The Relationship between Movement and Pain Related Fear, Function, and Depression in Chronic Pain Patients

By: Melissa Joy Roumanis, B.A, CAT(C), ATC

A Thesis

In the Department

Of

Exercise Science

Presented in Partial Fulfillment of the Requirements

For the Degree of

Masters of Science (Exercise Science) at

Concordia University

Montreal, Quebec, Canada

July 2014

CONCORDIA UNIVERSITY
School of Graduate Studies

This is to certify that the thesis prepared

By: Melissa Joy Roumanis

Entitled: The relationship between movement and pain related fear, function, and depression in chronic pain patients

and submitted in partial fulfillment of the requirements for the degree of

_____

complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

_____
Signed by the final examining committee:

Dr. Richard Courtemanche Chair

Dr. Thanh Dang-Vu Examiner

Dr. Richard Courtemanche Examiner

Dr. Geoff Dover Supervisor

Approved by _____
Chair of Department or Graduate Program Director

_____
Dean of Faculty

Date _____

CONCORDIA UNIVERSITY

ABSTRACT

The relationship between movement and pain related fear, function, and depression in chronic pain patients

Melissa Joy Roumanis

Chronic pain affects multiple facets of a person's life. Interdisciplinary programs are effective in treating chronic pain, but approaches used to improve function are different between programs. It is unclear which aspect of rehabilitation is responsible for improving function. In these programs, patients' allocation to groups and post program assessments are based on subjective and self-report evaluations from the patients. The purpose of this study was to objectively evaluate chronic pain patients' day and night movement to see the relationship between movement to baseline and final outcomes in pain related fear, function, depression, and pain. Twenty-four patients were diagnosed with chronic pain and wait listed for a chronic pain rehabilitation program (age=48.1±11.8years, weight=76.2±21.2kg, height=164.6±7.3cm). There were two groups at this rehabilitation center, specialized (S) and super-specialized (SP), 12 patients in each group. Patients' pain related fear, function, depression, and pain was assessed prior to the starting the program and at the completion of the 9-week program. Day movement and night movement were monitored for 7 days prior to starting the program using actigraphy. All pain related fear, function, depression, and pain variables significantly improved upon completion of the program. Movement during the day was significantly related to self-reported function, but not to the 6-minute walk test. Moreover, movement during the day was correlated with depression and pain. In conclusion, day and night movement cannot be used to predict successful completion of the program. Clinicians should use self-reported and objective function measurements to accurately reflect patient ability.

Table of Contents

Introduction:

Chronic pain is a debilitating condition affecting multiple facets of a person's life. Chronic pain is characterized by reoccurring pain extending beyond three months.[33] In addition, chronic pain can include a variety of conditions such as, fibromyalgia, musculoskeletal pain, arthritis, and chronic joint symptoms (CJS). Arthritis and CJS are the most common chronic conditions, affecting 70 million U.S adults aged ≥ 65 years in 2001.[14] U.S adults with arthritis and CJS are the leading cause of disability in the U.S and the number of people ≥65 years will double by 2030.[14] A total cost of $128 billion dollars was attributed to arthritis and other rheumatic conditions in the U.S in 2003.[14]

Chronic pain affects a person physically, mentally, and socially.[31] Interdisciplinary rehabilitation programs are the leading option for treating chronic pain patients because all three aspects are addressed throughout treatment.[31] Although interdisciplinary programs have proven to be successful, the approach used to improve function and quality of life are quite different between the programs.[31] It is unclear which specific intervention used during rehabilitation is the primary factor and which addresses the improvement in function the best. In some programs there are different specific rehabilitation options with regards to treatment. In these programs, patients' allocation to groups and post program assessments are based on subjective evaluations of physical and emotional stability.[71] When there is more than one treatment option, there is a need for an accurate baseline assessment to determine which group or program the patient will be placed. There are few objective variables that can be measured in this case to determine group allocation. Part of the reason why there are few objective measures for chronic pain patients, is because pain is subjective. However, the amount of movement or activity can be measured objectively and has been correlated to depression and function.[37]

Physical activity is commonly affected in chronic pain patients and can be easily measured.[20] Previous research suggests chronic pain patients may be less active during the day.[42] Physical activity is an important aspect of vitality and is commonly used to measure quality of life in people.[37] Movement

during the day is measured among people with depression to evaluate the severity of depression and determine impairment.[42] The lower the amount of activity the more depressed a person may be. Chronic pain patients also have a low level of day activity due to their pain and potentially their depression as well. Since movement is correlated to depression and function, it is possible that chronic pain patients' movement, prior to rehabilitation, will be related to their starting measures of function and depression. Furthermore, patients' movement prior to starting the program may indicate how successful they will be in the program.

A clinical prediction rule is a guide or a test used to enhance practitioners' decision making of patient management.[54] For example, clinical prediction rules assist decision making for the use of imaging for the diagnosis of ankle, knee, cervical, and minor head injuries.[72-74] Furthermore, clinical prediction rules have not only been used for diagnosing, but help decide who will respond to a particular intervention successfully.[32, 54] A clinical prediction rule was developed for low back pain (LBP) due to array of treatments, the rule was developed to see who would benefit from spinal manipulative therapy (SMT).[12] Patients meeting at least four of the five criteria qualified for SMT and had a success outcome of 92%.[12] Patients meeting fewer than three of the criteria only had 7% success rate with SMT, indicating the need for alternative treatment.[12] To date, there is no evidence supporting a clinical prediction rule for the management of chronic pain. A clinical prediction rule based on the amount of movement either during the day or at night could determine the severity of dysfunction at the beginning of the program and potentially could correlate to the successful completion of the program. A clinical prediction rule could be one of the few objective measures used for chronic pain patients to help allocate patients into groups and determine success of interdisciplinary rehabilitation programs.

As mentioned previously, there are numerous ways to treat chronic pain and each program varies. [31] Furthermore, the assessments within an interdisciplinary program are based on subjective evaluations, not objective evaluations.[71] Therefore, a person's movement or amount of activity is one of

the few variables that can be measured objectively and is correlated to depression and function. Chronic pain patients' movement could be used as a clinical prediction rule that could help determine who will react successfully to a particular treatment. The purpose of this study was to evaluate chronic pain patients' movement during the day and night to see if there is a relationship between the movement prior to the program to baseline and final outcomes which include pain related fear, function, depression, and pain.

Literature Review:

Interdisciplinary Rehabilitation Programs and Chronic Pain

Pain is viewed as a multidimensional phenomenon involving sensory, affective, motivational and cognitive components.[63] Due to pain being viewed as multidimensional, chronic pain is regarded as multidimensional.[31] Chronic pain affects a person physically, mentally, socially, and occupationally. [31] The treatment of chronic pain use to be done by a single discipline treatment, such as medical therapy or physical therapy.[63] The current treatment for chronic pain, however, has shifted to interdisciplinary rehabilitation because chronic pain affects multiple facets of a person's life.[24]

Interdisciplinary programs combine individual and group-based therapies such as physical and occupational therapy, psychology, relaxation therapy, counseling, vocational rehabilitation services, nursing education, and aerobic rehabilitation.[71] Even though a patient is involved in an interdisciplinary program the patient is seen by many disciplines, all disciplines share common values and goals for the patient. [71] The goals include promotion of self-management perspective, relaxation skill training, cognitive restructuring, behavioral activation (goal setting), problem solving, increase knowledge on postural hygiene and stress management. The therapies focus on integrating the new knowledge into activities of daily living, habit reversal (unlearning pain behaviors), and maintenance and relapse

prevention.[71] Each discipline has a clearly defined role but interdisciplinary programs emphasizes integrating skills from one discipline into another.[71]

The American Pain Society (APS) has developed evidence-based components for effective care in interdisciplinary rehabilitation programs. The first component is assessment. The assessment of a patient should include various team members and is an ongoing process throughout treatment.[81] How the treatment plan is executed is important among interdisciplinary programs. Disciplines involved in care collaborate and commence in unison.[81] The second critical part to an interdisciplinary rehabilitation program, is communication.[81] Communication does not only occur between the disciplines involved, but also between the patient, family, and significant others.[81] The third component is proper documentation.[81] Proper documentation is essential when many disciplines are involved to establish progress towards short-term and long-term goals.[81] Education to third-party payers is an important component in interdisciplinary pain care as well because negotiations may be required to obtain third-party support.[81] Follow-up care is the final component of interdisciplinary programs. After patients are discharged from care, patients, caregivers, and significant others are provided with appropriate information on continuing care plans, maintenance and strategies for addressing relapse symptoms.[81]

The Mayo Clinic Pain Rehabilitation Center, The rehabilitation Institute of Chicago and The Cleveland Clinic are three established institutions with interdisciplinary rehabilitation programs. These programs are good examples of how interdisciplinary programs address multiple factors that influence the chronic nature of chronic pain patients.

The Mayo Clinic Pain Rehabilitation Center located in Rochester, Minnesota uses an interdisciplinary rehabilitation program. The center is a tertiary hospital-based outpatient program and has existed since 1974.[71] The program admits new patients yearly and treats 25 patients daily.[71] Patients go through a treatment consisting of a three week intensive (120 hours) program from 8AM-5PM.[71] First, patients go through a two day admission process which entails an evaluation of the patients'

physical and emotional stability, treatment goals, medication, and an agreement not to pursuit further medical or surgical interventions.[71] After evaluations, patients are divided into two treatment groups. One rehabilitation group focuses on functional restoration.[71] The other group receives rehabilitation plus substance use education for patients who are at risk for substance abuse.[71] Both groups go through 15 treatment days (8AM-5PM), daily supervised physical exercise, and 10 hours of family/support group education sessions per week.[71] Assessment of physical and emotional functioning upon admission and discharge includes the Multidimensional Pain Inventory (MPI), a measure of pain severity and suffering level, Short Form-36 Health Status Questionnaire (SF-36), Center for Epidemiologic Studies-Depression (CES-D) scale, Pain Catastrophizing Scale (PCS), Pain Self-Efficacy Questionnaire (PSEQ), Pain Anxiety Symptoms Scale (PASS), Canadian Occupational Performance Measure (COPM), personality assessment, and a brief structured interview to identify major psychiatric disorders [71].

The Mayo Clinic Pain Rehabilitation Center published outcomes reporting the efficacy of treatment.[79] The purpose of the longitudinal study was to assess chronic pain patients using opioids to chronic pain non-opioid patients after completing the interdisciplinary program.[79] The total study population was 373 patients and the patients were divided into two groups.[79] One group of 213 patients taking opioids on admission was compared to 160 non-opioid patients at the time of admission.[79] Patients taking opioids averaged 99.0mg/day of morphine.[79] Chronic back pain, fibromyalgia and chronic headaches/migraines were the primary pain conditions for both groups.[79] The average number of years patients complained of pain was nine years.[79] On admission, all patients completed the questionnaires as mentioned earlier to measure pain severity, pain interference, level of function, life control, depression, pain catastrophizing, and pain-related anxiety.[79] Two hundred and thirty-eight patients completed the 3-week interdisciplinary program. The patients taking opioids at the time of admission completed the 3-week program as well as opioid withdrawals.[79] On admission, patients taking opioids reported higher levels of depression and pain severity than the non-opioid group.[79] At the conclusion of

the program, improvements were seen in pain severity, mood, pain catastrophizing, and functioning 6 months post-treatment regardless of the opioid admission status.[79]

Another interdisciplinary program is the Brooks Pain Rehabilitation Program located in Jacksonville, Florida. The facility treats an average of 8 patients a day.[71] Brooks Pain Rehabilitation Program has two different care options, both lasting 5 weeks.[71] The first option is a full-day (6 hours) or partial-day (3 hours) daily program.[71] The Brooks facility focuses on functional restoration with therapy reactivation, reducing catastrophizing and fear avoidance behavior, enhancing internal locus of control, and detoxification of opioid medications.[71] In a study, Brooks Pain Rehabilitation Program evaluated patient outcome pre-program, post-program, and long-term (3 months, 6 months, 9 months, 12 months, 24 months).[71] Data was collected from the patients after completing the program. After completion of the program, range-of motion of specific joints were measured, and a specific follow-up tool was developed to monitor changes in patients.[71] According to the 6-month follow-up data, an overall level of activity and ability to perform daily activities of life progressed or continued at improved levels in nine of the ten patients. Pain levels also decreased or stayed the same for three of four patients, and emotional distress decreased by nearly 50%.[71]

An interdisciplinary clinic located in Chicago, Illinois evaluates 1000 new patients per year.[71] The Rehabilitation Institute of Chicago Center for Pain Management evaluates a patient for 3 to 4.5 hours before admission.[71] If the patient is a candidate for treatment, the patient has a variety of program options.[71] Patients may participate in a 4-week (full program), 8 hour per day program that runs from Monday through Friday.[71] The other pain program option is 4 weeks with a modified 4 hour per day.[71] Both program options include physical therapy and occupational therapy, relaxation training, pain psychology, nursing education, opioid detoxification, medical management and group therapy.[71] All patients have a 4 week followed-up after completing a treatment program. The Chicago Center for Pain Management measures functional status using the Pain Disability Index (PDI) of discharged patients.[71]

Improvements were noted in patients' functional status at discharge, 6 months and 1 year after participation in the rehabilitation program.[71]

Interdisciplinary rehabilitation programs do not target a specific anatomic source of pain but addresses the physical, psychological, emotional, social, and professional needs to treat chronic disorders.[24] As noted in the three interdisciplinary rehabilitation programs discussed earlier, interdisciplinary rehabilitation programs are associated with improvements in pain and function for chronic pain patients.[31] Even though the American Pain Society has described components for a successful interdisciplinary rehabilitation facility, programs still vary.[13] Interdisciplinary rehabilitation programs are effective however, the features of the program that are responsible for improvement have yet to be clarified.[63] Some authors argue that the psychological factors play the greatest role in successful outcomes in rehabilitation.[34] Another author assumes changes in coping strategies and beliefs are the most critical aspect of interdisciplinary rehabilitation programs.[70]

A barrier of interdisciplinary programs is the subjective evaluations of patients and how patients are separated into treatment groups. As seen in all three rehabilitation programs mentioned previously, patients were examined and evaluated differently. Each clinic used different tools, questionnaires and scales to evaluate pre and post treatment. An objective evaluation needs to be implemented in conjunction with self-reports for determining what rehabilitation group is appropriate for the patient. Self-report measures do not adequately capture the changes in habitual activity patterns after pain interventions and therefore need to be used in conjunction with objective measures.[28] [17, 18] Another barrier of intensive interdisciplinary rehabilitation programs, is the high cost and limited insurance coverage.[13] Some chronic pain patients need insurance companies and government assistance to pay for the rehabilitation program. Third-party payers need significant information on treatment plans, treatment methods and outcomes to assess treatment effectiveness.[81] Education to third-party supporters may be needed for the patients to receive continued support and prevent being dropped

from coverage.[81] Along with the subjective evaluation given to third-party payers, an objective evaluation of the patient's day and night activity level can be given.

For Chronic pain patients, physical activity is disrupted due to pain and it has long been theorized that the relief of pain is accompanied by improvement in function.[20] The two main studies that support the relationship between physical activity and pain intensity were completed in 1981 and 1990.[51, 62] However, more recently the relationship between pain intensity and physical activity is described as modestly associated.[80] One possible reason for the difference in results in previous research are the different methods used for measuring movement. Some studies have used self-report questionnaires to determine activity. Others have used objective function measures including the six minute walk. However, in chronic pain patients their self-awareness of movement and pain is known to be disrupted. Therefore, more studies are needed that measures function in chronic pain patients using objective measures of movement and activity. Objectively measuring day and night movement are difficult for patients to conceal and/or alter. As a result of the relationship between day and night activities with chronic pain, an objective measurement based on these can help patients receive continued support from third-party supporters. In addition, supplying this information to third-party payers will help demonstrate that the patient does in fact need an interdisciplinary rehabilitation program.

