee at al. (2016) strengthening the deep abdominal muscles, including the transversus abdominis muscle, and multifidus are important to reduce back pain. These have proven to be effective in decreasing LBP in chronic patients, by enhancing the strength and stability of the spine. Like core strength, poor muscular endurance has been reported to be associated with LBP, so by practicing good postural habits and increasing endurance of the muscles that support the spine, which can be achieved through core exercises (Datta, 2014). According to the ACSM GTEP 10 (2018) deficits in core muscular endurance is often associated with LBP in individuals, although they concede that the relationship is still slightly unclear. Although, core strength and endurance are not the only factors contributing to LBP, as other factors such as decreased flexibility and range of motion of the lower back and hamstrings muscles also have an impact. A study, conducted by Sadler et al. (2017), determined that subjects with deficits in lateral flexion, hamstring flexibility, and reduced lumbar lordosis were at an increased risk for developing LBP. Other studies have shown that in adolescents, poor leg flexibility is a risk factor for developing LBP, and that regular flexibility exercises can provide symptom relief, although flexibility does not seem to reduce the risk of developing LBP (Sandler, 2014). Once again, the relationship between flexibility and LBP is still relatively unclear, but it has been shown by studies that there is an association between the development of LBP, and spine and hip flexibility (American College of Sports Medicine, 2018). An additional factor which may affect LBP is body composition.

Leading a sedentary lifestyle and being physically inactive has become a significant problem in the U.S.A., much like LBP, and has been described as, "the greatest public health problem of the 21st century (Griffin, 2012). Staying physically active has been recognized as a very effective strategy to manage both acute, subacute, and chronic LBP, while participating in sedentary behaviors may see no improvements or even progress LBP (Hendrick, 2011). While leading a sedentary or inactive lifestyle may impact the development and management of LBP through several factors, such as the accumulation of body fat, especially in the abdominal region. It has been demonstrated many times by research that when obese people are treated for LBP, they will likely experience better much outcomes if they lose weight. Obesity is associated with increased body fat percentage, and it is believed that excess body fat within the abdominal region is associated with LBP, as a study by Spyropoulos et al. (2008) found that female office workers that complained of LBP had statistically higher BMI and percent body fat measurements compared to those who did not experience pain. Especially if the clients body mass index (BMI) is $\geq$40 kg/m^2, as excess weight in the abdomen is associated with early disc degeneration, but it remains unclear whether obesity is a cause or a consequence of LBP (Ewald, 2016). This proposes an issue because according to the Centers for Disease Control and Prevention (2017), more than one-third of adults in the United States of America (USA) classifies as obese, which has also become an issue in young adults and children. Increased waist circumference is generally associated with excess adipose tissue and obesity.

Most previous LBP research has been conducted with middle-aged and elderly populations, due to these populations suffering from this condition the most. However, the prevalence continues to rise across most populations, including college-aged individuals. A study conducted by Nordin et al. (2014) with 142 undergraduate students yielded a self-reported prevalence of 40.3% of subjects were experiencing LBP, and the significantly associated risk factors were age, years of study, fitness level, and hrs. spent sitting per day. Lower incidence of LBP was reported by students of good fitness level, while a higher incidence of LBP was reported in students >23 yrs. old, had studied for >3 yrs., and sat for an average of 4 hrs. per day (Nordin, 2014). Another one-year study with 188 Physical Education and Sports & Exercise Science students, determined that LBP was the most frequently reported and treated condition with a prevalence of 32%, with approximately 77% reporting their problem as recurring, and 14% reporting the problem as constant or ongoing (Brennan, 2007). The only two factors that were significantly associated with an increased prevalence of reported LBP were increased age, and hours of physical activity per week (Brennan, 2007). A cross-sectional survey conducted by Issa et al. (2016) with 1000 male students for seven months determined that the prevalence of reported LBP was 30% and that LBP was more common in medical and business administration students. Studying for extended periods of time, academic success, and leading a sedentary lifestyle were all significantly associated with increased prevalence of reported LBP (Issa, 2016). This study also revealed that there was a significant association between LBP and sedentary behavior or less active students, which has been a consistent finding (Issa, 2016). Abdelraouf et al. (2016) conducted a study with 55 male collegiate athletes from a variety of sports and determined that athletes with nonspecific LBP had significantly lower muscular endurance test values, compared to healthy control group. Therefore, this study stressed the importance of core muscular endurance in rehabilitation programs geared towards this population (Abdelraouf, 2016). LBP across all populations is a very complex process, especially in younger populations, such as college-aged individuals, as there are a variety of factors that can play a role, and this study aims to identify these factors within this specific population.

Problem Statement

The purpose of the present study is to evaluate the impact of core strength, endurance, flexibility, body composition, and physical activity on the reported prevalence of LBP in college-aged individuals.

Research Questions

1. Is low core strength associated with an increased reported prevalence of LBP in college-aged individuals?
2. Is low core endurance associated with an increased reported prevalence of LBP in college-aged individuals?
3. Is decreased lower back and hamstring flexibility associated with an increased reported prevalence of LBP in college-aged individuals?
4. Is high body fat percentage associated with an increased reported prevalence of LBP in college-aged individuals?
5. Are low self-reported physical activity levels associated with an increased reported prevalence of LBP in college-aged individuals?

Hypotheses

1. Individuals with lower core strength, as determined by the muscular strength protocol, will have a higher prevalence of reported LBP.
2. Individuals with lower core endurance, as determined by the muscular endurance protocol, will have a higher prevalence of reported LBP.

3. Individuals with decreased lower back and hamstring flexibility, assessed by the results of the sit-and-reach test, will have a higher prevalence of reported LBP.
4. Individuals that report low self-reported physical activity, assessed by the Modifiable Activity Questionnaire and Sedentary Behavior Questionnaire, will have a higher prevalence of reported LBP.
5. Individuals with higher body fat percentage, as assessed by a BOD POD machine, will have a higher prevalence of reported LBP.

Assumptions

1. Subjects will be between the ages of 18-25 years(yrs.) old and have a BMI between 18.5-34.9 kg/m^2 (Normal – Class 1 Obesity).
2. Subjects understand that low back pain does not prevent participation in this study.
3. Subjects will NOT have a serious back injury in the past 3 months or have a previous history of surgeries or serious back injuries that may prove to be debilitating if exercised, as determined by their physician.
4. Subjects will NOT be pregnant, or currently taking prescription pain medications for the lower back.
5. Subjects will NOT be university athletes to prevent from other possible influencing factors, such as a competition related injury.
6. Subjects will abstain from provided list of products/medications 48 hours(hrs.) prior to the exercise session to ensure there are no outside factors that can impact performance.

Limitations

1. Participants may not have accurately reported their physical activity history and experience in resistance training.

2. Other confounding factors could affect LBP and exercise performance such as dietary intake, amount of sleep, and stress.
3. Participants may not have abstained from prescription pain medications for the lower back as instructed prior to testing.
4. A small sample size could lead to slightly variable results.

Significance

Currently, there is a vast body of research regarding chronic LBP in the field, as this issue has plagued the medical system and our society over the past several decades, due to a variety of causes. Much of the current research in the field focuses strictly on core strength and its association with LBP. Therefore, throughout this study our goal would be to identify and other possible associations besides core strength, examining body fat percentage and waist circumference of all participants, and determining if there is an association with LBP. Most of the current research has been conducted with middle-aged to elderly individuals, who tend to be more susceptible due to the aging process and increased inactivity. Therefore, with so little research being done with populations outside middle-aged and elderly populations, this study will strive to help fill this void. Even the studies that have been conducted with younger populations, like the population in question, college-aged individuals, have mainly relied on only subjective measures, such as administering the questionnaire and using self-reported data. Therefore, this study aims to collect both objective and subjective measurements to solidify the findings. Objective data will be collected from this population through the completion of several muscular strength, endurance, and flexibility assessments. Other objective measurements that will be assessed in this study are body composition, height, weight, heart rate, and blood pressure. The subjective measure will be collected throughout the administration of several questionnaires related to LBP and physical activity. Other subjective measurements that will be taken is each subject's perceived pain and exertion at the beginning of the session, after the completion of each exercise, and at the completion of the session. This study focused on college-aged individuals, between the ages of 18-25 yrs. Conducting a study such as this likely solidifies the results of prior studies, yield a new perspective, and present additional information related to medically treated LBP. So, the purpose of the present study is to evaluate the impact of core strength, endurance, flexibility, body composition, and physical activity on the reported prevalence of LBP in college-aged individuals.

Definition of Terms

Acute Low Back Pain- pain occurring for <6 weeks (American College of Sports Medicine, 2018).

Body Composition- relative proportions by weight of fat and lean tissue (National Strength & Conditioning Association, 2008).

Body Mass Index (BMI)- assesses weight relative to height and is calculated by dividing body weight in kilograms by height in meters squared (American College of Sports Medicine, 2018).

Core- the major muscles that move, support, and stabilize the spine. Includes the rectus abdominis, transverse abdominis, erector spinae, and external/internal obliques (American Council on Exercise, 2013)

Chronic Low Back Pain- pain occurring for >12 weeks (American College of Sports Medicine, 2018).

Exercise- a type of physical activity consisting of planned, structured, and repetitive bodily movements done to improve and/or maintain one or more components of physical fitness (American College of Sports Medicine, 2018).

Flexibility- the ability to move a joint through its complete range of motion (American College of Sports Medicine, 2018).

Gluteal Muscles- consists of the Gluteus Maximus, Medius, and Minimus to form the buttock, and is responsible for some lower limb movement (O'Rahilly, 2004)

Low Back Pain- pain, muscle tension, or stiffness localized below the rib margin and above the inferior gluteal folds, with or without leg pain (American College of Sports Medicine, 2018).

Moderate Physical Activity- activity requiring between 3.0-5.9 METs (American College of Sports Medicine, 2018).

Muscular Endurance- the ability of a muscle group to execute repeated muscle actions over a period sufficient to cause muscular fatigue (American College of Sports Medicine, 2018). A training regimen that involves performing many repetitions, 12 or more, per set (National Strength & Conditioning Association, 2008).

Muscular Strength- the external force that can be generated by a specific muscle or muscle group, and it commonly expressed in terms or resistance met or overcome (American College of Sports Medicine, 2018).

Obesity- a BMI $\geq$30 kg/m^2 (American College of Sports Medicine, 2018).

Physical Activity- any bodily movement produced by the contraction of skeletal muscles that results in a substantial increase in caloric requirements over resting energy expenditure (American College of Sports Medicine, 2018).

Repetition- The number of times an exercise can be performed in one set (National Strength & Conditioning Association, 2008)

Resistance Training- a form of physical activity that is designed to improve muscular fitness by exercising a muscle or a muscle group against external resistance (American College of Sports Medicine, 2018).

Rest Period- Time dedicated to recovering between sets and exercises (National Strength & Conditioning Association, 2008).

Subacute Low Back Pain- pain occurring for 6-12 weeks (American College of Sports Medicine, 2018).

Vigorous Physical Activity- activity requiring $\geq$6.0 METs (American College of Sports Medicine, 2018).

CHAPTER II

REVIEW OF LITERATURE

The following chapter will provide a review of the current literature that exists on LBP and its relationship to physical activity, and obesity, along with core strength, endurance, and flexibility. This chapter will discuss the background, potential causes, risks, abilities, and behaviors related to LBP. Additionally, the effect physical activity or lack of physical activity, obesity, core strength, core endurance, and core flexibility in college-aged individuals will be discussed.

Anatomy of Low Back Pain

The cause of LBP in most people is unknown, as it may be caused by a specific injury, strain from lifting, twisting, bending, or possibly due to a more serious condition (University of Maryland Medical Center, 2016). According to Kravitz et al. (1990), LBP is experienced in the lumbosacral area of the spine, which is where the lordotic curve is formed, consisting of all vertebrae between the first lumbar and the first sacral vertebrae, with the most common site being the fourth and fifth lumbar vertebrae. Between each vertebra is a strong and spongy disk, which when ruptured or bulging is the most common cause of LBP (University of Maryland Medical Center, 2016). Also recognized by the University of Maryland Medical Center (2016) as a common cause is spinal stenosis, which is arthritis of the spinal column that causes the space around the spinal cord to narrow. Other potential causes include weak, tight, degenerated, or deviated spinal structures, including ligaments, facet joints, and muscles in the region like the paravertebral muscles (Deyo, 2001). Risk factors for LBP include age, family history, heavy lifting and twisting, smoking, being overweight, poorly conditioned, depressed, and excessive physical or sedentary work (University of Maryland Medical Center, 2016). However, there is often no definitive cause for initial episodes, as some risk factors are population specific, and often weakly associated with the development of LBP (Delitto, 2012). Thus, according to Deyo et al. (2001) individuals are often diagnosed with a strain, sprain, or degenerative processes, leaving much ambiguity with diagnoses. This region of the body is relatively unstable due to the anatomical structure, and there is a lot of complexity and uncertainty with pain in this region, which is why LBP has become such a significant issue.

Low Back Pain

According to the American College of Sports Medicine Guidelines for Exercise Testing and Prescription (2018), pain, muscle tension, and stiffness, without the presence of leg pain, that is localized below the rib cage and above the gluteal muscles, is defined as LBP. LBP has become a significant medical and economic burden in the USA and globally. In the USA, LBP has become a significant economic, and societal burden, typically exceeding two-hundred billion dollars annually (Ewald, 2016). Upwards of 84% of the USA population, is likely to experience LBP throughout their lifetime, which can progress into chronic back pain or even disability. Point prevalence typically falls between 4 and 33% (American College of Sports Medicine, 2018). LBP is currently ranked as the number one cause of disability and loss of time from work worldwide, yet is still a very vague and complex condition, as in most cases there is no singular cause or event, but rather combinations of several factors (Brennan, 2007). Thus, with such a high reported prevalence of this condition, and a variety of professional and medical treatments utilized, this remains a very significant health and economic issue globally (Deyo, 2001). Although, these are only a few associated causes, as in recent years LBP has been associated with many other factors, often behavioral or lifestyle related which will continue to be discussed.

Low Back Pain and Sedentary Lifestyle

Sedentary lifestyle and physical inactivity has become a significant problem in the USA and other industrialized countries throughout the world, and has been described as, "the greatest public health problem of the 21st century (Griffin, 2012)." Sedentary lifestyles have become commonly associated with the development of acute LBP and possibly chronic LBP. Remaining physically active throughout a lifetime is recommended, as moderate physical activity and conditioning will likely reduce the risk of developing LBP. Studies have shown significant associations between physical inactivity and LBP in the general population (Issa, 2016). Staying physically active has been recognized as a very effective strategy to manage both acute, subacute, and chronic LBP, while participating in sedentary behavior may see no improvements or even progress LBP (Hendrick, 2011). Although, leading a sedentary or inactive lifestyle may impact the development and management of LBP through several factors, such as the accumulation of body fat, especially in the abdominal region.

Low Back Pain and Obesity

As rates of LBP continue to increase, so has the obesity epidemic throughout many industrialized countries. It has been demonstrated many times by research that when obese people are treated for LBP, they will likely experience better much outcomes if they lose weight. Especially if the clients BMI is $\geq$40 kg/m^2, as excess weight in the abdomen is associated with early disc degeneration (Ewald, 2016). Obesity relationship to LBP is still a somewhat unclear, especially for those with a BMI $<$40 kg/m^2, but it is still often noted as a cause of increased LBP rates (Kaçuri, 2015). Therefore, even though obesity has been associated with LBP, it remains unclear whether obesity is a cause or a consequence of LBP (Ewald, 2016). Freburger et al. (2009) studied the rising prevalence of LBP in North Carolina citizens and determined several factors contributed to this increase, including that North Carolinians have grown considerably more obese over the past decades, and throughout the 14-year study. Although there is still some uncertainty in the relationship between LBP and obesity, the evidence is clear that an association between the two exists.

Low Back Pain and Core Strength, Endurance, and Flexibility

Core strength is also associated with LBP, as low core strength can lead to lumbar instability, which reduces the flexibility of the spine (Lee, 2016). Although the relationship between core muscular strength and LBP is still unclear, as according to the American College of Sports Medicine Guidelines for Exercise Testing and Prescription (2018), individuals with LBP often have deficits in core and trunk muscular strength, along with neuromuscular imbalances. Therefore, there are several different exercises which individuals with LBP can use to increase core strength and stability. These may yield different results but still be effective, as many of these exercises are very important aspects of sports medicine and rehabilitation programs (Wang, 2012). According to Lee at al. (2016) strengthening the deep abdominal muscles, including the transversus abdominis muscle, and multifidus are important to reduce back pain. These have proven to be effective in decreasing LBP in chronic patients, by enhancing the strength and stability of the spine. The counterparts to core muscular strength, are core muscular endurance and flexibility, which will next be discussed in terms of their relationship to LBP.

Like core strength, poor muscular endurance has been reported to be associated with LBP, so by practicing good postural habits and increasing endurance of the muscles that support the spine, which can be achieved through core exercises (Datta, 2014). Therefore, exercising and training the muscles of the trunk or spinal stabilizers is beneficial, as it improves the endurance of these muscles, which helps prevent future LBP (Datta, 2014). According to the American

College of Sports Medicine Guidelines for Exercise Testing and Prescription (2018) deficits in core muscular endurance is often associated with LBP in individuals, although they concede that the relationship is still slightly unclear, and more research must be performed in this area. Studies in male collegiate athletes with nonspecific LBP demonstrated that they had significantly lower trunk musculature endurance test values, compared to their healthy counterparts (Abdelraouf, 2016). This same study emphasized that a rehabilitation program, especially with the athletic population, should include exercises that increase the muscular endurance of the trunk extensors and flexors, for individuals with nonspecific LBP (Abdelraouf, 2016). Deficits in core muscular strength and endurance have been studied and associated with LBP, and another, arguably more crucial factor at play, is the effect that core muscular flexibility has on LBP.

Flexibility also plays a key role, as a restriction in lateral and hamstring flexibility results in the development of LBP (Sadler S. G., 2017). Studies have shown that in adolescents, poor leg flexibility is a risk factor for developing LBP, and that regular flexibility exercises can provide symptom relief, although flexibility does not seem to reduce the risk of developing LBP (Sandler, 2014). Datta et al. (2014) showed very similar results in their study, as decreased muscle flexibility, was reported to be associated with the development of LBP. Once again, the relationship between flexibility and LBP is still relatively unclear, but it has been shown by studies that there is an association between the development of LBP, and spine and hip flexibility (American College of Sports Medicine, 2018). Decreased muscle flexibility, especially poor hamstrings flexibility has been associated with LBP in cross-sectional studies in both adolescents and adults, yet it is still unclear if poor hamstrings flexibility is a result or a cause of LBP (Feldman, 2001). LBP is obviously a very complex ailment, as each case is very specific and individualized, with multiple factors in play, and historically it has been associated with the aging process, although recently it has been recorded in increasingly younger populations, especially college-aged individuals.

Low Back Pain in College-Aged Individuals

LBP is no longer considered a disease or condition that affects the older populations, as approximately 39.8% of the adolescent population reports LBP (Aggarwal, 2013). Aggarwal et al. (2013) conducted a study utilizing a self-administered questionnaire in an Indian medical college, with 160 random undergraduate medical students that were assessed for one year using a validated questionnaire. This study revealed a 47.5% prevalence of LBP among the students, which was very similar to the 43% rate reported at the University of Colorado, and the 53% rate reported at Paracelsus Medical University (Aggarwal, 2013). Significant associations were found in coffee drinking, body posture, place of study, family history, & carrying backpacks, while no association was seen in weightlifting participation, excessively watching television/working on computers, excessive driving, wearing heels, increased physical activity, or increased BMI (Aggarwal, 2013). A similar study conducted by Nordin et al. (2014) yielded a similar prevalence rate, with 40.3% reporting they were experiencing LBP, and the significantly associated risk factors were age, years of study, fitness level, and hrs. spent sitting per day. Lower incidence of LBP was reported by students of good fitness level, while a higher incidence of LBP was reported in students >23 yrs. old, had studied for >3 yrs., and sat for an average of 4 hrs. per day (Nordin, 2014). Another one-year study with 188 Physical Education and Sports & Exercise Science students, which used a validated questionnaire, determined that LBP was the most frequently reported and treated condition with a prevalence of 32%, with approximately 77% reporting their problem as recurring, and 14% reporting the problem as constant or ongoing

(Brennan, 2007). The only two factors that were significantly associated with an increased prevalence of reported LBP were increased age, and hrs. of physical activity per week (Brennan, 2007). A cross-sectional survey conducted by Issa et al. (2016) with 1000 male students for seven months determined that the prevalence of reported LBP was 30% and that LBP was more common in medical and business administration students. Studying for extended periods of time, academic success, and leading a sedentary lifestyle were all significantly associated with increased prevalence of reported LBP (Issa, 2016). This study also revealed that there was a significant association between LBP and sedentary behavior or less active students, which has been a consistent finding (Issa, 2016). Abdelraouf et al. (2016) conducted a study with 55 male collegiate athletes from a variety of sports and determined that athletes with nonspecific LBP had significantly lower muscular endurance test values, compared to healthy control group. Therefore, this study stressed the importance of core muscular endurance in rehabilitation programs geared towards this population (Abdelraouf, 2016). Other behaviors have also been noted to increase the prevalence of reported in college-age students such as prolonged sitting using a computer/tablet, an uncomfortable mattress, and carrying a heavy backpack (AlShayhan, 2017). LBP across all populations is a very complex process, especially in younger populations, such as college-aged individuals, as there are a variety of factors that can play a role, and this study aims to identify these factors.

CHAPTER III

METHODS

Purpose

The purpose of this study was to evaluate the impact of core strength, endurance, flexibility, body composition, and physical activity on the reported prevalence of LBP in college-aged individuals.

Participants

Participants for the current study were college-aged individuals, both males and females, from the Indiana University of Pennsylvania, to see if determined associations would hold true for both genders. Subjects that were recruited were required to be between the ages of 18-25 yrs. old and have a BMI between 18.5-34.9 kg/m^2. Subjects must not be pregnant, currently taking prescription pain medications for the lower back, have a serious back injury in the past 3 months, or have a previous history of surgeries or serious back injuries that may prove to be debilitating if exercised, as determined by their physician. Collegiate athletes were excluded from the study, to prevent possible influencing factors, such as a competition related injury. A wide variety of subjects were recruited throughout several weeks, considering gender, body composition, demographics, among other variables, to ensure that the results are not biased towards one specific population. Subject recruitment was achieved through word of mouth and visiting classrooms in the Kinesiology, Health, and Sports Science Department. An email was also sent to all students in the department regarding participation, along with creating and hanging flyers around Zink Hall, and the multiple dining and residence halls throughout the campus.