Clinical Prediction Rule

Clinical prediction rules have been developed to determine what patients respond to a particular treatment.[32] Clinical prediction rules are used every day and are designed to assist clinical decision making when caring for patients.[54] Clinical prediction rules assist decision making for using imaging on patients with ankle, knee, cervical, spine or minor head injuries.[72-74] Furthermore, clinical prediction rules have not only been developed for diagnosing, but for predicting an individual's response to a particular intervention.[54] As mentioned above, there are a variety of approaches and program

structures to treat chronic pain. Researchers are unaware as to what aspects (psychological or coping strategies) are the most influential in treating chronic pain, suggesting that interdisciplinary programs can benefit from a clinical prediction rule.

Recently, a clinical prediction rule was developed to see who would respond to spinal manipulative therapy for the treatment of low back pain (LBP).[23] A trial was performed to validate the spinal manipulation clinical prediction rule.[12] One hundred and thirty-one patients with LBP participated in the study and were between the ages of 18-60 years.[12] Patients completed self-reported measurements such as the Fear-Avoidance Beliefs Questionnaire (FABQ) and pain rating scale.[12] Physical therapists were blinded, but examined the patients' range of motion, hip internal rotation and assessed the 5 criteria in the spinal manipulation clinical prediction rule.[12] To further minimize bias, physical therapists were unaware of the patients' status on the clinical prediction rule.[12] The 5 criteria in the spinal manipulation clinical prediction rule assesses the duration of low back pain, extent of distal symptoms, fear-avoidance beliefs and hip internal range of motion.[12] To be considered positive on the rule, patients must of met 4 of the 5 criteria: current duration of low back pain is <16 days or less, no distal pain below the knee, fear-avoidance belief score of <19, hypo-mobile lumbar spine, and >35 degrees of internal range of motion.[12]

After examinations, patients were assigned to one of two groups.[12] Seventy patients were randomly assigned to the first group that consisted of spinal manipulation plus an exercise treatment.[12] Sixty-one patients were assigned to the second group that consisted solely of an exercise treatment.[12] Patients in both groups attended physical therapy twice during the first week and then once a week for the next three weeks.[12]

As previously mentioned, patients who met at least 4 of the 5 criteria were considered positive on the rule.[12] The results suggested patients who were positive on the rule and treated with manipulation had greater improvements in pain and disability after 1 and 4 weeks than patients who

were negative on the rule and received manipulation.[12] These results were maintained at the 6 month follow-up.[12] Furthermore, patients who were positive on the rule and received manipulation experienced greater improvements after 1 and 4 weeks than patients who were positive on the rule and received exercise intervention.[12] At the 6 month follow up, patients in the exercise group demonstrated greater medication use, health care utilization and more time off work due to back pain.[12] Patients who were positive on the rule and treated with spinal manipulations had a 92% chance of achieving a successful outcome by the end of 1 week.[12] Patients with fewer than 3 criteria would have only a 7% probability of success, indicating the need for alternative treatment.[12]

There is no clinical prediction rule for treating chronic pain. Developing a clinical prediction rule for chronic pain can potentially save the yearly cost that is attributed to treating chronic pain. Not all chronic pain patients have the same pain causing condition. However, the connection between chronic pain, physical activity, and sleep disturbances gives the potential for using activity and movement during the night as a potential clinical prediction rule for chronic pain. Assessing a patient's day and night activity could assist a clinician's decision on what treatment group is appropriate for the individual. Hopefully, measuring day activity level, night movement, and subjective questionnaires can be used in developing a clinical prediction rule to assist interdisciplinary rehabilitation programs with consistent results.

Specialized (S) and Super Specialized (SP) groups of the self-management chronic pain program

One of the few chronic pain programs in Montreal is housed at the Constance Lethbridge Rehabilitation Centre (CLRC). The program is a 9-week interdisciplinary rehabilitation program for chronic pain patients. While other chronic pain programs focus on the reduction of pain medication as one of their main goals, the CLRC does not.[71] The CLRC is non-pharmacological based and uses an

interdisciplinary cognitive behavior approach. Some of the CLRC clinicians describe the program as a self-management program because the goal is not to treat the disease or condition the patient is suffering from. The clinician's goals focus on personal goals for the patient and managing their life with pain. The main goal for the rehabilitation program is not to decrease the patient's pain but improve to function for activities of daily living. The interdisciplinary program's main approach is targeting risk factors for chronicity. The CLRC objective is to improve self-management skills in daily activities, psychological function, behavior reversal, and increase daily physical activities. People with chronic pain must first meet certain criteria to become a client of CLRC. The person must be 18 years or older, be referred from a physician with a precise medical diagnosis and neuromusculoskeletal disability, require interdisciplinary or adaptation rehabilitation, have a medically stable condition that will not interfere with rehabilitation, and must be able to participate actively in an individual or group rehabilitation approach.

The CLRC has two interdisciplinary rehabilitation treatment groups; a specialized (S) and a super-specialized program (SP). To determine what group is appropriate for the individual, further screening is needed. Once the participant is accepted as a client, he or she is evaluated by a CLRC doctor to determine what treatment group is appropriate for the individual. Both the S and SP groups are intensive rehabilitation programs, but the SP group is more intensive than the S group. The SP group receives treatment 4x per week from 9:00am-2:30pm while the S group receives treatment 2x per week from 8:45am-12:00pm. Tables 1 and 2 for a sample week schedule for the S and SP groups. Despite the frequency and daily duration, the objectives and activities of both groups are the same (Refer to Table 3 for a list of all activities).

S Group: Week	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Week 1		**8:45-10:15AM:** GYM **10:30-12:00PM:**		**8:45-10:15AM:** Postural Hygiene **10:30-**	

		What is Chronic Pain?		**12:00PM:** Stress management	

Table 1: S group week schedule.

SP Group: Week	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1	**9:00-10:15AM:** Objectives **10:30-12:00PM:** Nutrition **1:00-2:30PM:** Pool	**9:00-10:15AM:** Gym/Physio **10:30-12:00PM:** Task simulation **1:00-2:30PM:** Pool	**9:00-10:15AM:** Group discussion/passive relaxation **10:30-12:00PM:** Gym/Physio **1:00-2:30PM:** Pool	**9:00-10:15AM:** Gym/Physio **10:30-12:00PM:** Task simulation **1:00-2:30PM:** Pool	

Table 2: SP group week schedule.

Program Activities for the S and SP Groups
Education of what is chronic pain
Energy management
Postural hygiene
Sleep hygiene
Body mechanics
Ergonomics
Stress and chronic pain
Managing stress
Relaxation techniques
Group discussion
Managing thoughts
Managing emotions and fears
Communication and problem solving
Nutrition

Table 3: List of topics addressed for the S and SP group during the 9-week program.

Actigraphy and Activity

Symptoms of pain, fatigue and depression produce a complex relationship between sleep and chronic pain patients.[42] However, it is difficult to interpret descriptions of fatigue from subjective measurements.[42] There is no objective tool for measuring fatigue, but measuring levels of activity during the day can provide an objective indication of impaired physical functioning among chronic pain patients.[42] Actigraphy has been used as an objective method for recording activity and sleep patterns.[42]

Understanding how consumed a chronic pain patient is by their pain, it is important to determine their daily activity.

Before determining daily activity levels of chronic pain patients, activity parameters need to be defined and understood for the actigraphy. When using an actigraphy, a sedentary minute is when the monitor output < 100 counts per minute.[53] The ability for the actigraphy to distinguish between postures (sitting vs. standing) is important because some standing activities can be or are below 100 counts per minute and not considered sedentary.[44] Activities such as folding laundry and washing dishes are examples of standing activities where the counts per minute are below 100 but are not considered sedentary.[44] However, the ability of the actigraphy to differentiate between sedentary time and light activity is unknown.[43]

To determine if the actigraphy is able to distinguish between sedentary and non-sedentary activities, a wrist actigraphy was compared to the activPAL.[43] An activPAL is a tool designed to measure living activity, has the ability to differentiate among postures and classify an individual's activity into time sitting, standing and stepping.[43] The activPAL has been validated in a laboratory setting compared with direct observation and was found to be 100% accurate for measuring sitting, standing, and walking.[30] Although the activPAL has been validated in a laboratory setting, the activPAL has not been validated in a free-living setting compared to direct observation.[43] The aim of the study comparing the activPAL versus actigraphy was to validate the actigraphy at 100 counts per minute and the activPAL for assessing sedentary behavior.

The sample included 5 males and 15 females who were overweight or obese and who participated in <3 days a week of moderate activity for 20 minutes in the last 6 months.[43] All participants completed two 7-day conditions.[43] Participants were instructed to wear the monitors during all waking hours.[43] The first condition was baseline measurements where participants maintained a normal level of activity and were directed to not initiate an exercise program.[43] The second condition consisted of

participants completing tasks that reduced sitting time.[43] Standing during commercial breaks or taking a 5 minutes standing/walking break for each hour of work were strategies given to participants to decrease sedentary time and increase light-intensity activities.[43] Also, participants had to complete daily and hourly checklist tasks to break up sitting time and to ensure compliance.[43] During both conditions, participants were directly observed once for 6 hours in their free-living environment.[43]

The results of the study showed that, on average, both the activPAL and 100 count per minute actigraphy underestimated sedentary time compared with direct observation.[43]The activPAL underestimated sitting time by 2.8% and the 100 count per minute actigraphy underestimated sitting time by 4.9%[43]. The 150 count per minute actigraphy had the lowest bias of 1.8%.[43] Although the 150 count per minute actigraphy had the lowest bias for monitors, the actigraphy was not sensitive to distinguishing between sedentary and active conditions.[43]

The current study supports the activPAL as an accurate and precise monitor for measuring sedentary behaviors and is sensitive to distinguishing between sedentary and active conditions.[43] Also, the results suggest the 150 count per minute actigraphy provided better estimates of sedentary behavior than the 100 count per minute actigraphy and the activPAL.[43]. However, the actigraphy is not as precise at distinguishing sedentary and active conditions.[43]

Even though the activPAL is able to differentiate an individual's activity into sitting, standing and stepping, an actigraphy will be used for the proposed study. The 150 count per minute actigraphy is more accurate in determining sedentary behavior and registers slight movement such as folding laundry and washing dishes. Determining if a patient sits, stands or steps more is not important for the proposed study as long as activity or the lack of activity is recorded. Actigraphy is a very diverse tool and will be used for this study to determine how much chronic pain patients move throughout the day as well as their sleep efficiency.

A study was done on chronic pain patients to determine daily activity level. A comparison of patients with fibromyalgia without depression, fibromyalgia with depression, depression alone, and healthy controls was performed.[42] The healthy control group was comprised of 28 women with a mean age of 53.4 (±2.4) years.[42] The fibromyalgia without depression group had 16 patients all women with a mean age of 49.2 (±2.4) years.[42] Four men and five women made the depression alone group with a mean age of 45.8 (±2.7) years.[42] The fibromyalgia with depression groups had one man and five women with a mean age of 48 (±2.4) years.[42]

An actigraphy wristwatch was worn on the non-dominant arm for 7 days and data was recorded every minute.[42] Subjects also had to keep a sleep diary, recording sleep-wake time as well as activities.[42] The mean of daytime activity levels, nighttime activity levels, and percentage of time spent asleep during the daytime and nighttime were calculated from the actigraphy to determine level of activity.[42]

The control group's results after seven days showed a consistent and regular sleep-wake cycle with high activity levels during the day.[42] Also, the control group showed uninterrupted periods of sleep at night with a sleep efficiency of 92.3%.[42] The fibromyalgia patients showed similar levels of daytime activity to normal controls, but showed signs of disturbed sleep with significant increased levels of activity at night.[42] Fibromyalgia patients had a sleep efficiency of 89.16%.[42] The patients in the depression group showed signs of disturbed sleep, significant increased levels of nighttime activity and decreased sleep efficiency of 73.48%.[42] The group of patients with fibromyalgia and depression showed impairment with reduced daytime activity, significant increase in time spent sleeping during the day and more sleep interruption and movement during the night.[42] Depressed fibromyalgia patients had a sleep efficiency of 78.85%.[42]

This study demonstrated that the actigraphy is a useful tool not only to measure sleep patterns but activity levels among chronic pain patients as well. Measuring chronic pain patients' daytime and nighttime activity levels can help determine what rehabilitation treatment group is appropriate for the

patient. At the CLRC, patients are separated into the specialized (S) or super specialized (SP) group. Both groups are assigned into intensive rehabilitation programs but the SP group is more intensive than the S group and patients are separated into either group by subjective evaluations and interviews. As a result of the recall effect from patients when filling out subjective questionnaires, objective and subjective measurements, and as both correlate modestly with each other, therefore both measurements should be used [59]. For my study, subjective and objective measurements will be used to determine patient placement in rehabilitation programs and program success.

Actigraphy and Night Movement

In laboratory settings, polysomnography (PSG) is considered the "gold standard" for diagnosing sleep disturbances but actigraphy is commonly used as an alternative for some variables.[22] The PSG gathers data about oximetry, airflow, heart rate fluctuations, snoring, movement of the ribs and abdominal area, and electrical activity through electroencephalography and electromyogram.[21] An actigraphy is a small body-mounted device capable of collecting data while individuals are living in their natural environment. The sampling is more representative pattern of daily activity.[28] Furthermore, the actigraphy is a well validated, low-cost alternative technology for assessing sleep disorders.[49] Due to the expense of equipment, laboratory settings, technicians and the "first night" effect in healthy populations not suffering from sleep disturbances, an actigraphy will be used for this study.[39, 48]

The actigraphy is a watch that contains an accelerometer that records movement throughout the day.[78] The actigraphy determines the sleep-wake measures by comparing the amount of movement to the amount of lack of movement.[65] Actigraphy correlates well with the polysomnography in measuring sleep parameters.[11] When worn on the non-dominant wrist, the actigraphy has shown to have very good interunit reliability ($r=0.98$).[28] Furthermore, the reliability has been shown to be constant over long periods of time, as the sensitivity of the actigraphy does not significantly change [39].

The actigraphy has not only been compared to Polysomnography (PSG), but the The actigraphy has been analyzed by units worn at different body sites (intersite reliability) and units worn at the same site (interunit reliability).[28] In a 2-hour trial, a study was designed to evaluated interunit and intersite reliability by attaching two units at each site: wrist, waist, and ankle [28]. In this case, an actigraphy was attached to the non-dominate side of each subject.[28] From a pool of 20 units, 6 units were randomly chosen for testing.[28] The actigraphy placement was rotated across the three subjects so no actigraphy was tested at the same site twice and no pair was matched more than once.[28] The three subjects being tested (2 males and 1 female), were instructed to perform normal daily activities.[28] For the two male subjects, the study was conducted during household chores and activities that included cleaning, sweeping, reading, and working at the computer.[28] For the female subject, the study was performed during routine clinical-care activities that included reviewing charts, examining patients, walking between examination rooms and the front desk.[28]

The interunit coefficients revealed excellent agreement between matched units within each placement site.[28] The intersite coefficients indicated that the waist and ankle activity measurements were highly correlated ($r=0.97 \pm 0.01$),[28] whereas, the wrist measurement demonstrated a more modest agreement with the waist ($r= 0.56 \pm 0.03$) and ankle ($r= 0.58 \pm 0.06$).[28] The results of the study indicated, that the actigraphy has excellent interunit reliability and good validity when used at any of the three potential locations.[28]

In the same study, the actigraphy validity was measured. The validity of the actigraphy was tested during the study by measuring 3-D movement using the VICON system. Only one of the three subjects was tested.[28] The ability of the actigraphy to evaluate 3-D movement was done during two 15 minutes trials. The first trial consisted of lumbar stabilization exercises that included pelvic tilts, bridges, leg lifts, prone extensions, and lunges.[28] Lumbar exercises were chosen because the exercises are

commonly prescribed for back pain rehabilitation.[28] The second trial consisted of walking at a pace of one meter/second.[28]

The validity results showed that the counts of wrist and waist placement during the lumbar exercises were highly correlated with the VICON measurements and that the ankle placement was moderately correlated with the VICON.[28] During the walking trial, the actigraphy located at the waist and ankle demonstrated excellent association with the VICON and the wrist placement was moderately correlated with the VICON.[28]

The validity of the actigraphy during the lumbar exercises and walking trials suggests that the placement site be considered when measuring activity for greatest accuracy of measurement.[28] The ankle and waist actigraphy placement provided better measurements during walking activity, while the wrist and waist actigraphy placement were better measurements during lumbar exercises.[28] For my research study, a wrist actigraphy was used because chronic pain patients do not perform strenuous activities throughout the day and many studies that measure movement on chronic pain patients use a wrist actigraphy to gather information. The next section goes into greater detail about chronic pain patient and movement.