During initial contact with potential participants, the principal investigator explained the purpose of the study and criteria that needed to be met to participate. They were also provided the contact information of the principal investigator if they showed interest in participating. When the subjects contacted the principal investigator, they were provided a more detailed explanation and requirements of the study. Individuals who verbally ensure that they meet the inclusion criteria were asked to meet for a pre-assessment session. Potential participants were notified they are to report for a total of two sessions, for approximately 1-1.5 hrs. in duration, and at least one week of time separating the sessions, which they understood.

Procedures

Session 1 & 2 (Orientation/ Pre-Assessment & Exercise Session)

During the first session (Orientation/Pre-Assessment), all potential participants were asked to report to the James G. Mill Fitness Center in Zink Hall. The orientation and exercise sessions were identical in terms of protocol, with the administration of the questionnaires during the orientation session being the only exception. Subjects were familiarized with the rating scales and questionnaires that were used and provided a list of products/medication to abstain from 48 hrs. prior to the exercise session to ensure there are no outside factors impacted their performance. They were given an overview of the study and explained that it is important to get a good night's sleep, avoid any vigorous activity the day before the protocol.

Questionnaire Administration

Then the subjects completed several questionnaires regarding perceived LBP and reported physical activity. The subjects completed the following questionnaires regarding perceived LBP, the Roland–Morris disability questionnaire 7p, and the revised Oswestry disability index, which only take 15-20 mins. to complete. The questionnaires the subjects were asked to complete regarding reported physical activity were the Modifiable Activity

Questionnaire (MAQ) Past Year Version and the Sedentary Behavior Questionnaire (SBQ) which takes approximately 10-15 mins. to complete.

Body Composition & Physiological Measurements

Resting heart rate (HR) and blood pressure (BP) was then assessed. Participants HR and BP was measured at rest, after the final repetition of each exercise, and at the termination of the session. Subjects were then weighed on a physician's scale, and their height was measured. This tool was used to determine participant's body weight to calculate their BMI, to ensure they fit the BMI criteria. Then the waist circumference of each subject was measured using a spring-loaded vinyl tape measure, placed directly above the iliac crests approximately level with the umbilicus. Finally, the body composition of all the subjects was determined by utilizing a BOD POD machine.

Warm-up

All required procedures and exercises throughout this study were first demonstrated by the principal investigator. The assessment began by performing a warm up on a Precor treadmill, walking for 5 mins. at 3 miles per hour(mph) with a 0% grade. Then, the subjects performed the muscular strength protocol, utilizing only their bodyweight.

Muscular Strength Protocol

All subjects performed both a partial curl-up test and back extension exercises. The partial curl-up test (National Strength & Conditioning Association, 2008), begins with the subject lying supine on a yoga mat on the floor with knees bent at 90°, and feet flat on the floor. The subject's arms and fingers are extended at their sides touching a piece of masking tape, with the second piece of tape placed 12 cm. beyond the first piece. A metronome is set at 40 beats per minute(bpm). At the first beep, the subject lifts their shoulder blades off the floor by contracting the abdomen until their fingertips reach the second piece of tape. At the second beep, the subject slowly returns to the starting position by relaxing the abdomen and flattening the back, completing one full curl-up repetition. Subjects repeat the curl-ups in cadence with the metronome, performing as many as possible without stopping for a maximum of 75 repetitions. If the cadence is broken, the test is terminated, and the number of repetitions is recorded.

The second muscular strength exercise, the back extension begins with the subject lying in a prone position, with the iliac crests at the front edge of the thigh pads of a Roman Chair and the back of the ankles pressing firmly against the ankle pads, while supporting the upper body with the arms, which are placed on the available handles. A metronome is set at 35 bpm, and the subject lifts the torso until it is parallel to the floor and in line with the legs, releasing their grip on the handles, and crosses their arms over the chest. At the first beep, the subject relaxes their low back muscles, hinge at the hips, creating approximately a 90° angle, as the upper body descends towards the floor. At the second beep, the subject slowly returns the upper body to its starting position, by contracting the muscles of the low back and returning the spine to a neutral position, which would complete one back extension repetition. Subjects repeated the back extensions, maintaining the tempo set by the metronome, performing as many as possible without stopping, for a maximum of 75 repetitions. If the cadence is broken, the test is terminated, and the number of repetitions is recorded.

Muscular Endurance Protocol

Subjects then performed the McGill's Torso Muscular Endurance Test Battery (American Council on Exercise, 2015), which consists of the three following individual exercises, trunk flexor endurance test, trunk lateral endurance test, and the trunk extensor endurance test. The trunk flexor endurance test aims to assess the muscular endurance of the deep core muscles, such as the transverse abdominis, and erector spinae. It is a timed test involving a static, isometric contraction of the spinal stabilizing muscles, which the individual maintains until they exhibit fatigue or can no longer hold the starting position. The subjects start seated on a yoga mat placed on the floor with the hips and knees bent to 90°, with the hips, knees, and the second toe all aligned. Then the subject folds their arms across their chest, and they lean against a board positioned at a 60° incline, while the head maintains a neutral position. The feet may be anchored by a strap or manually. It is important the subjects understand that they maintain this neutral spine position after the board is removed until they experience fatigue in the engaged abdominal muscles, or the back begins to arch, which leads to the termination of the test. The subject's goal is to maintain this position for as long as possible without the back-support assistance. A stopwatch is started when the board is removed, stopped when there is a noticeable change in the trunk or spinal position, and the final time was recorded.

The trunk lateral endurance test was administered next, which assesses muscular endurance of the lateral core muscles such as the obliques, quadratus lumborum, and erector spinae muscles. This is a timed test that involves static, isometric contractions of the lateral muscles that stabilize the spine. Subjects start in a position that requires them to lie on the floor on a yoga mat on their side, extended legs, align the feet on top of each other or in a heel-to-toe position, the lower arm is placed under the body and the upper arm on the side of the body. When the subject is ready, they assumed a full side-bridge position, keeping both legs extended, the sides of the feet on the floor, the elbow of the lower arm should be positioned directly under the shoulder with the forearm facing out, and the upper arm should be resting along the side of the body. The hips should be elevated off the mat and the body should be in straight alignment, and the body is only supported by the subject's feet and forearm. The goal of the test is to hold this position for as long as possible, with a stopwatch being started when the client moves into the side-bridge position and terminated when this position is broken. This time is then recorded, and the test is repeated on the opposite side following the same protocol.

The third a final exercise in this protocol is the trunk extensor endurance test, which is used to assess the muscular endurance of the torso extensor muscles, such as the erector spinae, longissimus, and multifidi. Like its counterparts, this is a timed test involving a static, isometric contraction of the trunk extensor muscles that stabilize the spine. Subject assume the starting prone position, with the iliac crests at the front edge of the thigh pads of a Roman Chair and the back of the ankles pressing firmly against the ankle pads, while supporting the upper body with the arms, which are placed on the available handles. The subject's objective is to hold a horizontal, prone position for as long as possible, so when the subject is ready they lift their torso until it is parallel to the floor and in line with the legs, releases their grip on the handles, and crosses their arms over the chest. Once this position is assumed the stopwatch was started, but once they can no longer maintain this position the test was terminated, and time recorded.

Physiological Measurements & Perception Ratings

Immediately following the final repetition of all the exercises, clients were asked to rate the perception of pain and effort, their HR and BP was measured, and rested for 3 mins. between all exercises. A blood pressure cuff and sphygmomanometer were used to determine subject resting and exercise BP, while a Polar FT1 Heart Rate Monitor™ was used to determine HR**.** An OMNI rating of perceived exertion (RPE) scale and pain perception (PP) scale were used to help assess the subjects throughout the protocol**.** Participants were asked to rate their OMNI RPE and PP following the final failed repetition of each exercise.

Flexibility Protocol

Subjects then performed a sit-and-reach test to determine the flexibility of the lower back and hamstrings. This test requires the subjects to remove their shoes, sit on the floor with legs extended out straight, where the soles of the feet are placed flat against the sit-and-reach box, approximately 6 in. apart from each other, which was necessary to execute the test, and to determine the flexibility of the subject (American College of Sports Medicine, 2018). With both legs completely straight, the knees locked, and hands on top of each other with palms facing downwards, the subject reaches forward as far as possible along the measuring line. The subject must maintain this position for 2 secs., and the furthest distance reached by the hand was recorded to the nearest centimeter or half an inch.

Cool-down

At the end of the exercise session, clients were taken through a cool down which consisted of light stretching of the core and legs. All repetitions and resistances used were documented and used as the baseline for the exercise session. The orientation session took approximately 1.5-2 hrs., which included surveys, and several protocols. The exercise session lasted approximately 1-1.5 hrs., which did not require the subjects to complete the questionnaire and took place at least one week after the first session, but no more than 2 weeks(wks.). This concluded the exercise sessions.

Instrumentation

Low Back Pain Questionnaires

The Roland-Morris disability questionnaire 7p (Appendix E) is scored based on the response which is placed on a scale ranging from 0 to 6, which represents, ‘disagree totally’ to, ‘agree totally.’ The final questionnaire score is expressed as percentages of the total possible score with higher scores representing greater disability (Longo, 2010). The revised Oswestry disability index (Appendix F) consists of these 10 sections, pain intensity, personal care, lifting, walking, sitting, standing, sleeping, social life, traveling and changing degree of pain (Longo, 2010). Each section contains six statements that the subjects answered with a score ranging from 0 to 5, and the final score is determined using a standard scoring method.

Physical Activity Questionnaires

The MAQ (Appendix G) is both a reliable and valid assessment tool that aims to assess current leisure activities over the past year, with physical activity is calculated as the product of the duration and the frequency of each activity (hr./wk.), weighted by an estimate of MET of that activity, and summed for all activities performed (Newman, 2009). All this data was expressed in MET-hours per week (MET*hr./wk.). The SBQ (Appendix H) is designed to measure the amount of time spent performing nine sedentary behaviors throughout the week. These items are completed separately for weekdays and weekend days. Results of the all the completed questionnaires were kept secret from the principal investigator and subject until both sessions have been conducted, and all data is collected.

Scales

An OMNI Perceived Exertion Scale for Resistance Exercise (Appendix C) is a numerical and visual scale rated from 0-10 used to assess exertional perceptions of various population cohorts engaged in dynamic exercise modes including walking/running, stepping, cycling, and resistance exercise, to rate how much muscular effort they feel (Mays, 2010). A Pain Perception Scale (Appendix D) is a numerical scale rated from 0-10 that is defined as the intensity of pain that the individual feels. Subjects are asked to verbally state the number between 0 and 10 that fits best to their pain intensity, after the termination of each exercise. A rating of 0 represents 'no pain at all' whereas a rating of 10 represents 'extremely intense pain.'

Body Composition & Physiological Measurement Tools

A Polar FT1 Heart Rate Monitor^{TM} was used to measure heart rate at rest and during exercise. This monitor consists of a transmitter that is fastened to an elastic strap worn below the chest muscles and a watch worn around the wrist. There are two grooved electrodes on the back of the transmitter that transmits the heart rate signal to the watch where the heart rate is displayed. A blood pressure cuff was used to determine BP, which is a tool used to assess systolic and diastolic BP. It is commonly referred to as an aneroid sphygmomanometer. A physician's scale is used to measure an individual's height and weight. The scale used in this study is in the James G. Mill Fitness center. A spring-loaded vinyl tape measure was used to measure each subject's waist circumference, which is a cheap and effective way to measure body lengths and circumferences. A BOD POD Gold Standard Body Composition Tracking System machine was used to measure everyone's fat-free mass using air displacement plethysmography and required the subjects to wear compression shorts, cap, and bra if necessary. Subjects sat inside the machine for approximately 5 mins., remaining perfectly still as the machine goes through the process of assessing the subjects approximate body fat percentage, based on the information given.

Fitness Equipment

The Precor Treadmill E956I ™ used, is a cardiovascular machine with a continuous belt that allows individuals to walk or run while adjusting the grade. A sit-n-reach box is a valid, clinically utilized tool, that is used to determine the flexibility of the hamstrings and lower back of the individual. A roman chair is a piece of exercise equipment mainly used to target the lower back but can target other muscles like the abdominals, and hamstrings. A yoga mat that is used as an aid during the practice of yoga to prevent hands and feet slipping. The ACCUSPLIT Survivor III S3MAGXLBK Stopwatch ™ was used to time all necessary protocols throughout the study. This is a watch with a digital display that can be started and stopped at will for exact timing. The metronome application by Soundbrenner on a mobile device was used during the muscular strength protocols. All the data collected during both sessions was recorded on a specialized data sheet (Appendix I) developed by the researcher.

Statistical Analyses

The study design is a double-blind, cross-sectional survey design with both qualitative and quantitative dimensions. After the collection of all the data, individuals were classified into two different perceived back pain groups, Little/No Low Back Pain, and Moderate Back Pain, based on the results of their questionnaires. Once stratified their performance on the four exercises, flexibility test, and body composition was compared to one another, analyzing differences between core strength, endurance, flexibility, and body composition in the three groups. All data was assessed for normality, with normal data being presented as a mean and standard deviation, non-normal data presented as a median and interquartile range, with the 25th and 75th percentiles and categorical data as proportions. Collected data was categorized and examined by gender, to determine if any differences exist in height, weight, physical activity level, flexibility, endurance, among all other variables that are being measured. Comparisons between genders were assessed using a two-sample t-test or the Wilcoxon test, while categorical variables were assessed using the Pearson chi-square test. Descriptive characteristics were used to describe the demographics and anthropometric data of the study population. Pearson or Spearman correlations were used to assess the relationship or association between each client's questionnaire results and their scores on the fitness assessments and evaluations. SPSS Statistics 24 software was used to organize and represent all the data collected throughout the protocol.

CHAPTER IV

RESULTS

Descriptive Statistics

Subjects were eligible to participate in the study if they were between the ages of 18-25 yrs. old, had a BMI between 18.5-34.9 kg/m^2, a current Indiana University of Pennsylvania student, not pregnant, not a college athlete, currently taking prescription pain medications for the lower back, have a serious back injury in the past 3 months, or have a previous history of surgeries or serious back injuries that may prove to be debilitating if exercised, as determined by their physician. Out of 26 total participants that met these criteria, 11 subjects were male and 15 were female. Table 1 reports the participant physical characteristics.

Table 1

Descriptive Statistics of the Subjects (26)

	N	Minimum	Maximum	Mean	Std. Deviation
Age (yrs.)	26	19	25	22.12	1.451
Height (in.)	26	62.00	73.75	66.9904	3.27680
Weight (lbs.)	26	117	230	163.08	26.072
Body Mass Index (kg/m^2)	26	21.25	31.29	25.4358	2.79708
% Body Fat	26	12.6	39.6	24.327	7.2889
Waist Circumference (in.)	26	24.50	40.00	29.8846	3.38912
Resting Systolic BP (mmHg)	26	98	126	109.69	7.604
Resting Diastolic BP (mmHg)	26	58	78	67.00	5.886
Resting HR (bpm)	26	51	123	75.19	14.461
Resting RPE	26	6	7	6.19	.402
Resting PP	26	.0	2.0	.385	.6528

Participants were between the ages of 18 and 25 years (M = 22.12 years, SD ± 1.45) with a BMI of 18.5 to 34.9 kg/m^2 (M = 25.44 kg/m^2, SD ± 2.80 kg/m^2). Among all 26 subjects, the mean height was 66.99 ± 3.28 in., the mean body fat percentage was 24.33 ± 7.29 percent fat, the mean weight was 163.08 ± 26.07 lbs., and the mean waist circumference was 29.89 ± 3.39 in (Table 1). Therefore, according to these results and the BMI categories, 14 of these subjects classified as Normal weight, while 9 were overweight and 3 were classified as Obese (Class 1).

Prior to their participation in the necessary exercise protocols, resting physiological measurements were taken for each subject, such as systolic and diastolic BP, HR, RPE, and PP. Table 1 also reports these resting measurements that were taken from the subjects throughout the study. The mean systolic BP of the subjects was 109.69 ± 7.60 mmHg, while the mean diastolic BP was 67 ± 5.89 mmHg. According to the data collected the mean resting HR was 75.19 ± 14.46 bpm, the resting RPE was 6.19 ± 0.40, and the mean resting PP was 0.39 ± 0.65 (Table 1).

To assess each subjects level of LBP two separate questionnaires were used, and according to the Roland-Morris Disability Questionnaire, 20 subjects were classified as having "Little/No LBP," and 6 were classified as having "Moderate LBP," so no subjects were categorized as having "Severe LBP" (Table 2).

Table 2

Roland-Morris Disability Questionnaire Results of the Subjects (26)

		Frequency	Percent	Valid Percent	Cumulative %
Valid	Little/No LBP	20	76.9	76.9	76.9
	Moderate LBP	6	23.1	23.1	100.0
	Total	26	100.0	100.0	

According to the Revised Oswestry Disability Index, the other questionnaire utilized, there were no subjects with "severe LBP, while 18 subjects were regarded as having "Little/No LBP," and the other 8 subjects had "Moderate LBP" (Table 3).

Table 3

Revised Oswestry Disability Index Results of the Subjects (26)

		Frequency	Percent	Valid Percent	Cumulative %
Valid	Little/No LBP	18	69.2	69.2	69.2
	Moderate LBP	8	30.8	30.8	100.0
	Total	26	100.0	100.0	

Core Strength

Hypothesis #1 states that individuals with low core strength, as determined by the muscular strength protocol, will have a higher prevalence of reported LBP. A t-test was conducted on each questionnaire utilized to analyze each gender individually to determine if there was a significant association between a low core strength and LBP. The tests reported there was no significant difference between individuals with Little/No LBP and Moderate LBP and their overall core strength. This held true for both genders and both questionnaires. According to the results from the subjects with Little/No and Moderate LBP that completed the Roland-Morris Disability Questionnaire those with Little/No LBP completed a mean of 29.63 ± 11.54 reps (Table 4), and those with Moderate LBP completed a mean of 31.22 ± 11.66 reps (Table 4), so this was not a statistically significant difference ($t = -0.295$, $p = 0.770$) (Table 5).

Table 4

Core Strength of the Subjects (26) According to the RMDQ

Roland-Morris Disability Questionnaire Results		N	Mean	Std. Deviation
Core Strength	Little/No LBP	20	29.6275	11.54342
	Moderate LBP	6	31.2167	11.65790

Table 5

Core Strength Significance According to the RMDQ

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Core Strength	Equal variances assumed	-.295	.770

Considering the subjects that completed the Revised Oswestry Disability Index there was not a significant difference in core strength (t = -0.490, p = 0.629) (Table 7), as the subjects with Little/No LBP completed a mean of 29.56 ± 12.48 reps, and those with Moderate LBP completed a mean of 31.66 ± 8.79 reps (Table 6).

Table 6

Core Strength of the Subjects (26) According to the RODI

Revised Oswestry Disability Index Results		N	Mean	Std. Deviation
Core Strength	Little/No LBP	18	29.2556	12.48444
	Moderate LBP	8	31.6563	8.79442

Table 7

Core Strength Significance According to the RODI

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Core Strength	Equal variances assumed	-.490	.629

According to the results from the males with Little/No and Moderate LBP that completed the Roland-Morris Disability Questionnaire subjects with Little/No LBP completed a mean of 26.04 ± 11.79 reps, and subjects with Moderate LBP completed a mean of 30.38 ± 10.89 reps (Table 8), so this was not a statistically significant difference (t = -0.601, p = 0.563) (Table 9).

Table 8

Core Strength of the Males (11) According to the RMDQ

Roland-Morris Disability Questionnaire Results		N	Mean	Std. Deviation
Core Strength	Little/No LBP	7	26.0429	11.78454
	Moderate LBP	4	30.3750	10.89384

Table 9

Core Strength Significance of the Males (11) According to the RMDQ

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Core Strength	Equal variances assumed	-.601	.563

For males that completed the Revised Oswestry Disability Index there was also not a significant difference in core strength (t = -1.578, p = 0.149) (Table 11), as the males with Little/No LBP completed a mean of 23.89 ± 12.24 reps, and those with Moderate LBP completed a mean of 34.15 ± 4.84 reps (Table 10).

Table 10

Core Strength of the Males (11) According to the RODI

Revised Oswestry Disability Index Results		N	Mean	Std. Deviation
Core Strength	Little/No LBP	7	23.8857	12.23801
	Moderate LBP	4	34.1500	4.83942

Table 11

Core Strength Significance of the Males (11) According to the RODI

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Core Strength	Equal variances assumed	-1.578	.149

While according to the results from the females with Little/No and Moderate LBP that completed the Roland-Morris Disability Questionnaire those with Little/No LBP completed a mean of 31.56 ± 11.40 reps, and those with Moderate LBP completed a mean of 32.90 ± 17.75 reps (Table 12), so this was not a significant difference (t = -0.147, p = 0.885) (Table 13).

Table 12

Core Strength of the Females (15) According to the RMDQ

Roland-Morris Disability Questionnaire Results		N	Mean	Std. Deviation
Core Strength	Little/No LBP	13	31.5577	11.40223
	Moderate LBP	2	32.9000	17.74838

Table 13

Core Strength Significance of the Females (15) According to the RMDQ

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Core Strength	Equal variances assumed	-.147	.885

For females that completed the Revised Oswestry Disability Index there was also not a significant difference in core strength (t = 0.505, p = 0.622) (Table 15), as the females with Little/No LBP completed a mean of 32.67 ± 11.92 reps, and those with Moderate LBP completed a mean of 29.16 ± 11.85 reps (Table 14).

Table 14

Core Strength of the Females (15) According to the RODI

Revised Oswestry Disability Index Results		N	Mean	Std. Deviation
Core Strength	Little/No LBP	11	32.6727	11.91945
	Moderate LBP	4	29.1625	11.85161

Table 15

Core Strength Significance of the Females (15) According to the RODI

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Core Strength	Equal variances assumed	.505	.622

Core Endurance

Hypothesis #2 states that individuals with low core endurance, as determined by the muscular endurance protocol, will have a higher prevalence of reported LBP. A t-test was conducted on each questionnaire utilized to analyze each gender individually, to determine if there was a significant association between low core endurance and LBP. The tests reported there was no significant difference between individuals with Little/No LBP and Moderate LBP and their overall core endurance. This held true for both genders and both questionnaires. Considering the subjects that completed the Roland-Morris Disability Questionnaire there was not a significant difference in core endurance (t = -0.018, p = 0.985) (Table 17), as the subjects with Little/No LBP completed a mean time of 2.10 ± 1.01 mins., and those with Moderate LBP completed a mean time of 2.11 ± 0.93 mins (Table 16).

Table 16

Core Endurance of the Subjects (26) According to the RMDQ

Roland-Morris Disability Questionnaire Results		N	Mean	Std. Deviation
Core Endurance	Little/No LBP	20	2.1028	1.00833
	Moderate LBP	6	2.1113	.93354

Table 17

Core Endurance Significance of the Subjects (26) According to the RMDQ

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Core Endurance	Equal variances assumed	-.018	.985

According to the results from the subjects with Little/No and Moderate LBP that completed the Revised Oswestry Disability Index those with Little/No LBP completed a mean time of 2.07 ± 1.08 mins., and those with Moderate LBP completed a mean time of 2.18 ± 0.75 mins. (Table 18), so this was not a statistically significant difference (t = -0.260, p = 0.797) (Table 19).