The actigraphy measures sleep onset (SOL), total sleep time (TST), wake after sleep onset (WASO) and sleep efficiency (SE).[65] Sleep onset latency (SOL) is the amount of time an individual takes to fall asleep after going to bed, measured by immobility.[11] Total sleep time (TST) is the time spent sleeping during the sleep interval.[39] The time spent awake after falling asleep until the final awakening is the wake after sleep onset (WASO).[38] Sleep efficiency is the total sleep time achieved from sleep onset to final awakening and is represented as a percentage.[65]

A sleep diary is used in conjunction with actigraphy.[39] A sleep diary is used to note bedtime, wake-up time, naps and times when the watch is removed for bathing purposes.[39] Bedtime components mark the day's events preceding sleep and wake time components mark the sleep period completed.[58]

The Pittsburgh Sleep Diary (PghSD) is a tool that measures daily activity and perceived sleep measures.[58] These measures include sleep duration, WASO, sleep quality, waking mood and alertness.[58]. The PghSD is very reliable, with high inter-test correlation.[58] I will use the PghSD to compare bedtime, number of wake times during the night, perceived sleep quality and mood and alertness from day to day. Furthermore, the journal serves as a reference for the actigraphy to explain longer term inactivity.

For the purpose of my study, a wrist actigraphy was used to collect sleep measurements from chronic pain patients. From the information mentioned previously, the actigraphy has a high interunit reliability, is a reliable tool to measure sleep without interfering with patient daily routine and is a cost effective method for collecting sleep measurements.

Chronic Pain and Night Movement

Research suggests at least 50-88% of patients with chronic pain disorders have significant sleep complaints.[68] Patients with rheumatoid arthritis, fibromyalgia and LBP are well known to have sleep disturbances.[69] In the United States alone, the number conservatively translates to 28 million Americans with chronic pain who complain of sleep disturbances.[68] Research suggests chronic pain and disturbed sleep are interconnected.[56] Pain interferes with sleep, but sleep disturbances also influence the experience of pain.[56] However, research is unable to conclude if sleep disturbances are a cause or a consequence of chronic pain.[55] Even though researchers can't conclude if sleep disturbances are a cause or an effect, research suggest there is a direct relationship between the intensity of pain and the degree of sleep disturbances.[52]

Chronic pain patients report more pain, pay more attention to the pain and have poorer sleep.[1] A day with more attention to pain was followed by a poorer night's sleep, and a more disturbed night's sleep was followed by a day with more attention to pain.[1] The relationship between sleep and pain means sleep deprivation and poor sleep quality can lower pain thresholds and the mental capacity to manage pain.[45] Impaired sleep not only effects pain severity experienced, but has a negative effect on

mood, daytime function and general quality of life.[56] Chronic pain patients are more anxious and depressed.[66] Chronic pain patients create a self-perpetuating cycle of sleep disturbances, increased pain and depression.[56] The next three sections go into more depth of the relationship between three chronic pain conditions and sleep.

Rheumatoid Arthritis and Night Movement

The prevalence of sleep disturbances have been very high in rheumatoid arthritis (RA) patients.[19] The prevalence of sleep disturbances among rheumatoid arthritis patient is 75%.[64] A several night actigraphy study was performed on patients with RA, LBP patients and healthy controls to determine the movement or sleep-wake behavior of chronic pain patients.[46] The study consisted of 13 women with RA, 9 women with LBP, and 12 healthy control women.[46] All participants wore the actigraphy for 7 nights, wearing the watch at bedtime and removing the watch when they woke.[46] LBP and RA participants were not taking non-steroidal anti-inflammatories (NSAIDs) or any medication that could affect their sleep.[46] Healthy controls were not on any medications.[46] The researchers concluded RA patients have periodic limb movements, more sleep disturbances, and decreased sleep efficiency compared to the control and LBP subjects.[46] Sleep disturbances among RA was associated with overnight increase in tenderness in peripheral joints and in the non-articular tender points typically found in fibromyalgia.[57]

Another study compared a self-report fatigue on adults with RA and healthy controls to determine the relationship of fatigue to pain, sleep, functional status and depressive symptoms.[6] A sample of 51 patients with RA was compared to 46 sex matched controls without RA.[6] Patients completed self-administered questionnaire 3 times at 6-8 week intervals.[6] The questionnaires included Multidimensional Assessment of Fatigue Scale, Sleep Survey, Health Assessment Questionnaire and Profile of Mood Status.[6] The results from the study showed significantly higher fatigue levels in patients

with RA.[6] The study concluded patients with RA are strongly associated with fatigue, poor sleep, functional disability, greater joint pain, and more depression in comparison to healthy controls.[6]

The two previously mentioned studies distinguish the close relationship between sleep and chronic pain. Furthermore, the studies demonstrate the common occurrence of sleep disturbances among chronic pain patients. As a result of the prevalence of sleep disturbances in chronic pain patients, measuring sleep efficiency among chronic pain patients is a good objective evaluation to use to determine the effect or influence chronic pain has on the patient.

Fibromyalgia and Night Movement

Sleep has been studied immensely with patients who suffer from fibromyalgia. Sleep difficulties, fatigue and morning stiffness have been reported in >75% of patients with fibromyalgia.[19] Furthermore, the prevalence of awakening and non-restorative sleep is reported more in fibromyalgia patients than RA patients.[19] A greater number of tender points were in fibromyalgia patients due to poorer sleep because the sleep quality was associated with musculoskeletal tenderness.[36]

A study on fibromyalgia patients was performed to examine the association between subjective sleep quality and pain threshold.[2] Sixteen patient (13 females and 3 males) with fibromyalgia were included in this study [2]. Sensory testing was determined by a manual algometer.[2] Two consecutive trials assessed mechanical pain threshold on 4 fingers of the non-dominate hand.[2] Sleep quality was assessed by the Pittsburgh Sleep Quality Index (PSQI). The PSQI was administered to assess the sleep quality of the patients during the previous month.[2] The study concluded the subjective quality of sleep in fibromyalgia patients was inversely related to pressure pain sensitivity.[2] In other words, increased pain sensitivity is associated with greater sleep disturbances.[2]

This study shows the importance of evaluating the subjective sleep quality on chronic pain patients. The PSQI is a reliable tool to measure subjective sleep quality. The PSQI will be administered twice to the patients during the course of the in study (once before starting the rehabilitation program

and once after completing the program). The PSQI is one more element to show patient improvement in the rehabilitation program. Measuring the subjective sleep evaluation before and after will help determine the effect the program has on sleep.

Low Back Pain (LBP) and Night Movement

Low back pain is the most common of all musculoskeletal disorders among adults.[56] In an actigraphy study mentioned previously, which measured sleep-wake behavior in LBP, concluded LBP patients did not significantly differ from RA patients in the number of sleep wake transitions.[46] The results of the study suggest patients with LBP didn't move as often as the RA patients at night, but LBP patients did not have as refreshing sleep as the healthy controls. The results of the previous study are similar to another actigraphy study conducted on LBP patients. The actigraphy recorded longer awakenings and patients reported more disturbed and un-refreshing sleep in comparison to the healthy control.[10]

A longitudinal prospective behavioral study was carried out on LBP patients.[16] The study was conducted on 148 workers who suffered from a soft tissue back strain or sprain and did not returned to work within 3 months.[16] The workers were interviewed at 3, 6, 9, 15, and 21 months after sustaining the injury.[16] The workers were assessed by the McGill Pain Scale Questionnaire, visual analogue scale, University of Alabama Pain Behavior Scale, pain threshold, sleep complaint questionnaire, psychological distress questionnaire, and functional and social disabilities and handicaps.[16] The results of the study suggested functional disability and psychological distress were negatively associated with the rate of return to work.[16] Also, if workers were positive on the distress scale they were one-and-a-half times less likely to return to work.[16] Furthermore, the subjects who did not return to work at 21 months post-injury were more likely to have increased sleep complaints, diffuse pain, fatigue, and psychological distress compared to subjects who had returned to work.[16]

As explained in the previous studies, subjective and objective measuring tools have been used to determine sleep disturbances among chronic pain patients, however the number or frequency of sleep disturbances have not been used as a tool to determine patient placement in a rehabilitation program. Additionally, sleep disturbances have not been used to determine if patients who have more sleep disturbances have a lower success rate in a rehabilitation programs. For this study, improvements in pain related fear and function will be calculated to determine success rate. My research study will use reliable subjective questionnaires to measure pain related fear, function, depression, and pain, as well as an actigraphy to measure objective evaluations of day time and night time movement to predict patient placement. In addition, the measures will be used to determine the successful outcome of interdisciplinary rehabilitation.

Objectives and Hypotheses

1) The first objective of this study was to measure the change in pain related fear, physical function, depression, and pain at baseline and upon completion of the 9-week chronic pain program and compare the changes between the S and SP groups.

   Hypothesis: All participants will experience an improvement in pain related fear, physical function, and depression with no significant change in pain. In addition and based on preliminary data, we hypothesize that there will be no difference between groups for any variable.

2) The second objective of this study was to use actigraphy to measure movement (during the day and at night) in all participants prior to starting the 9-week program and compare all movement variables between the S and SP groups.

   Hypothesis: The SP group will move less during the day and more during the night compared to the S group.

3) The third objective was to assess the relationship between movement during the day and at night to the baseline measures of pain related fear, function, depression, and pain.

   Hypothesis a): There will be a negative correlation between movement during the day and pain related fear, depression, and pain and a positive correlation with function.

   Hypothesis b): There will be a positive correlation between movement at night and pain related fear, depression, and pain with an associated negative correlation to function.

4) The fourth objective was to assess the relationship between movement during the day and at night to the change from baseline to completion of the 9-week program in pain related fear, function, depression, and pain.

   Hypothesis a): There will be a negative correlation between the amount of movement during the day and the change in pain related fear, function, depression, and pain.

   Hypothesis b): There will be a positive correlation between movement at night and the change in pain related fear, function, depression, and pain.

Methods:

Subjects

We approached 40 chronic pain subjects at the CLRC. All participants were on the CLRC wait list prior to starting their 9-week rehabilitation program. Participants suffered from a variety of chronic pain conditions including fibromyalgia, LBP, shoulder pain, arthritis, and pain due to occupational accidents. Subjects were asked to refrain from alcohol during the period the actigraphy was worn. Participants were excluded from the study if they consumed recreational drugs, have clinically diagnosed sleep disorders, seasonal affective disorders, or if they were on a prescribed sleep aid regiment. In addition, 16 participants were excluded from the study due to missing or incomplete questionnaires, inadequate

actigraphy use, and religious concerns. Therefore, a total of 24 subjects participated (17 females and 7 males) in our study (age=48.1±11.8years, weight=76.2±21.2kg, height=164.6±7.3cm). Twelve subjects were in the specialized group (S) and 12 in the super specialized group (SP).

Pain related fear

We assessed the subjects' pain related fear prior to and upon completion of the 9-week program. We used three self-report questionnaires to measure the amount of catastrophizing (PCS), kinesiphobia (TSK), and perceived injustice (IEQ).

The TSK is a 17-item questionnaire that assesses a patient's fear of movement or (re)injury.[41] A high scoring TSK indicates a high degree of kinesiophobia [41]. The total scores ranges from 17 to 68 with a value of 37 or higher as indicative of a high score.[41]

The PCS assesses catastrophizing which is a negative mental state brought on by actual or an anticipated painful experience.[76] The 13-item questionnaire asks participants to reflect how they feel and what they think when they are experiencing pain.[76] The PCS total score is calculated by summing all items. It ranges from 0-52 and a score of 30 indicates catastrophizing.[76]

The IEQ evaluates the perceived injustice or unfairness associated with injury.[75] The scoring is done by summing all 12 items and the range is from 0 to 48. A score of 30 or higher is considered to be high.[75]

Physical Function

Physical functioning is the ability to perform tasks or activities and we assessed this two ways (subjectively and objectively). We used a self-report questionnaire (PDI) to measure function subjectively and the 6-minute walk test to measure physical function objectively. We measured the PDI and the 6-minute walk at baseline and upon completion of the program in all patients.

The PDI discriminates between patients with low and high levels of disability.[77] Participants rate how pain interferes with functioning in family/home, responsibilities, recreation, social activities, occupation, sexual behaviors, self-care, and life-support activities.[77] The PDI ranges from a score of 0-70. A higher score on the index, the greater the person's disability due to pain.[77]

The 6-minute walk test was administered to assess physical capabilities of the patients.[40] Patients performed the test twice, once before the start of the 9-week rehabilitation program and once after completing the rehabilitation program.[40] The 6-minute walk test was measured in meters.

Depression

We measured depression using two scales; the PHQ-9 and the BECK depression inventory. We measured the patients' levels of depression at the beginning and at the end of the 9-week program.

The PHQ-9 is a 10 item questionnaire that assesses depression.[27] A score of 10-14 indicates moderate depression, 15-19 moderately severe depression, and 20-27 severe depression.[27] In addition, the BECK depression inventory measures the severity of a person's depression.[5] The highest possible score is 63.[5] A score of 10-18 indicates mild depression, 19-29 moderate depression and a score greater than 30 indicates severe depression.[5]

Pain

We used the McGill Pain Questionnaire to assess pain. This self-reporting questionnaire allows patients to describe the quality and intensity of their pain.[7] The McGill Pain Scale Questionnaire is composed of 78 words and scoring ranges from 0-78.[7]

Movement during the day

Patients were given an actigraphy to measure movement prior to starting the 9-week rehabilitation program. An actigraphy is a watch that contains an accelerometer that records movement

throughout the day and night. The actigraphy was worn 24 hours a day for 7 days, except for bathing purposes. The watch was worn by the participants on their non-dominate wrist. The actigraphy was set to a 1 minute epoch length and low wake threshold. The participants were informed that we were measuring movement at night but we did not tell them the watch was also recording the movement during the day. This was done to ensure an accurate representation of movement during the day prior to the program.

Patients filled out a diary for 7 days, at least twice a day. They recorded the time they woke up and the time they went to bed in order to have an accurate measurement of their awake time during the day for the calculation of movement for the actigraphy.[8] The diary was used to match the actigraphy data in order to create more accurate intervals of participants' wake and sleep time variables. Patients were instructed to write in the dairy the time they "went to bed" and the "lights out" time. Went to bed was defined as the time the participant went to bed but was not actively trying to fall asleep, reading or watching TV. Lights out was determined as the time the participant turned out the lights and attempted sleep. We identified on the actigraphy what time the watch indicated the subject went to bed. Then we checked the diary to see what time the subject indicated they turned the lights out and attempted sleep. This ensured that we used "lights out" as the correct time for actual sleep instead of starting the calculation when the participant was not actively attempting sleep. Furthermore, participants recorded in the dairy the number of wakes throughout the night, reason for waking, sleep quality, alertness on final wakening and mood on final wakening.[8] Naps were permitted during the data collection period, but participants recorded the time in the diary. Moreover, if and when the actigraphy was removed for bathing purposes or any other reasons, patients indicated the time in the dairy. The amount of wake time that was indicated by movement on the actigraphy was confirmed by the activity description in the diary. In order to make the daytime movement more accurate, the time the participant removed the

actigraphy was excluded from the daytime intervals. However, any naps the participant took over the course of the day were not excluded.