Table 18

Core Endurance of the Subjects (26) According to the RODI

Core Endurance of the Subjects (26) According to the RODI

Revised Oswestry Disability Index Results		N	Mean	Std. Deviation
Core Endurance	Little/No LBP	18	2.0710	1.07730
	Moderate LBP	8	2.1806	.74445

Table 19

Core Endurance Significance of the Subjects (26) According to the RODI

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Core Endurance	Equal variances assumed	-.260	.797

According to the results, males classified as Little/No and Moderate LBP that completed the Roland-Morris Disability Questionnaire those with Little/No LBP completed a mean time of

2.06 ± 0.88 mins., and those with Moderate LBP completed a mean time of 1.75 ± 0.74 mins. (Table 20), so this was not a statistically significant difference (t = 0.610, p = 0.557) (Table 21).

Table 20

Core Endurance of the Males (11) According to the RMDQ

Roland-Morris Disability Questionnaire Results		N	Mean	Std. Deviation
Core Endurance	Little/No LBP	7	2.0629	.87574
	Moderate LBP	4	1.7450	.73464

Table 21

Core Endurance Significance of the Males (1) According to the RMDQ

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Core Endurance	Equal variances assumed	.610	.557

For males that completed the Revised Oswestry Disability Index there was also not a significant difference in core endurance (t = -0.104, p = 0.919) (Table 23), as the males with Little/No LBP completed a mean time of 1.93 ± 0.92 mins., and those with Moderate LBP completed a mean time of 1.98 ± 0.70 mins (Table 22).

Table 22

Core Endurance of the Males (11) According to the RODI

Core Endurance of the Males (11) According to the RODI				
Revised Oswestry Disability Index Results		N	Mean	Std. Deviation
Core Endurance	Little/No LBP	7	1.9271	.91465
	Moderate LBP	4	1.9825	.69533

Table 23

Core Endurance Significance of the Males (11) According to the RODI

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Core Endurance	Equal variances assumed	-.104	.919

While according to the results from the females with Little/No and Moderate LBP that completed the Roland-Morris Disability Questionnaire those with Little/No LBP completed a mean time of 2.12 ± 1.11 mins, and those with Moderate LBP completed a mean time of 2.84 ± 1.06 mins (Table 24), so this was not a significant difference (t = -0.859, p = 0.406) (Table 25).

Table 24

Core Endurance of the Females (15) According to the RMDQ

Roland-Morris Disability Questionnaire Results		N	Mean	Std. Deviation
Core Endurance	Little/No LBP	13	2.1242	1.10676
	Moderate LBP	2	2.8438	1.06243

Table 25

Core Endurance Significance of the Females (15) According to the RMDQ

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Core Endurance	Equal variances assumed	-.859	.406

For females that completed the Revised Oswestry Disability Index there was also not a significant difference in core endurance (t = -0.328, p = 0.748) (Table 27), as the females with Little/No LBP completed a mean time of 2.16 ± 1.20 mins, and those with Moderate LBP completed a mean time of 2.38 ± 0.84 mins (Table 26).

Table 26

Core Endurance of the Females (15) According to the RODI

Revised Oswestry Disability Index Results		N	Mean	Std. Deviation
Core Endurance	Little/No LBP	11	2.1625	1.20304
	Moderate LBP	4	2.3788	.83963

Table 27

Core Endurance Significance of the Females (15) According to the RODI

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Core Endurance	Equal variances assumed	-.328	.748

Core Flexibility

Hypothesis #3 states that individuals with decreased lower back and hamstring flexibility, assessed by the results of the sit-and-reach test, will have a higher prevalence of reported LBP. A t-test was conducted on each questionnaire utilized to analyze each gender individually to determine if there was a significant association between decreased lower back and hamstring flexibility and LBP. Subjects were classified and ranked into flexibility groups, as determined by the sit-and-reach specifications, where a score of 1 = "Poor," 2 = "Fair," 3 = "Good," 4 = "Very Good," and 5 = "Excellent." The tests reported there was no significant difference between individuals with Little/No LBP and Moderate LBP, and their overall lower back and hamstring flexibility. This held true for both genders and both questionnaires. According to the results from the subjects with Little/No and Moderate LBP that completed the Roland-Morris Disability Questionnaire those with Little/No LBP had a mean flexibility score of 4.30 ± 1.34, and those with Moderate LBP had a mean score of 4.17 ± 1.33 (Table 28), so this was not a statistically significant difference ($t = 0.214$, $p = 0.832$) (Table 29).

Table 28

Core Flexibility of the Subjects (26) According to the RMDQ

Roland-Morris Disability Questionnaire Results		N	Mean	Std. Deviation
Flexibility	Little/No LBP	20	4.3000	1.34164
	Moderate LBP	6	4.1667	1.32916

Table 29

Core Flexibility Significance of the Subjects (26) According to the RMDQ

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Flexibility	Equal variances assumed	.214	.832

Considering the subjects that completed the Revised Oswestry Disability Index there was not a significant difference in lower back and hamstring flexibility (t = -0.269, p = 0.790) (Table 31), as the subjects with Little/No LBP had a mean flexibility score of 4.22 ± 1.40, and those with Moderate LBP had a mean flexibility score of 4.38 ± 1.19 (Table 30).

Table 30

Core Flexibility of the Subjects (26) According to the RODI

Revised Oswestry Disability Index Results		N	Mean	Std. Deviation
Flexibility	Little/No LBP	18	4.2222	1.39560
	Moderate LBP	8	4.3750	1.18773

Table 31

Core Flexibility Significance of the Subjects (26) According to the RODI

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Flexibility	Equal variances assumed	-.269	.790

According to the results from the males with Little/No and Moderate LBP that completed the Roland-Morris Disability Questionnaire those with Little/No LBP had a mean flexibility score of 3.71 ± 1.89, and those with Moderate LBP had a mean flexibility score of 3.75 ± 1.50 (Table 32), so this was not a statistically significant difference (t = -0.032, p = 0.975) (Table 33).

Table 32

Core Flexibility of the Males (11) According to the RMDQ

Roland-Morris Disability Questionnaire Results		N	Mean	Std. Deviation
Flexibility	Little/No LBP	7	3.7143	1.88982
	Moderate LBP	4	3.7500	1.50000

Table 33

Core Flexibility Significance of the Males (11) According to the RMDQ

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Flexibility	Equal variances assumed	-.032	.975

For the males that completed the Revised Oswestry Disability Index there was not a significant difference detected in lower back and hamstring flexibility (t = 1.176, p = 0.270) (Table 35), as the males with Little/No LBP had a mean flexibility score of 3.29 ± 1.89, and those with Moderate LBP had a mean flexibility score of 4.50 ± 1.00 (Table 34).

Table 34

Core Flexibility of the Males (11) According to the RODI

Revised Oswestry Disability Index Results		N	Mean	Std. Deviation
Flexibility	Little/No LBP	7	3.2857	1.88982
	Moderate LBP	4	4.5000	1.00000

Table 35

Core Flexibility Significance of the Males (11) According to the RODI

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Flexibility	Equal variances assumed	-1.176	.270

According to the results from the females with Little/No and Moderate LBP that completed the Roland-Morris Disability Questionnaire those with Little/No LBP had a mean flexibility score of 4.62 ± 0.87, and those with Moderate LBP had a mean flexibility score of 5.00 ± 0.00 (Table 36), so this was not a significant difference (t = -0.606, p = 0.555) (Table 37).

Table 36

Core Flexibility of the Females (15) According to the RMDQ

Roland-Morris Disability Questionnaire Results		N	Mean	Std. Deviation
Flexibility	Little/No LBP	13	4.6154	.86972
	Moderate LBP	2	5.0000	.00000

Table 37

Core Flexibility Significance of the Females (15) According to the RODI

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Flexibility	Equal variances assumed	-.606	.555

While for females that completed the Revised Oswestry Disability Index there was also not statistically significant difference found between the groups in lower back and hamstring flexibility ($t = 1.212$, $p = 0.247$) (Table 39), as the females with Little/No LBP had a mean flexibility score of 4.82 ± 0.41, and those with Moderate LBP had a mean flexibility score of 4.25 ± 1.50 (Table 38).

Table 38

Core Flexibility of the Females (15) According to the RODI

Revised Oswestry Disability Index Results		N	Mean	Std. Deviation
Flexibility	Little/No LBP	11	4.8182	.40452
	Moderate LBP	4	4.2500	1.50000

Table 39

Core Flexibility Significance of the Females (15) According to the RODI

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Flexibility	Equal variances assumed	1.212	.247

Reported Physical Activity Level & Sedentary Behavior

Hypothesis #4 states that individuals that report low levels of self-reported physical activity, assessed by the Modifiable Activity Questionnaire and Sedentary Behavior Questionnaire, will have a higher prevalence of reported LBP. Since the data collected by the Modifiable Activity Questionnaire and the Sedentary Behavior Questionnaire was not normally distributed, the median and interquartile range is reported. According to the results yielded by the Modifiable Activity Questionnaire subjects spent a median of 37.73 ± 30.42 MET*hr./wk. being physically active (Table 40).

Table 40

Physical Activity Level of the Subjects (26)

		Statistic	Std. Error
Modifiable Activity Questionnaire Results	Median	37.7250	
	Interquartile Range	30.42	
	Skewness	.580	.456

While according to the Sedentary Behavior Questionnaire these same subjects spent a median of 7.00 ± 3.25 hrs. (Table 41) participating in sedentary behaviors daily.

Table 41

Sedentary Behavior of the Subjects (26)

		Statistic	Std. Error
Sedentary Behavior Questionnaire Results	Median	7.0000	
	Interquartile Range	3.25	
	Skewness	1.134	.456

Also, independent samples non-parametric tests were conducted on each activity assessment tool utilized, to determine if there was a significant association between physical activity and LBP. These tests determined there was not a significant difference between individuals with Little/No LBP and Moderate LBP, and their participation in physical activity or sedentary behaviors. This held true for both the Modifiable Activity Questionnaire and the Sedentary Behavior Questionnaire. Considering the subjects that completed the Roland-Morris Disability Questionnaire there was not a significant difference in reported physical activity level according to the Modifiable Activity Questionnaire ($p = 1.000$), which also holds true for the Revised Oswestry Disability ($p = 1.000$) (Table 42). Therefore, the null hypothesis is retained.

Table 42

Physical Activity Level Significance of the Subjects (26)

Null Hypothesis	Test	Sig.	Decision
The Medians of the MAQ Results are the same across categories of the RMDQ Results	Independent Samples Median Test	1.000	Retain the null hypothesis
The Medians of the MAQ Results are the same across categories of the RODI Results	Independent Samples Median Test	1.000	Retain the null hypothesis

When analyzing the subjects that completed the Roland-Morris Disability Questionnaire there was not a significant difference in reported sedentary behavior according to the Sedentary Behavior Questionnaire (p = 0.645), which also holds true for the Revised Oswestry Disability (p = 0.673) (Table 43). So, the null hypothesis was retained in both these scenarios as well.

Table 43

Physical Activity Level Significance of the Subjects (26)

Null Hypothesis	Test	Sig.	Decision
The Medians of the SBQ Results are the same across categories of the RMDQ Results	Independent Samples Median Test	0.645	Retain the null hypothesis
The Medians of the SBQ Results are the same across categories of the RODI Results	Independent Samples Median Test	0.673	Retain the null hypothesis

Body Composition

Hypothesis #5 states that individuals with higher body fat percentage, as assessed by a BOD POD machine, will have a higher prevalence of reported LBP. A t-test was conducted on each questionnaire utilized to analyze each gender individually, to determine if there was a significant association between increased body fat percentage ranking and LBP. Subjects were classified and ranked into body fat percentage groups, as determined by the BOD POD machine specifications, where a score of 1 = “Risky (high body fat),” 2 = “Excess Fat,” 3 = “Moderately Lean,” 4 = “Lean,” 5 = “Ultra Lean,” and 6 = “Risky (low body fat).” The tests reported there was no significant difference between individuals with Little/No LBP and Moderate LBP, and their overall body fat percentage. This held true for both genders and both questionnaires. Considering the subjects that completed the Roland-Morris Disability Questionnaire there was not a significant difference in body fat percentage ranking (t = 0.909, p = 0.373) (Table 45), as the subjects with Little/No LBP had a mean body fat percentage rank of 4.20 ± 0.768, and those with Moderate LBP had a mean body fat percentage rank of 3.83 ± 1.17 (Table 44).

Table 44

Body Composition of the Subjects (26) According to the RMDQ

Roland-Morris Disability Questionnaire Results		N	Mean	Std. Deviation
Body Fat % Ranking	Little/No LBP	20	4.20	.768
	Moderate LBP	6	3.83	1.169

Table 45

Body Composition Significance of the Subjects (26) According to the RMDQ

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Body Fat % Ranking	Equal variances assumed	.909	.372

According to the results from the subjects with Little/No and Moderate LBP that completed the Revised Oswestry Disability Index those with Little/No LBP had a mean body fat percentage rank of 4.28 ± 0.83, and those with Moderate LBP had a mean body fat percentage rank of 3.75 ± 0.89 (Table 46), so this was not a statistically significant difference (t = 1.471, p = 0.154) (Table 47).

Table 46

Body Composition of the Subjects (26) According to the RODI

Revised Oswestry Disability Index Results		N	Mean	Std. Deviation
Body Fat % Ranking	Little/No LBP	18	4.28	.826
	Moderate LBP	8	3.75	.886

Table 47

Body Composition Significance of the Subjects (26) According to the RODI

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Body Fat % Ranking	Equal variances assumed	1.471	.154

Although, when the genders were analyzed separately one statistically significant result was yielded among the females tested. According to the results from the males with Little/No and Moderate LBP that completed the Roland-Morris Disability Questionnaire those with Little/No LBP had a mean body fat percentage rank of 4.29 ± 0.49, and those with Moderate LBP had a mean body fat percentage rank of 4.50 ± 0.58 (Table 48), so this was not a statistically significant difference (t = -0.658, p = 0.975) (Table 49).

Table 48

Body Composition of the Males (11) According to the RMDQ

Roland-Morris Disability Questionnaire Results		N	Mean	Std. Deviation
Body Fat % Ranking	Little/No LBP	7	4.29	.488
	Moderate LBP	4	4.50	.577

Table 49

Body Composition Significance of the Males (11) According to the RMDQ

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Body Fat % Ranking	Equal variances assumed	-.658	.527

For males that completed the Revised Oswestry Disability Index there was also not a significant difference in fat percentage ranking (t = 0.544, p = 0.599) (Table 51), as the males with Little/No LBP had a mean body fat percentage rank of 4.43 ± .54, and those with Moderate LBP had a mean body fat percentage rank of 4.25 ± 0.50 (Table 50).

Table 50

Body Composition of the Males (11) According to the RODI

Revised Oswestry Disability Index Results		N	Mean	Std. Deviation
Body Fat % Ranking	Little/No LBP	7	4.43	.535
	Moderate LBP	4	4.25	.500

Table 51

Body Composition Significance of the Males (11) According to the RODI

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Body Fat % Ranking	Equal variances assumed	.544	.599

While according to the results from the females with Little/No and Moderate LBP that completed the Roland-Morris Disability Questionnaire those with Little/No LBP had a mean body fat percentage rank of 4.15 ± 0.90, and those with Moderate LBP had a mean body fat percentage rank of 2.50 ± 0.707 (Table 52), which is a statistically significant difference (t = 2.459, p = 0.029) (Table 53).

Table 52

Body Composition of the Females (15) According to the RMDQ

Roland-Morris Disability Questionnaire Results		N	Mean	Std. Deviation
Body Fat % Ranking	Little/No LBP	13	4.15	.899
	Moderate LBP	2	2.50	.707

Table 53

Body Composition Significance of the Females (15) According to the RMDQ

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Body Fat % Ranking	Equal variances assumed	2.459	.029

Although, for females that completed the Revised Oswestry Disability Index there was also not a significant difference in body fat percentage ranking (t = 1.635, p = 0.126) (Table 55), as the females with Little/No LBP had a mean body fat percentage rank of 4.18 ± 0.98, and those with Moderate LBP had a mean body fat percentage rank of 3.25 ± 0.84 (Table 54).

Table 54

Body Composition of the Females (15) According to the RODI

Revised Oswestry Disability Index Results		N	Mean	Std. Deviation
Body Fat % Ranking	Little/No LBP	11	4.18	.982
	Moderate LBP	4	3.25	.957

Table 55

Body Composition Significance of the Females (15) According to the RODI

Levene's Test for Equality of Variances: t-tests for Equality Means			
		t	Sig. (2-tailed)
Body Fat % Ranking	Equal variances assumed	1.635	.126

Correlations

Statistical correlations between all the variables in question for both genders determined that there was a statistically significant correlation between body fat percentage ranking and core strength (p = 0.016) and between body fat percentage ranking and core endurance (p = 0.001) (Table 56). The correlation between body fat percentage rank and core strength classifies as a negative moderately strong correlation (Pearson Correlation = -0.467), while the correlation between body fat percentage rank and core endurance also classifies as a negative moderately strong correlation (Pearson Correlation = -0.599) (Table 56).

Table 56

Body Fat % Ranking Correlations

		Core Strength	Core Endurance
Body Fat % Ranking	Pearson Correlation	$-.467^{*}$	$-.599^{**}$
	Sig. (2-tailed)	.016	.001
	N	26	26

There were several other statistically significant correlations also detected. Core strength and endurance were significantly correlated (p = 0.000) to each other, and core strength was also significantly correlated to the subject's flexibility score on the sit-and-reach test (p= 0.004) (Table 57). The correlation between core strength and core endurance classifies as a positive strong correlation (Pearson Correlation = 0.700), while the correlation between core strength and flexibility classifies as a positive moderately strong correlation (Pearson Correlation = 0.548) (Table 57).

Table 57

Core Strength Correlations

		Core Endurance	Flexibility
Core Strength	Pearson Correlation	.700**	.548**
	Sig. (2-tailed)	.000	.004
	N	26	26

The Roland-Morris Disability Questionnaire and the Revised Oswestry Disability Questionnaire were also significantly correlated (p = 0.001). This correlation, between the two LBP questionnaire utilized, classifies as a positive moderately strong correlation (Pearson Correlation = 0.624) (Table 58), so the results yielded by both are considered valid and reliable.

Table 58

LBP Questionnaire Correlations

		Revised Ostwestry Disability Index
Roland-Morris Disability Questionnaire	Pearson Correlation	.624**
	Sig. (2-tailed)	.001
	N	26

There did not appear to be any significant statistical correlations between reported physical activity level and any of the other variables in question, or between reported sedentary behavior and any of these same variables. Reported physical activity level and reported sedentary behavior were not significantly correlated to each other either.

CHAPTER V

DISCUSSION, LIMITATIONS, AND FUTURE RESEARCH

Discussion

The purpose of this study was to evaluate the impact of core strength, endurance, flexibility, body composition, & physical activity on the reported prevalence of LBP in college-aged individuals study. Prior studies have worked with several different populations of individuals with low back pain, but most of this research has focused on a specific variable and with aging or elderly population. Although, limited research has been conducted with college-aged individuals, which is a population currently yielding conflicting results, and have examined such a wide variety of variables. This study examined the role of flexibility, which few studies have done, as well as the impact of core strength, endurance, body composition, reported physical activity level.

To analyze the results t-tests were used, and most of the differences evaluated between individuals with Little/No and Moderate LBP proved to not be statistically significant at the 5% level of significance. Although, one variable proved to be significant at this level, as according to the results from the females with Little/No and Moderate LBP that completed the Roland-Morris Disability Questionnaire, subjects with Little/No LBP had a mean body fat percentage rank of 4.15 ± 0.90, and subjects with Moderate LBP had a mean body fat percentage rank of 2.50 ± 0.707 (Table 52), which is a statistically significant difference ($p = 0.029$, $t = 2.459$) (Table 53). Based on this information one would conclude that there is a statistically significant difference in the body fat percentage of college-aged females with Little/No LBP when compared to those with Moderate LBP, as the Little/No LBP group is likely to display a lover body fat percentage. This is significant information, as it appears that individuals, specifically females, who have a higher body fat percentage are more susceptible to develop or already have LBP according to the Roland-Morris Disability Questionnaire. Although, due to the small sample size these results should be interpreted with caution. This difference however did not hold true for the Revised Oswestry Disability Index. Several of the variables analyzed in this study could use much more intensive research, as their respective significant levels appears to be borderline. All other differences analyzed in this study between individuals with Little/No and Moderate LBP proved to not be statistically significant.

Statistical correlations between the variables in question were examined. It was determined that between all the variables in question for both genders a significant correlation was detected between body fat percentage ranking and core strength ($p = 0.016$), and between body fat percentage ranking and core endurance ($p = 0.001$) (Table 56). Based on this information one would conclude that as body fat percentage increases core strength decreases, or as core strength increases body fat percentage decreases. Also, as body fat percentage increases core endurance decreases, or as core endurance increases body fat percentage decreases. Core strength and endurance were significantly correlated ($p = 0.000$) to each other, and core strength was also significantly correlated to the subject's flexibility score on the sit-and-reach test ($p= 0.004$) (Table 57). Based on this information, as core strength increases core endurance increases, or as core endurance increases core strength increases. Also, as core strength increases flexibility increases, or as flexibility increases core strength increases. The LBP questionnaires utilized in this study, the Roland-Morris Disability Questionnaire and the Revised Oswestry Disability Questionnaire, were also significantly correlated ($p = 0.001$) (Table 58). Based on this information, one would expect that these questionnaires are addressing the same issue, therefore yielding comparable, valid, and reliable results. As previously discussed, there were not any significant statistical correlations between reported physical activity level and any of the variables, or between reported sedentary behavior and any of the variables. Interestingly, reported physical activity level and reported sedentary behavior were not significantly correlated with each other either. Once again, the results should be interpreted with caution due to the small sample size. So, utilizing a larger sample size would likely solidify the statistically significant findings and correlations yielded and may even yield more statistically significant results due to an increase in the number of subjects and therefore variability.

Limitations

Generalizability of the present results is somewhat limited by the selection criteria used to determine participation. To participate in this study participants had to be between the ages of 18-25 yrs. old, have a BMI between 18.5-34.9 kg/m^2, not be pregnant, an Indian University of Pennsylvania University student, not be a college athlete, not currently taking prescription pain medications for the lower back, not have a serious back injury in the past 3 months, and not have a previous history of surgeries or serious back injuries that may prove to be debilitating if exercised, as determined by their physician. Each of these inclusion criteria restricts the populations that these results can be applied to. However, some of the results yielded, specifically the correlations, are very interesting and could use more research.