The activity variables include movement efficiency, total wake time, minutes of movement, and mean activity level. Movement efficiency is expressed as a percent and is defined as to what extent how active a person is throughout the day. A simple ratio was used to calculate the movement efficiency. Movement efficiency was determined by dividing the minutes of movement by the total wake time minutes then multiplied by 100 to get a percentage. The higher the percentage of movement efficiency, the more physically active the person is. Total wake time was determined for each day by using the sleep diary and calculating the time the participant woke up to the time they went to bed. Minutes of movement were calculated by the amount of movement that actually occurred during the entire time they were awake. Mean activity was calculated as the mean number of activity counts per minute during each daytime wake period. Physical activity for patients was assessed across the wear of the actigraphy and activity levels were compared between groups.

Movement during the night

The actigraphy determines the sleep-wake measures by comparing the amount of movement to the amount of lack of movement. As mentioned earlier, we used the diary in order to have accurate total sleep times for all the patients. Sleep variables that were calculated from the actigraphy were: sleep efficiency (SE), total sleep time (TST), and wake after sleep onset (WASO). SE is expressed as a percent and a SE less than 85% is considered to be indicative of sleep disturbance.[67] TST is the total amount of time spent asleep from sleep onset to final awakening. WASO is referred to the time spent awake after sleep occurs.

6-Minute Walk Test:

Physical function is assessed by the 6-minute walk test. The 6-minute walk test is a safe, reliable and valid measurement for assessing patients' physical function.[29] Subjects walk at a fast but comfortable pace for 6 minutes.[29] The 6-minute walk test assesses the submaximal cardiorespiratory level of patients.[15] The test has been used for pre and post evaluation and for measuring the response to therapeutic interventions.[15] In my study, the distance the patient covers in 6 minutes will be recorded and be compared to their 6-minute walk test after completion of the 9-week rehabilitation program.

Procedures

1) Participants were contacted by a CLRC employee and were given details about the study. After agreeing to participate in the study, subjects were informed that the purpose of the study was to evaluate sleep performance and measure movement during sleep. Participants were asked to bring a printed list of medication they were prescribed to the first meeting with the researcher. Participants were not informed that their daily activity would be monitored in order to get a true representation of their normal daily activity.
2) Upon the first meeting, participants read and sign a consent form providing written details about the purpose, procedures, risk and contact numbers in case they have questions throughout the study duration. Also, patients were presented with the benefits of participating in the study.
3) As mentioned previously, patients filled out the questionnaires and performed the 6-minute walk test. This process took about one hour for each participant.
4) Subjects received an actigraphy set at 1 minute epoch length and low wake threshold, and a sleep diary. Participants were told how and when to fill out the diary as well as when to remove the watch for the 7 days.

5) Participants were given the rules for the next 7 days while the actigraphy was worn. Subjects were informed to follow their regular daily routines. Caffeine and tobacco were permitted for the course of the study if the participant consumed them on a regular basis. However, alcohol and illicit drugs were not permitted during the 7 days of testing.
6) Exercise was permitted as long as the participant performed them on a regular base. Participants were permitted to nap during the study.
7) Upon completion of the 7 day study, subjects returned the actigraphy and sleep diary. Then the subjects started the 9-week program in either the S or the SP program. At this time the data from the actigraphy was uploaded to a computer and analyzed.
8) After completing the 9-week rehabilitation, participants met with the researcher again, completed the 6-minute walk test and filled out the previously mentioned questionnaires. The questionnaires and 6-minute walk results were compared from those taken before the program began. Furthermore, participants were asked if they were still taking the same medications and dosage as at the start of the program.

Statistical Analysis

1) The first objective was to measure and compare the changes in pain related fear, function, depression, and pain upon completion of the 9-week program between the S and SP groups. To determine this, 8 separate 2X2 ANOVAs were performed. A separate ANOVA was used to identify differences in the: PCS, TSK, IEQ, PHQ-9, BECK, PDI, 6-minute walk test, and McGill Pain Scale between the S and SP groups.
2) The second objective of the study was to compare the movement between the S and SP groups during the day and at night. There were two groups (S and SP) and 6 days of movement during the day. We compared the two groups over the six days, therefore, separate 2X6 ANOVAs were

used to identify differences between movement efficiency, total wake time, mean minutes of movement, and mean activity level between the S and SP groups. In addition, the two groups (S and SP) and 5-nights of movement were analyzed to determine differences. Hence, 2X5 ANOVAs were used to identify differences in movement at night and sleep, which included sleep efficiency (SE), total sleep time (TST) and wake after sleep onset (WASO) between the two groups (S and SP).

3) The third objective of the study was to determine if the amount of movement during the day in chronic pain patients was related to poorer initial scores in pain related fear, function, depression, and pain. To complete this objective, Pearson correlations were performed on all movement variables (movement efficiency, total wake time, mean minutes of movement, and mean activity levels) to baseline scores of TSK, PCS, IEQ, PDI, 6-minute walk test, PHQ-9, BECK and the McGill Pain Scale. In addition, more Pearson correlations were completed to assess the relationship between movement at night (SE, TST, WASO) and the baseline measures of TSK, PCS, IEQ, PDI, 6-minute walk test, PHQ-9, BECK and the McGill Pain Scale.

4) The fourth objective of the study was to determine if chronic pain patient's movement prior to the program can predict a successful completion of the chronic pain program. A successful completion of the program would be a large decrease in pain, pain related fear, function, and depression. So again, we used Pearson correlations to determine the relationships between all movement variables (movement efficiency, total wake time, mean minutes of movement, and mean activity levels) to the change in scores of the TSK, PCS, IEQ, PDI, 6-minute walk test, PHQ-9, BECK, and McGill Pain Scale. Moreover, we used Pearson correlations to identify relationships between movement at night (SE, TST, WASO) and the changes in TSK, PCS, IEQ, PDI, 6-minute walk test, PHQ-9, BECK, and McGill Pain Scale.

Results

Our first objective was to determine the efficacy of the program or the amount of improvement in pain related fear, function, depression, and pain between the beginning and the end of the program. In addition, we wanted to identify any differences between the S and SP groups at baseline and upon completion of the program. There were significant time effects for all variables except for pain for all patients, indicating an improvement in all measures except for pain. However, there were two variables that had a significant group by time differences indicating a difference in improvement between the two groups.

1) Efficacy of the Program and S vs. SP Difference

A) Pain-Related Fear

The PCS decreased significantly in all participants from baseline to 9 weeks ($F(1, 11) = 53.7$, $p = <.001$). The initial PCS for the SP group was 30±7.5 and the final 15.6±13.1. The initial PCS for the S group was 31.4±17.5 and the final was 23.4±17.5. Moreover, participants' kinesiophobia significantly decreased after completing the 9-week program, which was measured by the TSK. The TSK was the first variable that had a significant group by time effect ($F(1, 11) = 5.0$, $p = .048$). The average initial TSK for the SP group was 46.9±3.1 and the final was 35.2±11.2. The initial TSK for the S group was 44.2±10, with a final of 40.7±8.4. The significant group by time effect suggests that the SP group had less kinesiophobia than the S group at the completion of the 9-week program. The IEQ, the third pain related fear questionnaire, also significantly decreased from baseline to 9 weeks ($F(1, 11) = 5.8$, $p = .035$), but had no significant group by time effect.

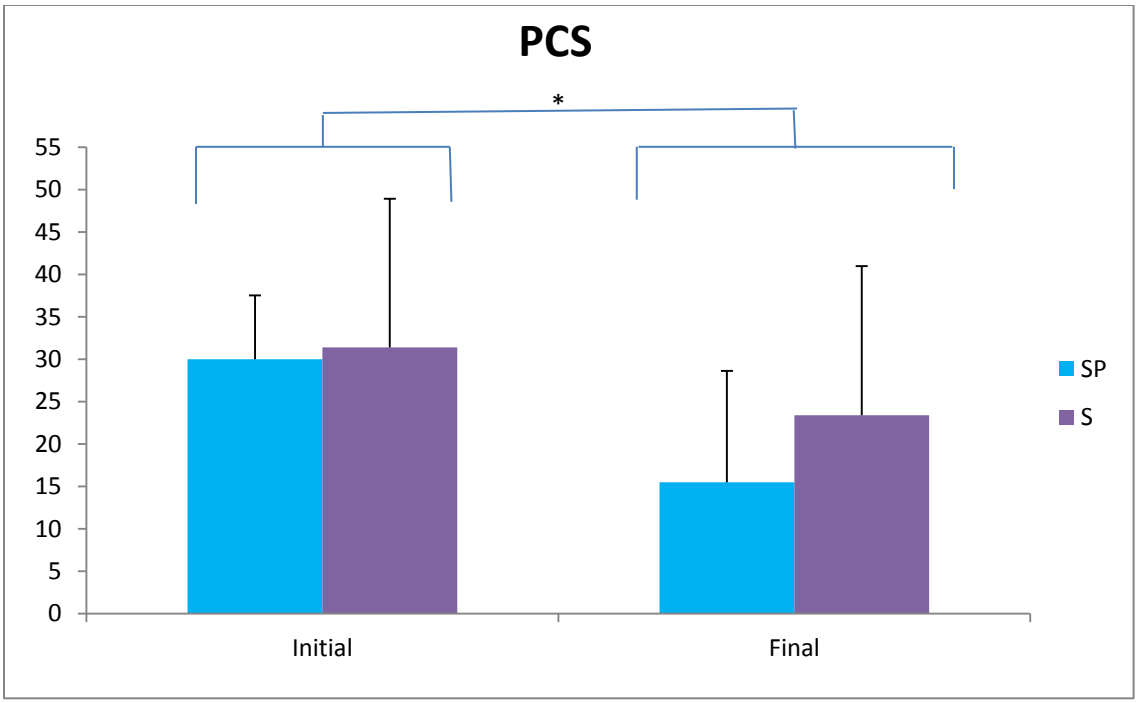

Figure 1: Average baseline and final catastrophizing scores for the S and SP groups (*indicates statistically significant relationship p<0.05).

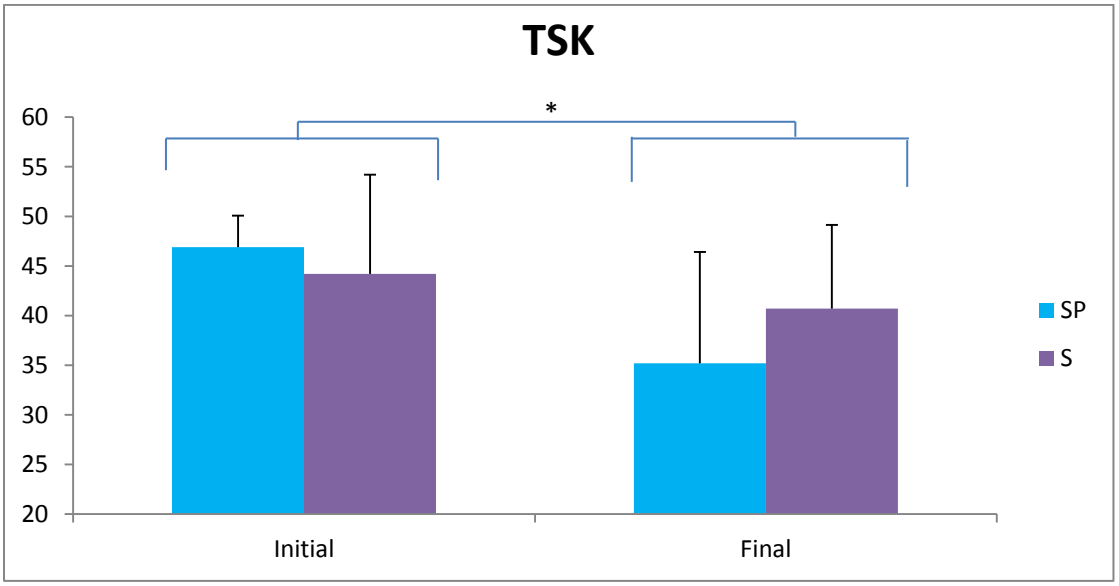

Figure 2: Initial and final TSK results for both groups (*indicates statistically significant relationship p<0.05).

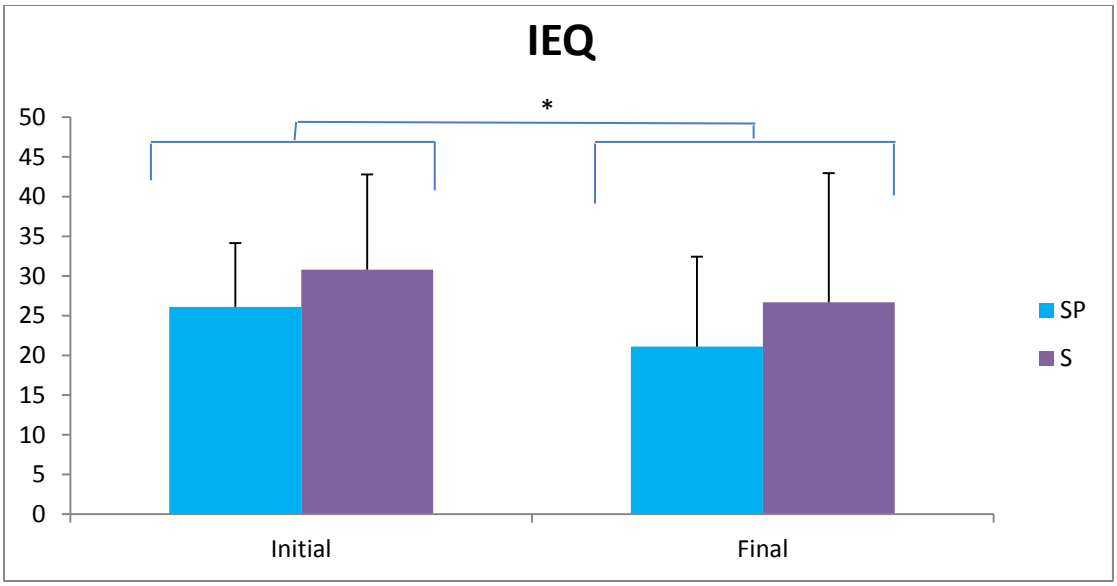

Figure 3: Initial and final IEQ results (*indicates statistically significant relationship p<0.05).

B) Function

The self-report measurement of function (PDI) significantly improved at 9 weeks (F (1, 11) = 40.8, p<.001). The initial SP group PDI was 41.7±8.4 and the final was 28.7±13.8. The S group initial was 44.7± and the final was 29±18. Participants' function was also measured objectively using the 6 minute walk test. The 6 minute walk test was the second variable that had a significant group by time effect (F (1, 11) =5.5, p= .041). The significant group by time effect suggests that the SP group improved more in the 6 minute walk test than the S group at the completion of the 9-week program.

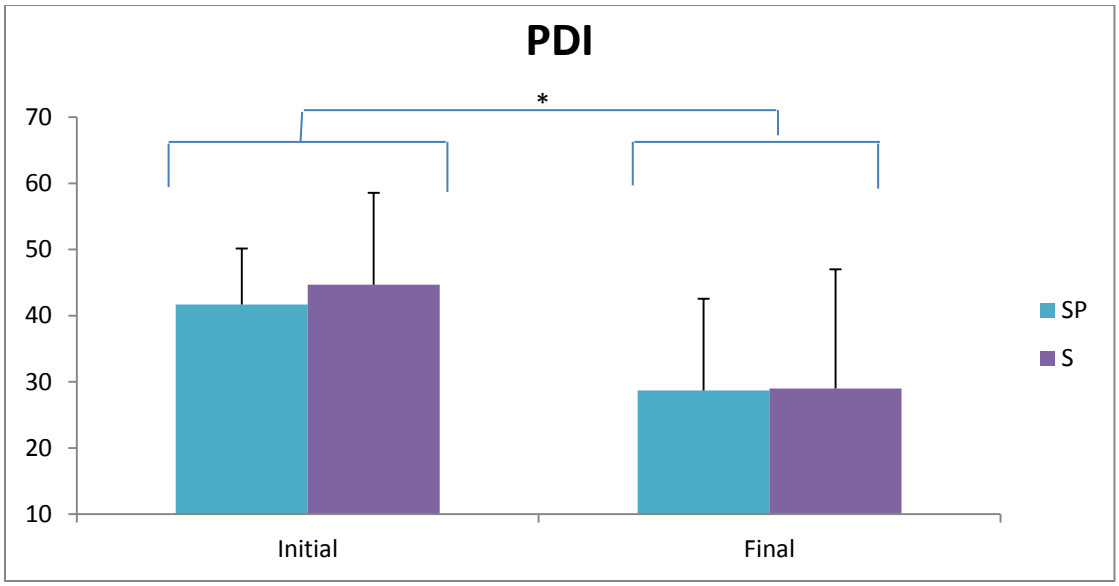

Figure 4: Initial and final subjective function results for the S and SP groups (*indicates statistically significant relationship p<0.05).

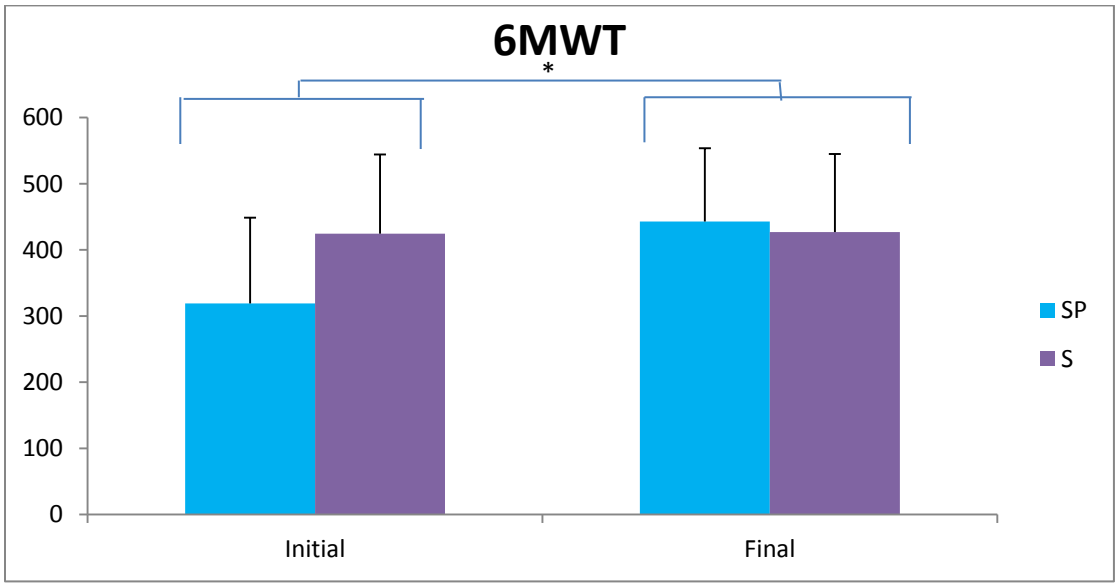

Figure 5: Baseline and final objective function results for the S and SP groups (*indicates statistically significant relationship p<0.05).

C) Depression

Participants suffered from less depression after completing the 9-week program. The initial scores for depression on the PHQ-9 for the SP group 14.9±6 and the final was 8.9±6. The S group initial depression was 16.4±7.2 and the final was 13.2±7.9 ($F(1, 11) = 30.2$, $p < .001$). The BECK was

used to measure the severity of depression. After completing the 9-week program, there was a significant improvement in the severity of depression in all participants (F (1, 11) =10.4, p=.012).

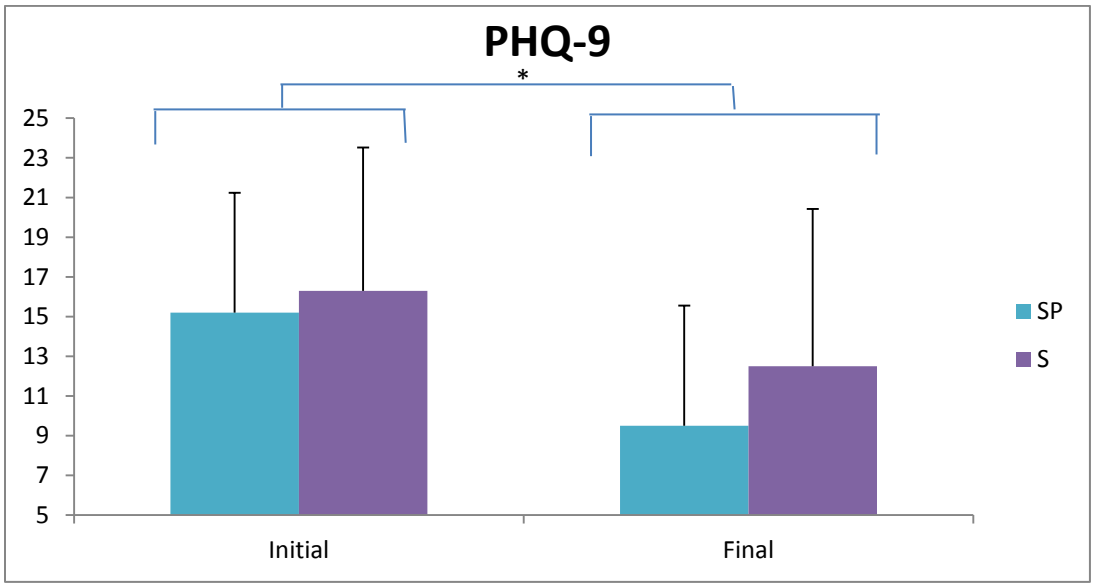

Figure 6: Average initial and final depression scores for the S and SP groups (*indicates statistically significant relationship p<0.05).

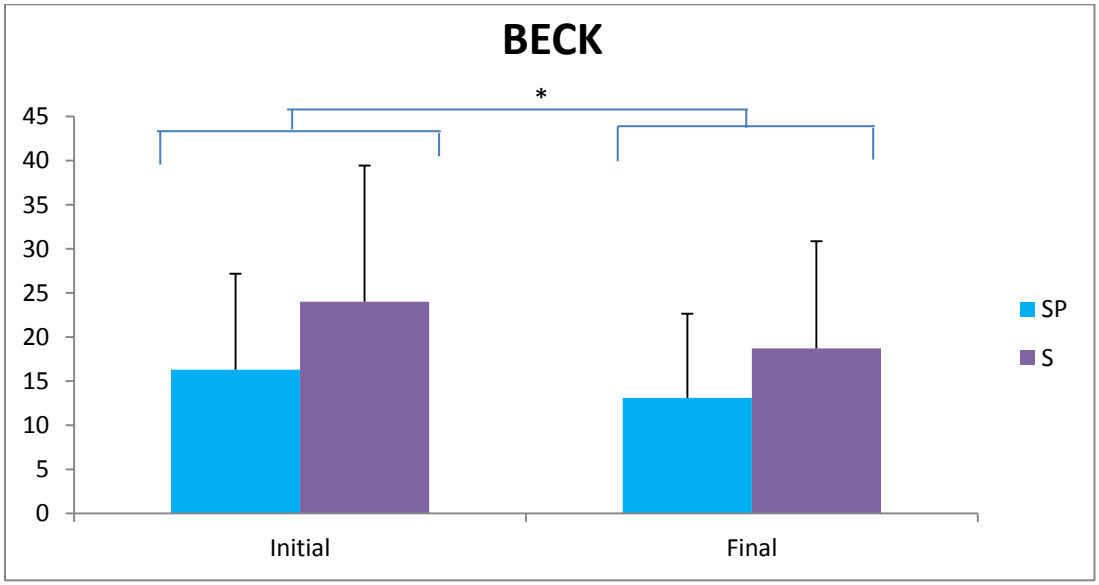

Figure 7: Average initial and final severity depression scores for the S and SP groups (*indicates statistically significant relationship p<0.05).

D) Pain

The McGill Pain Scale measured quality and intensity of pain and was the only variable that did not change significantly for either group. The average initial pain level for the SP group was 36±10 and the final was 34.4±14.7. The initial pain level for the S group was 36.2±16.9 and the final was 32.8±22.4 (F (1, 11)= 1.5, p=.243).

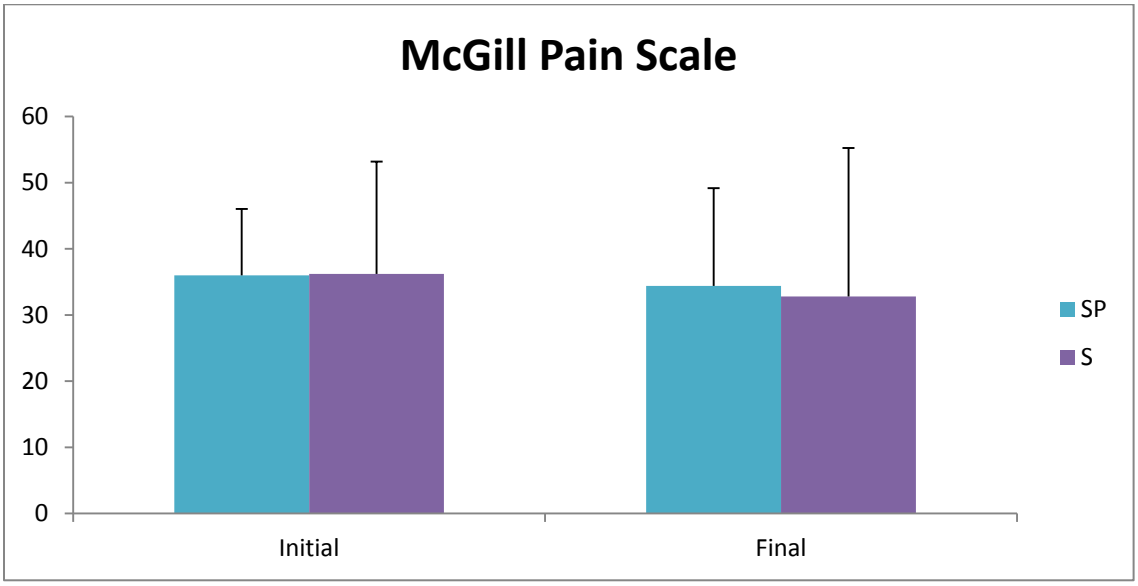

Figure 8: No change between baseline and final McGill Pain Scale scores for the S and SP groups.

2) Movement Comparison Between S and SP

A) Movement During the Day

Using the methods mentioned previously on how to calculate participants' physical activity, their six-day mean activity was calculated then separate 2X6 ANOVA's was used to compare the two groups over the 6 days of activity. In order to make physical activity calculations more accurate, every participant's first day of physical activity was excluded from the data due to the varying times participants received the actiwatch on the first day. Participants' physical activity was calculated from day two through day seven. The mean six day movement efficiency for both of the groups was 84% (SP 84.4%±10.9 and S 83.3%±10.4) and there was no statistical significance between the groups (F (1, 11)

=.091, *p*=.769) (See figure 12). Furthermore, there was no statistical significant difference in total wake time between the groups (F= (1, 11) .539, p=.480). The total wake time for the SP group was 856.5±151.5 and S group 896±94 (See Figure 13). The average minutes of movement for the SP group was 721.6±151.1 and the S group was 738.1±122.2 (F= (1, 11) .127, p=.729) (See figure 14). The six day mean activity level for the SP group was 347.3±119.9 and 353.1±137.8 for the S group (F= (1, 11) 0.17, p=.989) (See figure 15).

Figure 12: The average movement efficiency for both groups over the six days of actigraphy usage.

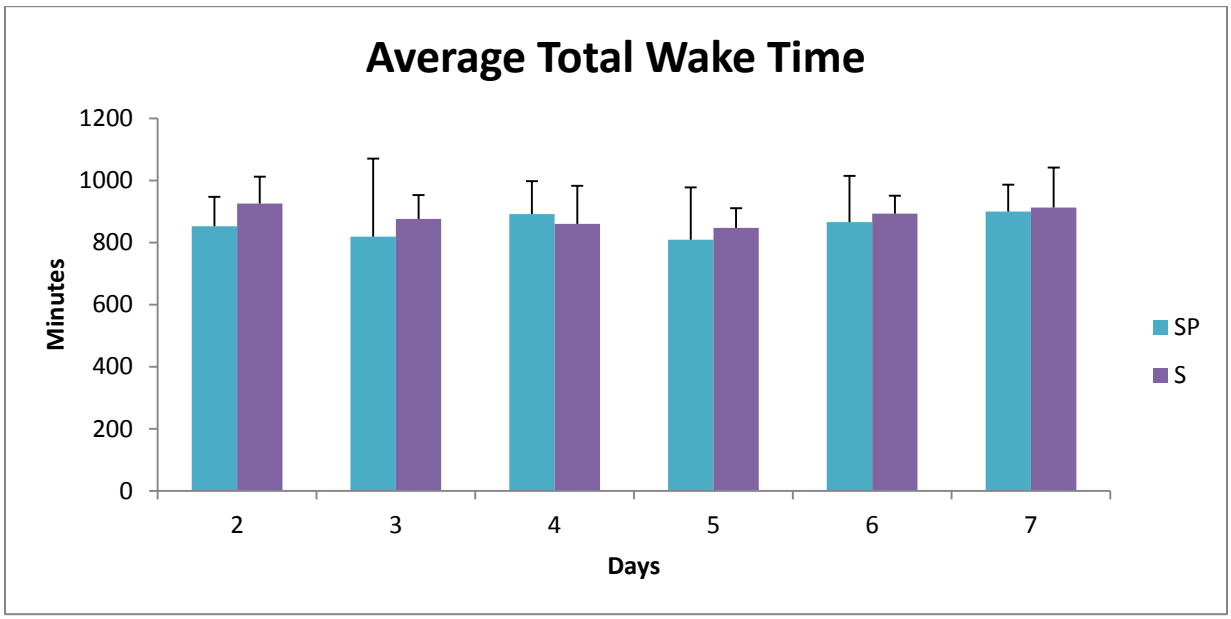

Figure 13: The average total wake time over six days of actigraphy usage.

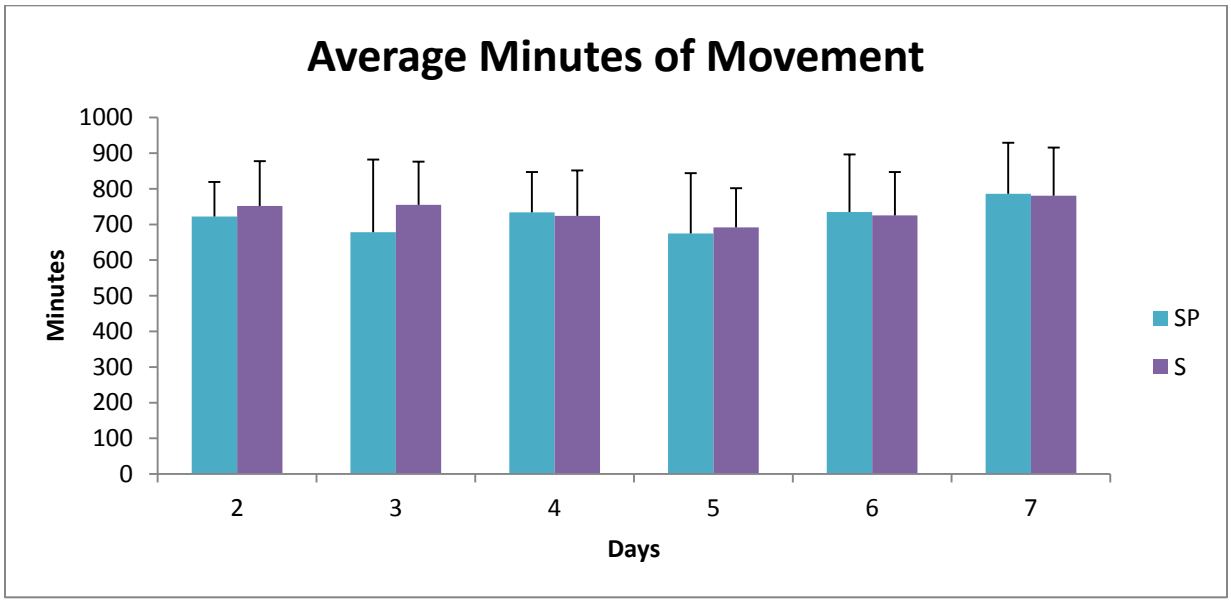

Figure 14: The average six day minutes of movement for the S and SP group.