Another limitation that could likely play a significant role is the fact that the subjects may not have accurately reported their physical activity history, sedentary behavior, and experience. Inaccurate reporting would yield variable results, although it is the assumption that the subjects accurately reported these variables. Also, LBP is very complex, so other confounding factors could affect LBP and exercise performance such as dietary intake, amount of sleep, and stress. Another possible limitation of this study is that participants may not have abstained from prescription pain medications for the lower back as instructed prior to testing, which would likely impact the results. Therefore, the inability to control for these factors likely leads to some variability, as controlling for these variables is very difficult, as the researcher is required to trust the subjects reporting.

Lastly, but arguably the greatest limitation of this study was the fact that a relatively sample size was used for this study. Only 26 subjects participated, with a limited and convenient population, therefore the results yielded should be interpreted with caution, as this sample size is small it may not reflect this population accurately, and probably does not represent the general population accurately. Utilizing such a small sample size makes it more difficult to detect significant differences between groups when analyzing specific variables. So, utilizing a larger sample size in this study would have yielded more accurate, reliable, and valid results, as well as increasing the generalizability of the findings.

Future Research

Future research is needed to verify the findings of this study, especially with a larger sample size. Studying this population specifically needs to be research more intensely, as LBP continues to have a significant impact on younger and younger populations, so more research will likely yield interesting results. Although, applying the methods utilized in this study to other populations would also likely present very interesting data, as this study analyzed several more variables than other studies. So, this is something that should be considered. Especially since the impact of flexibility has yet to be positively associated with LBP, so more research needs to be conducted with these variable, specifically flexibility. Another future consideration, although likely difficult and expensive to accomplish, would be to figure out how to determine each subject's actual physical activity level prior to participation. Also establishing a way to monitor the subjects before the test to confirm compliance with the instructions would be something to consider, to ensure accurate results.

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Appendix A

Pre-Screening Verbal Check List

Once individuals contact the principal investigator to express interest in the study, these questions will be asked to determine eligibility.

1. Are you between the ages of 18-25?
2. Is your BMI between 18.5-34.9kg/m^2 (Normal-Class 1 Obesity)?
3. Are you currently pregnant?
4. Are you currently taking prescription pain medications for the lower back?
5. Have you had a serious back injury in the past 3 months?
6. Do you have a previous history of surgeries or serious back injuries that may prove to be debilitating if exercised, as determined by your physician?
7. Are you an Indiana University of Pennsylvania athlete?

Appendix B

Informed Consent

Primary Investigator:
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You are being invited to participate in this research study. While reading this consent form, if you have any questions you are advised to contact the principal investigator listed above. The purpose of this study is to determine how core strength, flexibility, endurance, body composition, and physical activity are associated with lower back pain in college aged individuals.

You were invited to participate in this study because you are currently a student enrolled at, Indiana University of Pennsylvania, during the Spring 2018 semester. You are between the ages of 18-25 years old and have a body mass index (BMI) between 18.5-34.9 kg/m^2. Subjects must not be pregnant, currently taking prescription pain medications for the lower back, have a serious back injury in the past 3 months, or have a previous history of surgeries or serious back injuries that may prove to be debilitating if exercised, as determined by their physician. Collegiate athletes are excluded from the study, to prevent possible influencing factors, such as a competition related injury. If any of these statements are not accurate, please notify the principle investigator immediately.

By qualifying and completing this study, you will be helping to increase knowledge regarding lower back pain, and possible risk factors or behaviors associated with low back pain. You will then complete two questionnaires regarding low back pain, the Roland-Morris disability questionnaire and the Oswestry disability index, and two questionnaires regarding reported physical activity, the Modifiable Activity Questionnaire Past Year Version, and the Sedentary Behavior Questionnaire. The questionnaires used will take about 30 minutes or less to fill out. Then you will report to the Human Performance Laboratory in Zink Hall to determine your body composition using a BOD POD machine. Then you will be asked to report to the James G. Mill Fitness Center in Zink hall for assessments of resting heart rate and resting blood pressure. You will be weighed on a scale, and height measured, to determine your BMI. You will be made familiar with rating scales that will be used. You will be provided a list of products/medication to abstain from 48 hours prior to the day you come to the fitness facility for the exercise session to ensure there are no outside factors that can impact your performance. It is important that you get a good night's sleep and avoid any vigorous activity the day before the protocol.

The principal investigator will demonstrate the exercises to be performed during the study. You will begin this assessment by performing a 5-minute warm up on a treadmill, walking at 3 miles per hour, and a 0% incline. You will then be taken through two exercise assessments to test your core muscular strength using only your bodyweight as resistance. The two strength exercises that you will perform are the partial curl-up test, and a back-extension exercise on a roman chair, both maintaining a cadence set by a metronome. You will then perform McGill's Torso Muscular Endurance Test Battery, which consist of three muscular endurance exercises with your bodyweight only. The three muscular endurance exercises that you will perform are the trunk flexor endurance test, trunk lateral endurance test, and the trunk extensor endurance test, which are all timed assessments. Immediately following completion of each individual exercise, you will be asked to rate your perception of pain and exertion. You will you will rest for three minutes between all exercises, and your heart rate and blood pressure will be taken by the principal investigator during these rest periods. You will then perform a sit-and-reach test to determine your flexibility of the lower back and hamstrings. At the end of the exercise session, you will be taken through a cool down which will consist of light stretching of the core and legs.

If you choose to participate in this study, you will be asked to participate in only two sessions for approximately 2 hour each. It is important to understand that you will not be required to participate in exercise that is beyond your physical ability.

The main researcher is both a Certified Exercise Physiologist through the American College of Sports Medicine and is Basic Life Support (CPR and AED) certified through the American Heart Association, and the co-investigators will at least be Basic Life Support certified. If your heart rate, blood pressure, or pain elevates to unsafe levels, you will rest and be continually monitored by the principal investigator and other designates. If heart rate, blood pressure, or pain do not subside, you will be advised to visit IUP's Center for Health and Well-Being located at 901 Maple Street, in the Suites of Maple East (724-357-9355). If you are still experiencing adverse effects, 911 emergency responders will be called per Zink Hall emergency response protocol. These adverse effects are not expected to occur. There is also a potential that you will feel muscle soreness following the exercises, or possibly sprain or strain a body part. This is not expected to be greater than what you would feel after a typical work out, and an injury to the back or any body part is not expected to happen

Benefits you may receive from participating in this study, you will gain insight to your core muscular strength and endurance from performing the back-extension exercise, partial curl-up test, and the McGill's Torso Muscular Endurance Test Battery. Further benefits include knowledge regarding lower back and hamstrings flexibility. You will also gain knowledge on your total body composition, as well as other possibly beneficial knowledge, such as learning new exercises. Understanding these concepts will allow you to understand risk factors associated with low back pain, and how to prevent or manage your own low back pain.

Your participation is strictly on a voluntary basis and you may decide to withdrawal at any point without penalty by contacting the principle investigator or the co-investigator. Results of the study may be presented at public conferences and publications, but there will be no individual results. All results will be in presented in aggregate form. All data collected during the study will be kept for three years in compliance with federal regulations in a place that will only be accessible to the principle investigator. The research team greatly thanks you for your interest and looks forward to working with you throughout the study.

THIS PROJECT HAS BEEN APPROVED BY THE INDIANA UNIVERSITY OF PENNSYLVANIA INSTITUTIONAL REVIEW BOARD FOR THE PROTECTION OF HUMAN RIGHTS SUBJECTS

(Phone: 724-357-7730).

Department of Kinesiology and Health and Sport Science

VOLUNTARY CONSENT FORM:

I have read and understand the information provided in the informed consent form. I volunteer to be a participant in this research study. I understand that there is no compensation for my participation. I understand that all my data is kept confidential and is only seen by the lead researcher, and I have the right to withdrawal at any time during the study without penalty. I have received an unsigned copy of the informed consent form to keep in my possession. I understand and agree to the conditions of this study as described.

Name (please print): ____

Signature: ____________________________________ Date: ________________________

Phone number or location where you can be reached: _________________________________

Best days to reach you: ____

I certify that I have explained to the above participant the purpose and nature of this study, and potential risks and benefits associated with participating in this study. I have answered any questions the participant posed, and have witnessed the above signature.

Investigators Signature: _________________________ Date: ________________________

Appendix C

OMNI Perceived Exertion Scale for Resistance Exercise

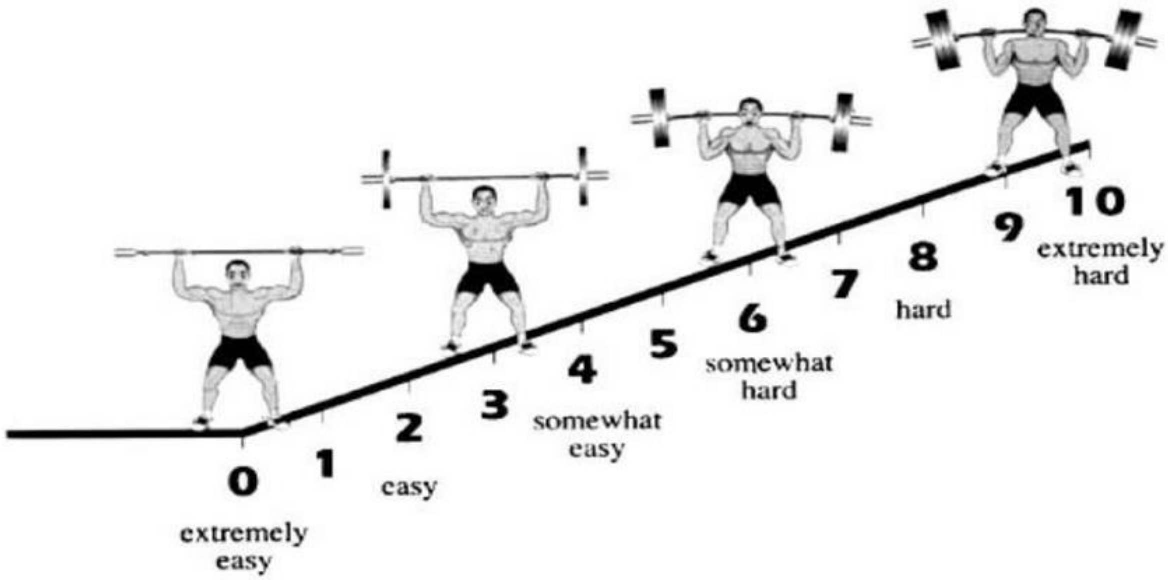

FIGURE 1. OMNI Perceived Exertion Scale for Resistance Exercise.

Appendix D

Pain Perception Scale

0- No pain at all

½-Very faint pain

1- Weak pain

2- Mild pain

3-Moderate pain

4-Somewhat strong pain

5- Strong pain

7- Very strong pain

10- Extremely intense pain

Appendix E

The Roland–Morris Disability Questionnaire 7p

The RDQ-7p is a modified version of Roland–Morris disability scale, where a seven-point Likert scale is used. For scoring, yes/no responses are replaced with a seven-point scale, ranging from 0 to 6. The scale is labelled as follows: 0 points means ‘disagree totally’, 3 points means ‘not sure’ and 6 means ‘agree totally’. The final questionnaire score is expressed as percentages of the total possible score with higher scores representing greater disability.

When your back hurts, you may find it difficult to do some things you normally do. This list contains sentences that people have used to describe themselves when they have back pain. When you read them, you may find that some stand out because they describe you today. As you read the list, think of yourself today. When you read a sentence that describes you today, put a tick against it. If the sentence does not describe you, then leave the space blank and go on to the next one. Remember, only tick the sentence if you are sure it describes you today.