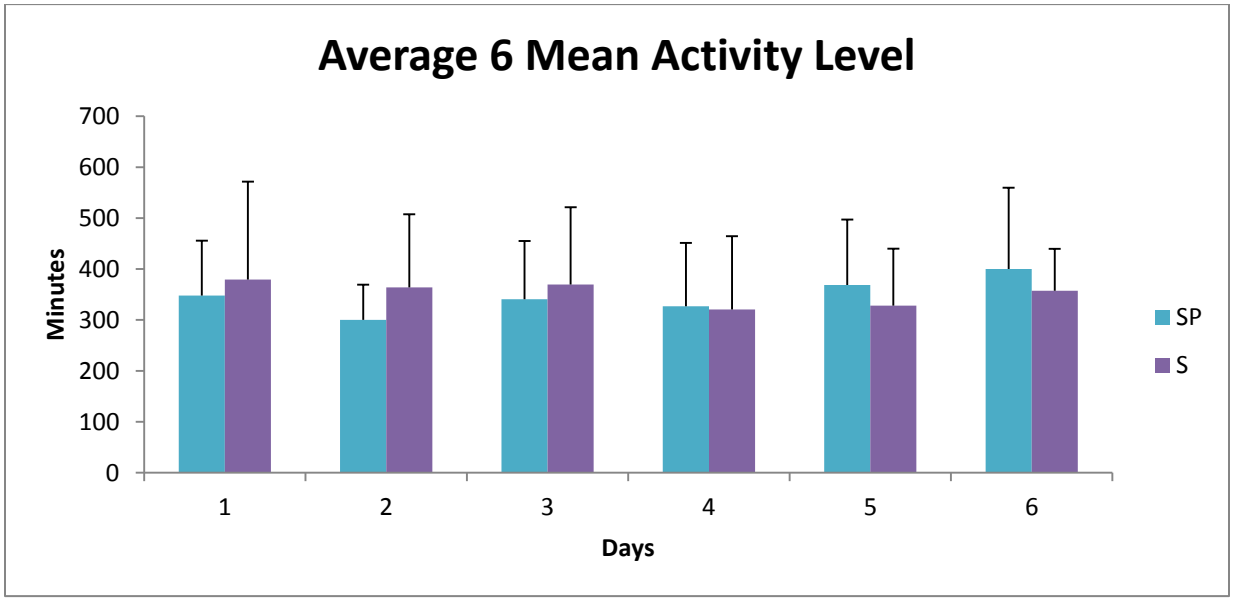

Figure 15: The average mean activity level for both groups over six days.

Groups	Movement Efficiency	Total Wake Time	Minutes of Movement	Mean Activity Level
SP	84.4±10.9	857.8±86.3	713.6±94.6	331.9±107.5
S	83.4±7.6	875.1±74	729.2±103.7	343.7±130.9

Table 4: S and SP daily activity.

B) Movement at night

Participants' movement at night was analyzed across five nights instead of seven due some participants not being compliant with wearing the watch. Instead of analyzing over 7 days and having missing data for some participants, we chose to eliminate day 6 and 7, primarily because those are the days the participants removed the watch. Each group's SE, TST, and WASO were averaged over the 5 nights then separate 2X5 ANOVA's were used to compare the movement at night between the groups. There was no statistical difference for sleep efficiency (SE) between the S and the SP group (See figure 6). The SP group mean SE was 82.6%±7.7and S 81±8.8 (F (1, 11) =.238, p=.635). Furthermore, there was no statistical difference between the groups in total sleep time (TST) (See figure 7). The mean TST for the SP group was 405.5 minutes±34.2 and TST for the S group was 406.6 minutes±79.5 (F (1, 11) =.002,

p=.967). A statistical difference between the groups for wake after sleep onset (WASO) was not found (See figure 8). The SP group's mean WASO was 89.9±62.2 and the S group's mean WASO was 96.1±58.5 (F (1, 11) = .082, *p*=.780).

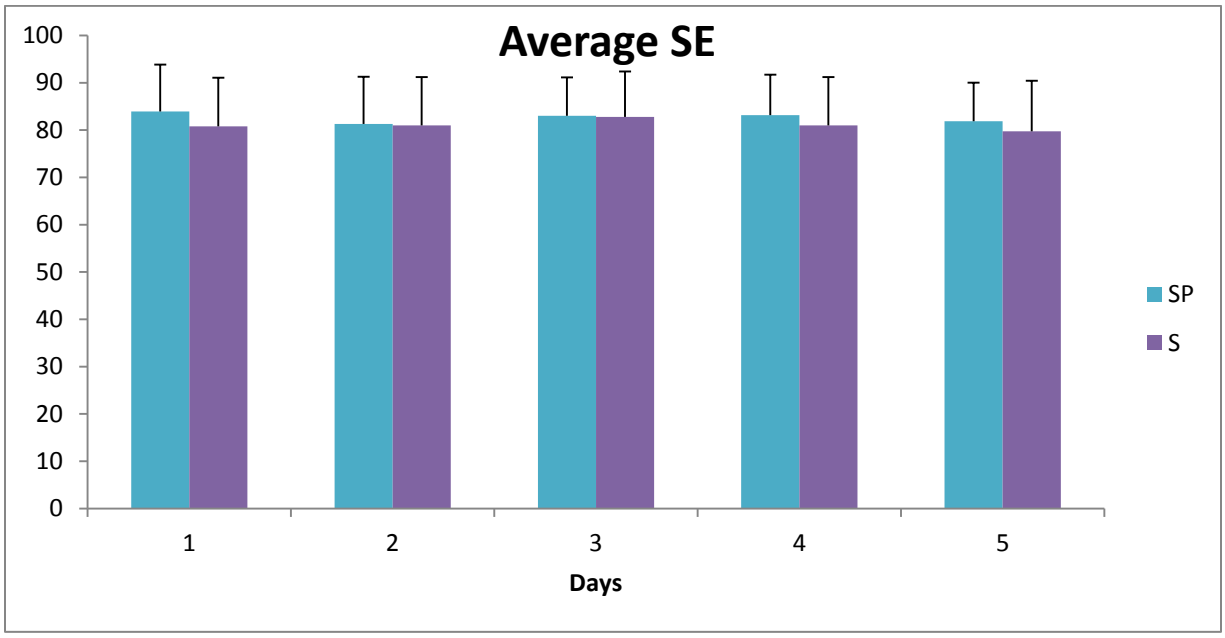

Figure 9: Average sleep efficiency for each group across the five nights

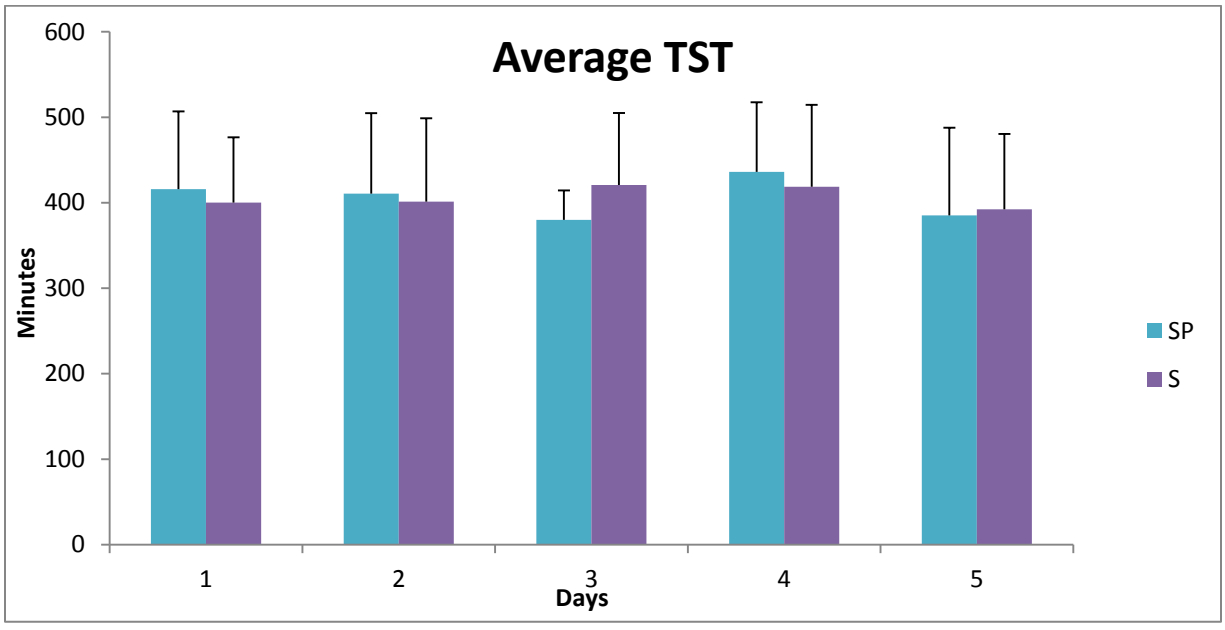

Figure 10: Average total sleep time for each group across the five nights.

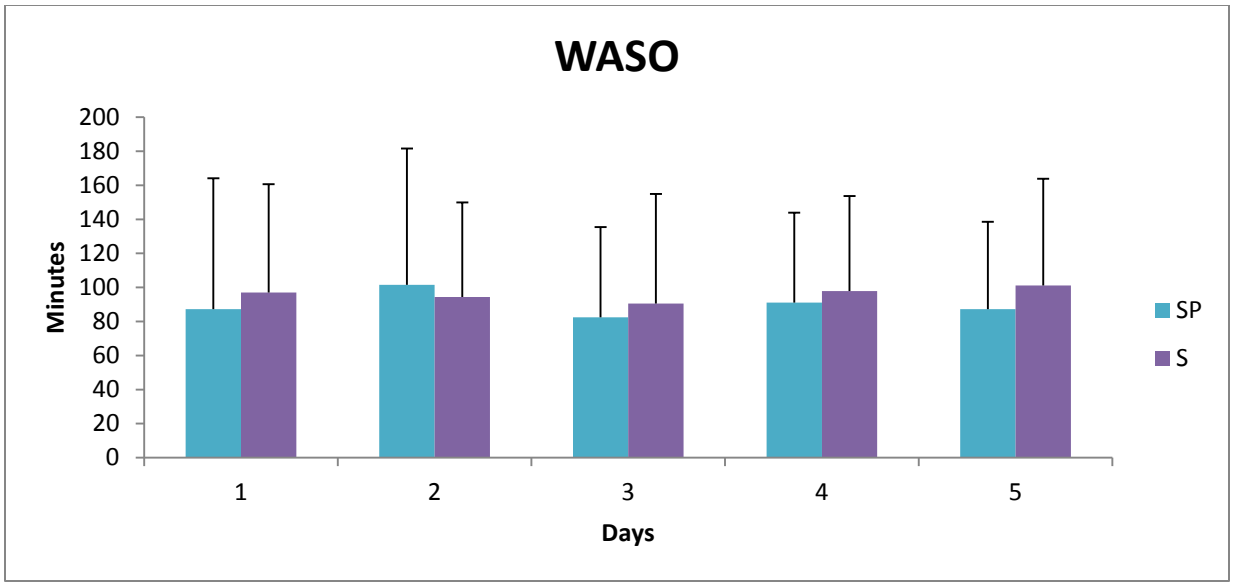

Figure 11: Average WASO for each group over the five nights.

Groups	SE	TST	WASO
SP	82.6±7.7	405.5±34.2	89.9±62.2
S	81±8.8	406.6±79.5	96.1±58.5

Table 5: S and SP night time movement.

3) Movement Correlated to Initial Pain Related Fear, Function, Depression, and Pain

Many correlations were calculated to determine if there was a relationship between movement during the day and movement at night with the initial results of pain related fear, depression, function and pain. There were a few statistically significant relationships identified (See tables 6-9).

A) Movement Correlated to Initial Pain-Related Fear

The relationships between movement during the day and movement at night and all pain related fear measures were examined. No significant relationships were found between the PCS, TSK, and IEQ with any of the day movement or night movement variables (see table 6).

Initial Scores	PCS	TSK	IEQ
Movement Efficiency	-.283	-.067	-.095
Total Wake Time	-.108	.001	-.183
Minutes of Movement	-.263	-.040	-.172
Mean Activity Level	-.214	-.096	-.101
SE	-.300	-.189	-.366

TST	.020	.014	.097
WASO	.274	.169	.357

Table 6: Pearson correlations between movement during the day and at night with initial scores in pain related fear (r values, *indicates statistically significant relationship p<0.05).

B) Movement Correlated to Initial Function

The relationships between movement during the day and movement at night and all subjective and objective measures were examined. Three strong correlations were identified (See table 7). There was a strong negative relationship between movement efficiency and the initial Pain Disability Index (PDI) questionnaire (R= -.500, p= .013). Another strong negative relationship was noted between the six-day mean activity level, measured by the actiwatch, and the PDI (R=-.427, p= .038). The third strong negative relationship was identified between minutes of movement and initial PDI (R= -.522, p=.009).

Initial Scores	PDI	6-minute walk test
Movement Efficiency	-.500*	.120
Total Wake Time	-.262	.044
Minutes of Movement	-.522*	.121
Mean Activity Level	-.427*	.327
SE	-.098	.007
TST	.207	.120
WASO	.123	.065

Table 7: Pearson correlations between movement during the day and at night with initial scores in function (r values, *indicates statistically significant relationship p<0.05).

C) Movement Correlated to Initial Depression

Two strong negative relationships were found between minutes of movement and total wake time with initial depression (See table 8). A strong negative relationship was found between total wake time and initial PHQ-9 (R= -.445, p= .029). The second strong negative relationship was found between minutes of movement and the initial PHQ-9 (R= -.467, p=.021).

Initial Scores	PHQ-9	BECK
Movement Efficiency	-.264	-.388
Total Wake Time	-.445*	-.208

Minutes of Movement	-.467*	.373
Mean Activity Level	-.258	-.273
SE	-.143	.044
TST	.237	.284
WASO	.191	-.056

Table 8: Pearson correlations between movement during the day and at night with initial scores in depression (r values, *indicates statistically significant relationship p<0.05).

D) Movement Correlated to Initial Pain

Two daily movement variables had a statistically significant relationship with initial pain (See table 9). Total Wake Time had a strong negative relationship with initial pain (R= -.505, p= .014) and minutes of movement had a strong positive relationship with the initial McGill Pain Scale (R= -.552, p= .006).

Initial Scores	McGill
Movement Efficiency	-.317
Total Wake Time	-.505*
Minutes of Movement	-.552*
Mean Activity Level	-.216
SE	-.101
TST	.265
WASO	.157

Table 9: Pearson correlations between movement during the day and at night with initial scores in pain (r values, *indicates statistically significant relationship p<0.05).

4) Movement and Change in Pain Related Fear, Function, Depression, and Pain

To determine if movement during the day or at night was related to a change in pain related fear, function, depression and pain at the completion of a chronic pain program, more correlations were performed. One strong relationship was found (See tables 12).

A) Initial Movement Correlated to Change in Pain-Related Fear

Initial movement during the day and movement at night variables were correlated to change in pain related fear scores. No significant relationships were found between initial activity and movement at night and change in PCS, TSK, and IEQ (See table 10).

Change in Scores	ΔPCS	ΔTSK	ΔIEQ
Movement Efficiency	-.206	-.179	.010
Total Wake Time	-.129	-.227	-.079
Minutes of Movement	-.250	-.299	-.047
Mean Activity Level	-.188	-.127	.105
SE	-.195	-.060	.168
TST	-.116	-.065	.153
WASO	.217	.105	-.118

Table 10: Pearson correlations between movement during the day and at night with changes in pain related fear (r values, *indicates statistically significant relationship p<0.05).

B) Initial Movement Correlated to Change in Function

Movement during the day and movement at night were correlated to the change in subjective and objective function (See table 11). No significant relationships were found between movement during the day and at night with the change in PDI or the 6MWT.

Change in Scores	ΔPDI	Δ6-minute walk test
Movement Efficiency	-.321	.141
Total Wake Time	-.117	.239
Minutes of Movement	-.325	.264
Mean Activity Level	-.212	.222
SE	-.142	.089
TST	-.108	-.094
WASO	.188	-.137

Table 11: Pearson correlations between movement during the day and at night with changes in function (r values, *indicates statistically significant relationship p<0.05).

C) Initial Movement Correlated to Change in Depression

Movement during the day and movement at night were correlated to the change in depression (See table 12). One strong correlation was noted. A strong negative relationship was identified between total wake time and change in PHQ-9 (R= -.452, p=.026).

Change in Scores	ΔPHQ-9	ΔBECK
Movement Efficiency	-.014	-.335
Total Wake Time	-.452*	-.067
Minutes of Movement	-.322	-.280
Mean Activity Level	-.101	-.394
SE	.029	.139
TST	.068	-.290

WASO	.031	-.244

Table 12: Pearson correlations between movement during the day and at night with changes in depression scores (r values, *indicates statistically significant relationship p<0.05).

D) Initial Movement Correlated to Change in Pain

Movement during the day and movement at night were correlated to the change in pain after completing the 9-week program (See table 13). No significant relationship was found between the McGill Pain Scale and any movement variable.

Change in Scores	**Δ**McGill
Movement Efficiency	.154
Total Wake Time	.220
Minutes of Movement	.235
Mean Activity Level	.299
SE	-.043
TST	-.163
WASO	.040

Table 13: Pearson correlations between movement during the day and at night with changes in pain (r values, *indicates statistically significant relationship p<0.05).

Discussion:

1) Program Efficacy and difference between S and SP group

Our first objective was to evaluate the efficacy of the treatment of chronic pain after completing a 9-week rehabilitation program at the CLRC. The results of our study supported our first hypothesis; the 9-week interdisciplinary rehabilitation program decreased pain related fear, increased function, and decreased depression in the participants. There were significant decreases from baseline measurements to completion of the 9-week program in PCS, TSK, IEQ, PDI, 6-minute walk test, PHQ-9, and the BECK for all subjects. However, there was no significant reduction in pain after completing the rehabilitation program. Participants went through a 9-week chronic pain rehabilitation program, but there was no change in pain levels. This finding is actually similar to previous research.[25] Despite no change in pain

levels, participants had significant improvements in depression and function, which could be due to the improvements in their psychological factors and pain related fear. Regardless of the specific injury or condition between patients, all subjects were rehabilitated in a similar fashion at the CLRC and the lesion site was not addressed throughout the 9-week rehabilitation. The CLRC's primary focus was to address the psychological factors of chronic pain. Our findings are supported by recent research with regards to treating chronic pain, it is more important to treat the psychological factors of pain than to treat the lesion site.[25]

One of the key pain related fear measures in our study was catastrophizing measured by the PCS. The change from initial PCS score to the final PCS score after the completion of treatment is an important tool used to measure success of this particular program. By decreasing the patient's pain related fear, it decreases the subject's catastrophizing which in turn changes how the patient views their pain. In changing how a patient views their pain, it decreases movement avoidance behaviors and may lead to increase patient function. A decrease in the PCS may be the reason for more function as well as less depression in these patients. The average initial PCS for the patients of this study was 30.7 ±13.2, which is very high. For example, the average initial PCS for patients at the Mayo Clinic Pain Rehabilitation Program was 23.3±11.5.[79] Furthermore, those patients at the Mayo Clinic were also receiving opioid medication to treat their pain.[79] Moreover, the non-taking opioid patients at the Mayo Clinic average PCS score was 25.3±13.1.[79] At the completion of our study, our participants' average PCS dropped to 19.5±15.6. This approximate 11 point improvement is similar to Mayo Clinic study.[79] The average PCS final for the patients at the Mayo Clinic who were taking opioids improved to 12.9±11 whereas the non-opioid patients decreased to 12.2±12.3.[79] The CLRC and the Mayo Clinic Pain Rehabilitation had different methods of addressing chronic pain, but both programs addressed the pain related fear and had similar decreases in the PCS. As mentioned previously the average pain did not change, but the change in pain related fear may be the reason for the improvement in function

because of the reduction of catastrophizing and movement avoidance behaviors. Addressing catastrophizing is an important factor in chronic pain programs and should continue to be addressed.

Another important measurement tool for chronic rehabilitation programs are self-report functional assessments questionnaires. The Pain Disability Index (PDI) is a common questionnaire used to assess participants' physical functioning. In a similar program from a study in 2010 at the Rehabilitation Institute of Chicago Center for Pain Management, participant's average initial PDI was 41.2 and the final PDI, after completing an interdisciplinary treatment program, was 18.[71] The initial PDI average for the current study was 43.2±11.3 and the final average was 28.9±15.7. The subjects' change in PDI in our program was not as significant compared to the Chicago program. The possibility why there was not as significant increase in function, measured by the PDI, can be due to the CLRC program not focusing on medication reduction or because patients started treatment with a higher initial PCS score. In addition, the patients in our program may have more comorbid conditions including depression and anxiety, which may limit the amount of improvement in self-reported function.

Both the Mayo and Chicago Rehabilitation Centers place an emphasis on medication management and reduction where the CLRC does not. The treatment protocol at the CLRC is non-pharmacological based program, emphasizing the self-management of chronic pain. Moreover, the CLRC program is a multidisciplinary cognitive behavior approach as well as occupational therapy. The goal for the rehabilitation program is to improve function for activities of daily living, which may explain why the pain related fear decreases at the end of the 9-week program. Despite program variations regarding pain medications, treatment strategies, and baseline levels of pain related fear, patients in our study demonstrated similar reductions in pain related fear and improvements in subjective physical functioning.[79]

The significant improvements in the psychosocial factors (PCS, TSK, IEQ, PDI, PHQ-9, and BECK) noted in the CLRC participants could be attributed to the amount of education that occurred throughout the 9-week program. Evidence-based education of chronic pain reduces the threat and fear of chronic pain and encourages coping strategies.[25] In a previous study, exercise and psychosocial education was used to lower the incidence of LBP in soldiers.[25] In that study, a cluster randomization strategy was utilized to sort 4,147 soldiers with no previous history of LBP.[25] Participants were divided into four interventions comprised of exercise and education programs (traditional lumbar exercise, traditional lumbar exercise plus psychosocial education, core stabilization exercise, core stabilization exercise plus psychosocial education).[25] The traditional and core exercise regimens were composed of 5 exercises each and performed for 5 minutes a day, 5 days per week for 12-weeks.[25] The psychosocial education program consisted of a 45 minutes lecture.[25] The lecture included information about the importance of returning to normal activity, decreasing fear-avoidance beliefs, and decreasing pain catastrophizing when experiencing pain.[26] Over the course of two years, 706 soldiers had LBP and the groups that had a lower incidence of LBP were seen in the traditional lumbar exercise plus psychosocial education and core stabilization exercise plus psychosocial education.[25] The results of this study suggest that education can help decrease the future development of chronic pain. The results from our study suggest that education can also reduce pain related fear and improve function in patients currently experiencing chronic pain. The George et al. study demonstrated that patient education alone was able to generate a decrease in the development of chronic low back pain.[25] Therefore, education about pain related fear is a critical aspect of treating chronic pain. The patient education is emphasized throughout the 9-week self-management rehabilitation program at CLRC. The program covered topics that include what chronic pain is, stress and chronic pain, managing stress, thoughts, emotions and fears, and relaxation techniques. The CLRC program encompasses an in-depth patient education

program which is specific to chronic pain and as a result may be the key reason for the significant decreases in kinesiophobia, catastrophizing, and depression in our subjects.

2) Movement Comparison between the S vs SP

A) Movement during Day

The second objective was to assess the physical activity in chronic pain patients in the S and SP groups. We hypothesized that the SP participants would have less activity compared to the S group and we made this hypothesis based on our preliminary data. However, our hypothesis was not supported. There were no differences identified between the groups for any physical activity variables that were calculated.

We calculated mean activity level in a similar fashion to previous studies and the 6-day mean activity level for the SP group was 347.3±119.9 and 353.1±137.8 for the S group. The mean activity level calculated for our participants varied from other studies. One study found that the mean activity level in adolescents with chronic pain was 464.8±150.6,[84] while another study found a mean activity of 415± 112.[50] Both studies noted a slightly higher level of activity in healthy adolescents of 515±111 and 517±115.3.[50, 84] It is likely that the increase in activity observed in these studies was due to the younger participants compared to our study.

The mean activity results of our study were higher in comparison to a study performed on adults with chronic low back pain (cLBP). Participants wore a wrist actigraphy, epoch set at 15 seconds, during waking hours for 5 days and entered pain severity in a diary every 4-hours.[3] The actigraphy data was analyzed and the average mean activity per 4-hour period was calculated.[3] The average mean physical activity for the participants with cLBP which was measured every 4-hours over 5 days was 228.2±80.1.[3] The participants of the cLBP study had a higher initial depression level in comparison to our study and

other research has shown participants who have more depression have less activity.[42] The difference in epoch length could also contribute to a lower activity count compared to our study.

In addition to depression, another study measured physical activity in subjects suffering from bipolar disorder.[37] Sixty adults with bipolar disorder wore a hip accelerometer at a 1 minute epoch for seven consecutive nights.[37] Adult bipolar disorder participants were matched by gender, age, and body mass index to users and non-users of mental health treatment.[37] The majority of the bipolar adults had moderate depression symptoms.[37] The study determined the mean activity level for bipolar disorder patients to be 159.3±87.2 and their minute per day activity was 229±87.[37] The group that included mental health treatment mean activity level was 238.4±114.1 and minute per day activity was 328±115.[37] The participants who did not receive mental health treatment mean activity level was 295.9±121.0 and minute per day activity was 379±107.[37] Our participants' mean minutes of movement for the SP group was 721.6±151.1 and the S was 738.1±122.2.[37] The study concluded that bipolar disordered adults have less activity and are more sedentary than users and non-users of mental health treatment.[37] Bipolar adults had two thirds of activity levels of users of mental health.[37] Comparing the activity levels of the two studies is difficult due to the fact that the accelerometer was placed at different locations, but the bipolar adults had moderate depression levels and the study found they moved less. The participants in our study have high depression levels which could explain the low activity levels.

Determining if the participants of our study have a low activity level is difficult to conclude due to the fact there is little research done on physical activity in adults with chronic pain. More studies need to be conducted on adults with chronic pain using the same actigraphy methods to determine their accurate levels of activity. Previous studies that used actigraphy to measure physical activity on adolescents with chronic pain did not calculate movement efficiency, total wake time, and minutes of

movement. Our study is among the first to report these physical activity variables in chronic pain patients. Therefore, further investigation is warranted to determine if the calculations reported in this study can be improved upon with treatment.

B) Movement at Night

With the use of an actigraphy, we were able to measure various sleep quality variables in adults with chronic pain. Part B of our second objective was to evaluate the movement at night in chronic pain patients in the S and SP group. Based on our preliminary data, we hypothesized the SP group would have more movement at night (more sleep disturbances) compared to the S group. The results from our study do not support our initial hypothesis; there is no statistical difference in any movement at night variable between groups. The average sleep efficiency for both groups is approximately 82%, which a sleep efficiency of 85% or less is considered to be poor sleep.

The sleep efficiency gathered from our study, varied to other studies that used actigraphy to measure sleep quality in participants with chronic pain. A seven-night actigraphy study was performed on adolescents and their SE was 76.1%.[61] Another study, performed on adults aged 45-53 with fibromyalgia and depression, reported a sleep efficiency of 78.85%. [42] Within the fibromyalgia study, sleep quality was assessed on participants who had fibromyalgia only and the sleep efficiency reported was higher at 89.16%.[42] In another seven night sleep study, chronic pain patients age and gender were matched to healthy controls, the reported sleep efficiency was 88.3% for cLBP participants and 87.8% for healthy controls.[82] The Palermo et al. study that measured the low (76.1%) SE in adolescents, did not assess if participants were diagnosed with a sleeping disorder prior to participating. It is possible that subjects with sleep disorders would have a decreased SE that may not be related to their chronic pain. Prior to allowing patients to participate in our study, they were asked if they have a history of sleep apnea or any clinically diagnosed sleep disorders. Also, the study that measured participants who had fibromyalgia with depression reported a low SE.[42] The study failed to mention what tool was used to

assess depression or the average level of depression among participants. It is possible that subjects with high levels of depression could alter the results of the sleep assessment. However, we learned from the study that depression plays a key role in sleep quality because the participants who only had depression had the lowest SE (73.4%) compared to everyone else.[42] Comparing the depression levels found from our study to the Korszun et al. study would have been interesting and may have explained the difference in SE between the subjects. While it seems apparent that pain negatively affects sleep, it seems even more apparent that pain in addition with pain related fear significantly decreases sleep quality. As noted in our study and previous studies, there is a significant decrease in sleep quality with an association of depression.[61] Based on the results from our study, pain related fear, like depression, negatively affects sleep significantly more than pain alone. A more accurate assessment of sleep using polysomnography is needed to determine if sleep is decreased more in patients with paint related fear and pain compared to depression alone.

Chronic pain patients often complain of sleep disturbances.[60, 69] Pain interferes with sleep and sleep disturbances have a direct influence on pain experienced. As mentioned before, chronic pain patients have increased pain sensitivity and create a self-perpetuating cycle of sleep disruption, increase pain and depression. Previous studies have showed that patients with fibromyalgia demonstrate increase body sensitivity, both physiologically and psychologically.[4] Patients with fibromyalgia experience more alpha electroencephalographic (EEG) interruption in non-rapid eye movement sleep, indicating an increase level of arousal.[4] The prominent alpha EEG sleep may contribute to unrefreshing sleep and help to re-enforce the perpetual pain-sleep cycle fibromyalgia patients experience.[4] As suggested above, more studies on patients who suffer from the combination of depression, pain, and pain related fear are warranted.

Similar to our sleep efficiency, the total sleep time (TST) of our study was lower compared to previous research. The TST for the SP group was 405.5±34.2 and TST for the S group was 406.6±79.5. Other studies reported higher averages, a pilot study using actigraphy to measure sleep in cLBP compared to healthy controls found a TST of 434.33±76.9 for pain patients.[60] Another study performed on cLBP patients reported a TST of 441.2±68.5 for CLBP.[82] Wake after sleep onset (WASO) is another variable calculated from the actigraphy and is expressed in minutes. The actigraphy calculates how many minutes the participant is awake after initially falling asleep through movement. The WASO results recorded in our study were significantly higher compared to other research. The mean WASO for the SP group was 89.9±62.2 and S group mean WASO was 96.1±58.5. Other research has reported levels of WASO of 43.3±15 and 35.5±12.4 in patients which cLBP.[60, 82] As mentioned above, there is a possibility that the combination of pain, pain related fear and depression is what significantly affects the WASO in these patients.

3) Movement Correlated to Initial Pain Related Fear, Function, Depression, and Pain

Our third objective was to evaluate if chronic pain patients with less movement during the day and more movement during the night have poorer initial scores in pain related fear, function, depression, and pain. We hypothesized that the patients with less day movement and more night movement would have higher baseline levels of pain related fear, less function, less depression, and more pain. The results of our study did not support our third hypothesis. Movement during the day did not correlate to any of the initial pain related fear questionnaires. Movement efficiency, minutes of movement and activity level were significantly correlated to the PDI. In addition, total wake time and minutes of movement were significantly correlated to the PHQ-9. Lastly, total wake time and minutes of movement correlated to initial pain levels. Night movement did not correlate to any initial pain related fear, function, depression and pain questionnaires.