		0	1	2	3	4	5	6
1.	I stay at home most of the time because of my back.							
2.	I change position frequently to try and get my back comfortable.							

3.	I walk more slowly than usual because of my back.	
4.	Because of my back I am not doing any of the jobs that I usually do around the house.	
5.	Because of my back, I use a handrail to get upstairs.	
6.	Because of my back, I lie down to rest more often.	
7.	Because of my back, I have to hold on to something to get out of an easy chair.	
8.	Because of my back, I try to get other people to do things for me.	
9.	I get dressed more slowly than usual because of my back.	
10.	I only stand for short periods of time because of my back.	
11.	Because of my back, I try not to bend or kneel down.	
12.	I find it difficult to get out of a chair because of my back.	
13.	My back is painful almost all the time.	
14.	I find it difficult to turn over in bed because of my back.	

15.	My appetite is not very good because of my back pain.
16.	I have trouble putting on my socks (or stockings) because of the pain in my back.
17.	I only walk short distances because of my back.
18.	I sleep less well on my back.
19.	Because of my back pain, I get dressed with help from someone else.
20.	I sit down for most of the day because of my back.
21.	I avoid heavy jobs around the house because of my back.
22.	Because of my back pain, I am more irritable and bad tempered with people than usual.
23.	Because of my back, I go upstairs more slowly than usual.
24.	I stay in bed most of the time because of my back.

Appendix F

The Revised Oswestry Disability Index

A revised Oswestry Disability Questionnaire was published by a chiropractic study group in the UK. This version consists of 10 sections: pain intensity, personal care, lifting, walking, sitting, standing, sleeping, social life, travelling and changing degree of pain. Also in this version each section contains six statements, ranging from 0 to 5, and the final score is calculated with standard scoring method.

This questionnaire is designed to enable us to understand how much your low back pain has affected your ability to manage your everyday activities. Mark one box only in each section that most closely describes you today.

Section 1: Pain intensity	
1.	The pain comes and goes and is very mild.
2.	The pain is mild and does not very much.
3.	The pain comes and goes and is moderate.
4.	The pain is moderate and does not very much.
5.	The pain comes and goes and is severe.
6.	The pain is severe and does not very much.

Section 2: Personal care

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

Section 3: Lifting

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

Section 4: Walking	
1.	I have no pain on walking.
2.	I have some pain with walking, but it does not increase with distance.
3.	I cannot walk more than 1 mile without increasing pain.
4.	I cannot walk more than 1/2 mile without increasing pain.
5.	I cannot walk more than 1/4 mile without increasing pain.
6.	I cannot walk at all without increasing pain.
Section 5: Sitting	
1.	I can sit in any chair as long as I like.
2.	I can sit only in my favorite chair as long as I like.
3.	Pain prevents me from sitting more than 1 h.
4.	Pain prevents me from sitting more than half an hour.
5.	Pain prevents me from sitting more than 10 min.
6.	I avoid sitting because it increases pain straight away.
Section 6: Standing	

1.	I can stand as long as I want without pain.
2.	I have some pain on standing but it does not increase with time.
3.	I cannot stand for longer than 1 h without increasing pain.
4.	I cannot stand for longer than half an hour without increasing pain.
5.	I cannot stand for longer than 10 min without increasing pain.
6.	I avoid standing because it increases pain straight away.
Section 7: Sleeping	
1.	I get no pain in bed.
2.	I get pain in bed, but it does not prevent me from sleeping well.
3.	Because of pain my normal night's sleep is reduced by less than 1/4.
4.	Because of pain my normal night's sleep is reduced by less than 1/2.
5.	Because of pain my normal night's sleep is reduced by less than 3/4.
6.	Pain prevents (me) from sleeping at all.
Section 8: Social life	
1.	My social life is normal and gives me no pain.

2.	My social life is normal but increases the degree of pain.
3.	Pain has no significant effect on my social life apart from limiting my more energetic interests (e.g. dancing, etc.).
4.	Pain has restricted my social life and I do not go out very often.
5.	Pain has restricted social life to my home.
6.	I have hardly any social life because of pain.
Section 9: Travelling	
1.	I get no pain whilst travelling.
2.	I get some pain whilst travelling but none of my usual sorts of travel make it any worse.
3.	I get extra pain whilst travelling but it does not compel me to seek alternative forms of travel.
4.	I get extra pain whilst travelling which compels me to seek alternative forms of travel.
5.	Pain restricts all forms of travel.
6.	Pain prevents all forms of travel except that done lying down.
Section 10: Changing degree of pain	
1.	My pain is rapidly getting better.

2.	My pain fluctuates but overall is definitely getting better.
3.	My pain seems to be getting better, but improvement is slow at present.
4.	My pain is neither getting better or worse.
5.	My pain is gradually worsening.
6.	My pain is rapidly worsening.

Appendix G

Modifiable Activity Questionnaire

Please check the box of all activities that you have participated in at least 10 times for 10 or more minutes during the past 12 months from _______________ to _______________ and then determine the average frequency and duration of each activity.

Activity	**Number of Months**	**Frequency** **Average number of times per month**	**Duration** **Average # of minutes each time**
☐ Aerobic Dance/Step Aerobics			
☐ Badminton			
☐ Baseball			
☐ Basketball			
☐ Bicycling (indoor, outdoor)			
☐ Bowling			
☐ Calisthenics/Toning Exercises			
☐ Canoeing/Rowing/Kayaking			
☐ Dancing (square, line, ballroom)			
☐ Elliptical Trainer			
☐ Fencing			
☐ Fishing			
☐ Football			
☐ Gardening or Yardwork			
☐ Golf			
☐ Hiking			
☐ Horseback Riding			
☐ Hunting			
☐ Jogging (outdoor, indoor)			
☐ Jumping Rope			
☐ Martial Arts (karate, judo)			
☐ Racquetball/Handball/Squash			
☐ Rock Climbing			
☐ Scuba Diving			
☐ Skating (roller, ice, blading)			
☐ Snow Shoeing			
☐ Snow Skiing (downhill)			
☐ Snow Skiing (x-country, Nordic Track)			
☐ Soccer			
☐ Softball			
☐ Stairmaster			
☐ Strength/Weight Training			
☐ Swimming (laps, snorkeling)			
☐ Tai Chi			
☐ Tennis			

☐ Volleyball			
☐ Walking for Exercise (outdoor, indoor, treadmill)			
☐ Water Aerobics			
☐ Water Skiing			
☐ Yoga			
☐ Other ____________________			

☐ I did none of these activities over the past month (4 weeks).

1. In general, was this past year reflective of your usual activity levels? ☐ YES ☐ NO

2. Excluding time at work, in general how many HOURS per DAY do you usually spend watching television or sitting at the computer? ______ hours.

3. Over the past month (4 weeks) have you spent more than one week confined to a bed or chair as a result of an injury, illness, or surgery? ☐ YES ☐ NO

If yes, how many weeks over the past month were you confined to a bed or chair? _____weeks.

4. Do you have difficulty doing any of the following activities?

a. getting in or out of a bed or chair? ☐ YES ☐ NO

b. walking across a small room without resting? ☐ YES ☐ NO

c. walking for 10 minutes without resting? ☐ YES ☐ NO

5. Did you ever compete in an individual or team sport (not including any time spent in sports performed during school physical education classes)? ☐ YES ☐ NO

If yes, how many total years did you participate in competitive sports? _____ years.

Appendix H

Sedentary Behavior Questionnaire

SEDENTARY BEHAVIOR: Weekday

On a typical WEEKDAY, how much time do you spend (from when you wake up until you go to bed) doing the following?

	None	15 min. or less	30 min.	1 hr	2 hrs	3 hrs	4 hrs	5 hrs	6 hrs or more
1. Watching television (including videos on VCR/DVD).	O	O	O	O	O	O	O	O	O
2. Playing computer or video games.	O	O	O	O	O	O	O	O	O
3. Sitting listening to music on the radio, tapes, or CDs.	O	O	O	O	O	O	O	O	O
4. Sitting and talking on the phone.	O	O	O	O	O	O	O	O	O
5. Doing paperwork or computer work (office work, emails, paying bills, etc.)	O	O	O	O	O	O	O	O	O
6. Sitting reading a book or magazine.	O	O	O	O	O	O	O	O	O
7. Playing a musical instrument.	O	O	O	O	O	O	O	O	O
8. Doing artwork or crafts.	O	O	O	O	O	O	O	O	O
9. Sitting and driving in a car, bus, or train.	O	O	O	O	O	O	O	O	O

SEDENTARY BEHAVIOR: Weekend Day									
On a typical WEEKEND DAY, how much time do you spend (from when you wake up until you go to bed) doing the following?									
	None	**15 min. or less**	**30 min**	**1 hr**	**2 hrs**	**3 hrs**	**4 hrs**	**5 hrs**	**6 hrs or more**
1. Watching television (including videos on VCR/DVD).	O	O	O	O	O	O	O	O	O
2. Playing computer or video games.	O	O	O	O	O	O	O	O	O
3. Sitting listening to music on the radio, tapes, or CDs.	O	O	O	O	O	O	O	O	O
4. Sitting and talking on the phone.	O	O	O	O	O	O	O	O	O
5. Doing paperwork or computer work (office work, emails, paying bills, etc.)	O	O	O	O	O	O	O	O	O
6. Sitting reading a book or magazine.	O	O	O	O	O	O	O	O	O
7. Playing a musical instrument.	O	O	O	O	O	O	O	O	O
8. Doing artwork or crafts.	O	O	O	O	O	O	O	O	O
9. Sitting and driving in a car, bus, or train.	O	O	O	O	O	O	O	O	O

Appendix I

Data Collection Sheet

Date:_______________ Subject ID:_________________

Orientation/Exercise Session Data Sheet

Sex: _____________ Age: _____________

Height: _____________ Weight: _____________ BMI: _____________

Body Composition: _____________ Waist Circumference: _____________

Resting BP: _____________ Resting HR: _____________ RPE: _____________ PP: _________

After Warm-up:

BP: _____________ HR: _____________ RPE: _____________ PP: _____________

Muscular Strength Protocol:

Partial curl-up test

Total repetitions completed: _____________ Percentile ranking: _____________

BP: _____________ HR: _____________ RPE: _____________ PP: _____________

Back extension test

Total repetitions completed: _____________ Percentile ranking: _____________

BP: _____________ HR: _____________ RPE: _____________ PP: _____________

Muscular Endurance Protocol:

Trunk flexor endurance test

Time to completion: _____________

BP: _____________ HR: _____________ RPE: _____________ PP: _____________

Trunk lateral endurance test

Right side time to completion: _____________ Left side time to completion: _____________

BP: _____________ HR: _____________ RPE: _____________ PP: _____________

Trunk extensor endurance test

Time to completion: _____________

BP: _____________ HR: _____________ RPE: _____________ PP: _____________

Flexion:extension ratio: _____________ Rating: _____Good _____Poor

Right-side bridge:left-side bridge ratio: ___________ Rating: _____Good _____Poor

Side-bridge (each side):extension ratio: ___________ Rating: _____Good _____Poor

Muscular Flexibility Protocol:

Sit-and-reach test

Trial 1: _____________cm. Trial 2: _____________cm. Best: _____________cm.

Fitness category: ____Excellent ____Very good ____Good ____Fair ____Poor

After Cool-down:

BP: _____________ HR: _____________ RPE: _____________ PP: _____________