A) Movement Correlated to Initial Function

An interesting finding from the study was that movement efficiency, minutes of movement, and mean activity level correlated to the initial PDI but not to the initial 6 minute walk test. The correlation between movement efficiency and initial PDI was R= -.500, p=.009, minutes of movement and initial PDI was R= -.522, p= .009, and mean activity level and initial PDI was R= -.427, p=.037. This is an interesting finding because three objective measurements correlate to a subjective evaluation of physical activity (PDI) but not to another objective evaluation of physical activity (6 minute walk test). For example, people with lower movement efficiency, minutes of movement, and mean activity level were associated to a lower initial PDI score but not necessarily a lower initial 6-minute walk test. The data suggests that people who feel like they are not that functional do not move that much and report that they do not move that much. However, if we test them to see how much they can move, they move well. These patients are choosing not to move, which could contribute to their prolonged rehabilitation. Moreover, our study suggests that when patients complete the PDI, their score will indicate their amount of activity but not what type of function or activity they are capable of performing. Our data supports using both subjective and objective measurements of physical activity to identify how much activity the patients are participating in as well as their actual capabilities.

The objective measurement of physical activity not correlating to self-reported function has been reported in previous research.[47] A study was performed to determine the relationship among self-reported activity limitations and clinician measured functional performance.[47] Eighty-three patients with LBP filled out the Roland-Morris Disability Questionnaire (RMDQ) and completed six physical performance measures (lumbar flexion, 50-foot walk at fastest speed, 5-minute walk, 5 repetitions of sit to stand, 10 repetitions of trunk flexion and loaded reach task).[47] The RMDQ is similar to the PDI because it is another subjective measurement of function and the six physical tasks are objective measurements of function. There was weak to moderate correlation between RMDQ and the subjects'

corresponding performance (R= .20 to .33).[47] The findings from this study do not correlate with the findings of our study. The correlation between movement efficiency and 6-minute walk test for our study was R= .120 and minutes of movement and 6-minute walk test was R= .121. The differences in the relationship between self-reported function and specific activity tasks may be due to the elevated pain related fear in our subjects. Psychological questionnaires were not mentioned in the study, but previous research has found psychological variables can explain the variance between self-report limitations and performance measures.[9] The psychological variables include fear-avoidance beliefs, psychological disturbances, and catastrophizing. Another study reported stronger correlations between psychological factors and subjective measurements than psychological factors and observed function with patients with acute LBP.[83]

The findings of our study support previous research that subjective measurements correlate more to activity limitations than objective measurements. Movement efficiency, minutes of movement, and mean activity level correlates with the subjective evaluation (PDI) and not the objective evaluation (6-minute walk test). Physical functioning is multidimensional, which includes an individual's subjective perception of their physical function and perceived difficulties performing activities.[84] Clinicians at the CLRC has described the difficulty with communicating with patients. Clinicians ask chronic pain patients to perform a task and patients immediately say they are unable, but clinicians know that physically the patients are able to complete the task, however they are just choosing not to, which is similar to their movement or lack of movement outside the clinic.

Neither self-reported activity nor objective performance measure is a pure measurement of physical functioning when used alone.[47] Both measurements (subjective and objective measures of function) are affected by physical and psychological factors and each measurement provides information to construct physical function.[47] As result of these findings, further investigation is needed to measure the relationship between movement efficiency, subjective assessments, and objective measures of function.

B) Movement Correlated to Initial Depression and Pain

Minutes of movement and total wake time correlated with initial PHQ-9 and pain. The correlation between minutes of movement and initial PHQ-9 was R= -.467, p= .021 and total wake time and initial PHQ-9 was R= -.445, p= .029. The negative correlation found between minutes of movement, total wake time and depression means participants who moved less and had shorter total wake time and also were experiencing more depression. As mentioned previously, depression has an influence on day time activity and our results are congruent with other research.[42] [37] We also noted a significant negative correlation between the McGill Pain Scale and minutes of movement and total wake time. The higher the initial pain level, the less minutes of movement patients had throughout the day and the less total wake time. Higher initial pain levels correlating negatively to minutes of movement and total wake time could be explained by psychological factors that are associated with pain. Patients have a fear of movement because they believe if they move it will cause them more pain (catastrophizing) which results in less minutes of movement.

A longitudinal study was performed to evaluate the influence of depression and pain intensity on self-report and objective measurements of physical activity on cLBP patients.[35] Sixty-six cLBP patients between the ages of 18-65 participated in a 14 day study.[35] Participants' activity levels were monitored using actigraphy for 14 days and an electronic diary that patients were required to fill out describing their daily activity.[35] Patients had to complete the diary 8 times a day, every time the diary's alarm sounded.[35] Prior to the actigraphy measurements, patients answered questionnaires that assessed their disability, habitual physical activity, pain intensity, and depression.[35] The Roland Morris Disability Questionnaire (RMDQ) assessed subjective function and the Baecke Physical Activity Questionnaire assessed subjective habitual activity.[35] The BECK Depression Inventory assessed depression and the Visual analogue scales determined pain intensity.[35] The results of the study suggest that depression was not associated with objective physical activity, but patients who were more depressed reported lower

levels of subjective physical activity in daily life compared to their actual level of physical activity.[35] However, depression was significantly associated with the discrepancy between self-report and objective assessment of physical activity.[35] In that study, pain intensity was not associated with patients' daily activity level.[35] The study was able to conclude that cLBP patients, who have higher levels of depression, underestimate their subjective daily activity, although their objective level of activity did not differ and pain intensity does not influence activity level.[35] The results of the study differed from our study in that two objective measurements of activity correlated to depression. The severity of depression can be the explanation as to why there is a difference between the two studies. Patients at the CLRC had significantly higher depression levels in comparison to the other study. The initial BECK depression level, for both groups, at the CLRC was 22.1±15.6 whereas; the other study's average BECK depression was 11±15. As mentioned previously, higher depression levels influence daily activity.[37, 42] The reason as to why pain intensity was not associated with the level of daily activity in the other study but a correlation was found in our study could be due to the level of pain intensity and pain related fear. The CLRC patients had very high pain intensity which was assessed by the McGill Pain Scale. Furthermore, the other study failed to mention the pain related fear levels of their participants, which plays a key role in function. Based on the results of our findings, the level of depression and pain intensity both influence daily activity.

4) Movement related to the Change in Pain Related Fear, Function, Depression, and Pain

Determining if day or night movement can predict outcomes in pain related fear, function, depression, and pain at the completion of a chronic pain rehabilitation program was our fourth objective for this study. We predicted patients with less movement during the day and more movement at night would be associated with smaller changes in pain related fear, function, depression, and pain. The results of this study did not support our hypothesis. The only significant correlation identified in this

study was between total wake time and change in PHQ-9 (R= -.452, p= .026). This moderate correlation suggests participants who initially had a higher total wake times were associated with a greater change in depression at the completion of the program.

A recent study was conducted to assess the strongest predictor of physical activity for chronic pain.[3] The study examined if fear-avoidance, operant, and pain could predict physical activity for chronic pain patients.[3] Patients completed questionnaires that assessed their depression, catastrophizing, kinesiophobia, psychosocial variables, and pain sensitivity.[3] After, participants wore a wrist actigraphy with the epoch set at 15 seconds, during waking hours for five days and entered pain severity every 4-hours.[3] The actigraphy data was analyzed and the average activity counts per minute over 4-hour periods were calculated.[3] The results of the study revealed that the response of the patients' spouses accounted for a significant amount of variance in physical activity, meaning reinforcement of behaviors from a spouse is a powerful mechanism for behavior change.[3] The results from our study are congruent with this study in the fact that the PCS, TSK, IEQ, PDI, PHQ-9, and BECK did not correlate to physical activity. The finding that patients' spouses accounted for a significant variance in physical activity could be confirmed by our study because the responses of spouses were not assessed.

As previously mentioned, correlating change in pain to all other variables was not part of our initial hypothesis. However, because pain can be considered a baseline or outcome measurement, we correlated the change in pain to the initial day and night movement, change in pain related fear, function, and depression. The change in pain was not correlated to day or night movement, pain related fear, function, or depression. Further investigation is needed to determine what factors can contribute to a successful outcome in a chronic pain rehabilitation program.

Limitations:

There are several limitations to this study that should be noted. The first limitation is the lack of consistency of the program coordinator at the CLRC. There were more than 4 clinical coordinators during the course of this study who were involved in determining patient placement within the groups. Not having a consistent person in the selection process may have affected the homogeneity of the patients in the S and SP groups. Another limitation of the study was the time of year participants were monitored with the actigraphy. Participants were recruited throughout an entire year and the amount of day light may have affected the total sleep time of patients. In addition, patients were not always compliant in describing their prescribed medication use. We anticipated that some participants used some medication without reporting it, which may have affected their movement at night.

Conclusion:

In conclusion, this study suggests that an interdisciplinary program that focuses on the self-management of chronic pain is effective in reducing pain related fear, and improving physical function, and depression. There was no statistical difference between the two groups at the CLRC for any movement during the day or night variables. This study mentioned new variables that can be used to help determine physical activity of adults with chronic pain in future studies. Our movement during the day and movement efficiency data has helped to establish baseline levels of physical function for adults with chronic pain. However, objective measures of movement during the day or night were unable to predict the successful completion of a chronic pain program. Although, movement efficiency, minutes of movement, and total wake time correlated to self-reported function (PDI), but not to another objective measure of function (6-minute walk test). Furthermore, minutes of movement and total wake time correlated to initial values of depression (PHQ-9) and pain (McGill Pain Scale). Total wake time was also correlated to one of changes in depression measurements (PHQ-9).

Clinicians should use self-report and objective functional measures to measure activity in chronic pain patients to determine how capable they are and how much activity they are partaking in. More research is needed to determine if depression and pain intensity influence daily physical activity. Future research should investigate why movement efficiency, minutes of movement, and mean activity levels correlated to the PDI and not the 6-minute walk test.

References

1. Affleck G, Urrows S, Tennen H, Higgins P, Abeles M. Sequential daily relations of sleep, pain intensity, and attention to pain among women with fibromyalgia. *Pain.* Dec 1996;68(2-3):363-368.
2. Agargun MY, Tekeoglu I, Gunes A, Adak B, Kara H, Ercan M. Sleep quality and pain threshold in patients with fibromyalgia. *Comprehensive Psychiatry.* May-Jun 1999;40(3):226-228.
3. Alschuler KN, Hoodin F, Murphy SL, Rice J, Geisser ME. Factors contributing to physical activity in a chronic low back pain clinical sample: A comprehensive analysis using continuous ambulatory monitoring. *Pain.* Nov;152(11):2521-2527.
4. Anch AM, Lue FA, Maclean AW, Moldofsky H. Sleep physiology and psychological aspects of fibroitis (fibromyalgia) syndrome. *Canadian Journal of Psychology-Revue Canadienne De Psychologie.* Jun 1991;45(2):179-184.
5. Beck A SR. psychometric properties of the BECK depression Inventory: Twenty-Five Years of Evaluation. *Clinical Psychology Review.*8:77-100.
6. Belza BL. Comparison of self-reported fatigue in rheumatoid arthritis and controls. *Journal of Rheumatology.* Apr 1995;22(4):639-643.
7. Burckhardt CS. The use of the McGill pain questionnaire in assessing arthritis pain. *Pain.* 1984;19(3):305-314.
8. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh sleep quality index-A new instrument for psychiatric practice and research. *Psychiatry Research.* May 1989;28(2):193-213.
9. Caporaso F, Pulkovski N, Sprott H, Mannion AF. How well do observed functional limitations explain the variance in Roland Morris scores in patients with chronic non-specific low back pain undergoing physiotherapy? *European Spine Journal.* May;21:S187-S195.
10. Cesta HM, FA Lue et al. Sleep and musculoskeletal pain in workers following a soft tissue injury. *Sleep.* 1998;21:289.
11. Chae KY, Kripke DF, Poceta JS, et al. Evaluation of immobility time for sleep latency in actigraphy. *Sleep Medicine.* Jun 2009;10(6):621-625.
12. Childs JD, Fritz JM, Flynn TW, et al. A clinical prediction rule to identify patients with low back pain most likely to benefit from spinal manipulation: A validation study. *Annals of Internal Medicine.* Dec 2004;141(12):920-928.
13. Chou R, Atlas SJ, Stanos SP, Rosenquist RW. Re: Chou R, Loeser JD, Owens DK, et al. Interventional therapies, surgery, and interdisciplinary rehabilitation for low back pain: an evidence-based clinical practice guideline from the American Pain Society. Spine 2009;34:1066-77 Response. *Spine.* Sep;35(19):1826-1827.
14. Cisternas MG, Murphy LB, Yelin EH, Foreman AJ, Pasta DJ, Helmick CG. Trends in Medical Care Expenditures of US Adults with Arthritis and Other Rheumatic Conditions 1997 to 2005. *Journal of Rheumatology.* Nov 2009;36(11):2531-2538.
15. Crapo RO, Casaburi R, Coates AL, et al. ATS statement: Guidelines for the six-minute walk test. *American Journal of Respiratory and Critical Care Medicine.* Jul 2002;166(1):111-117.
16. Crook J, Moldofsky H. *Prognostic indicators of disability after a work-related musculoskeletal injury*. Binghamton: Haworth Medical Press an Imprint of Haworth Pr, Inc; 1995.
17. Cunningham JM, Blake C, Power CK, et al. The impact on sleep of a multidisciplinary cognitive behavioural pain management programme: a pilot study. *Bmc Musculoskeletal Disorders.* Jan;12:7.
18. Deyo RA. Measuring the functional status of patients with low back pain. *Archives of Physical Medicine and Rehabilitation.* Dec 1988;69(12):1044-1053.

19. Drewes AM. Pain and sleep disturbances with special reference to fibromyalgia and rheumatoid arthritis. *Rheumatology.* Nov 1999;38(11):1035-1038.

20. Dworkin RT, DC. Core outcome measures for chronic pain clinical trails: IMMPACT recommendations. *Pain.* 2004;113(1-2):9-19.

21. Flemons WW, Littner MR. Measuring agreement between diagnostic devices. *Chest.* Oct 2003;124(4):1535-1542.

22. Flemons WW, Littner MR, Rowley JA, et al. Home diagnosis of sleep apnea: A systematic review of the literature - An evidence review cosponsored by the American academy of sleep medicine, the American College of Chest Physicians, and the American Thoracic Society. *Chest.* Oct 2003;124(4):1543-1579.

23. Flynn T, Fritz J, Whitman J, et al. A clinical prediction rule for classifying patients with low back pain who demonstrate short-term improvement with spinal manipulation. *Spine.* Dec 2002;27(24):2835-2843.

24. Gatchel RJ, Mayer TG. Evidence-informed management of chronic low back pain with functional restoration. *Spine Journal.* Jan-Feb 2008;8(1):65-69.

25. George SZ, Childs JD, Teyhen DS, et al. Brief psychosocial education, not core stabilization, reduced incidence of low back pain: results from the Prevention of Low Back Pain in the Military (POLM) cluster randomized trial. *Bmc Medicine.* Nov;9:11.

26. George SZ, Teyhen DS, Wu SS, et al. Psychosocial education improves low back pain beliefs: results from a cluster randomized clinical trial (NCT00373009) in a primary prevention setting. *European Spine Journal.* Jul 2009;18(7):1050-1058.

27. Gilbody S, Richards D, Brealey S, Hewitt C. Screening for depression in medical settings with the patient health questionnaire (PHQ): A diagnostic meta-analysis. *Journal of General Internal Medicine.* Nov 2007;22(11):1596-1602.

28. Gironda RJ, Lloyd J, Clark ME, Walker RL. Preliminary evaluation of reliability and criterion validity of Actiwatch-Score. *Journal of Rehabilitation Research and Development.* 2007;44(2):223-230.

29. Gowans SE, DeHueck A, Voss S, Silaj A, Abbey SE. Six-month and one-year followup of 23 weeks of aerobic exercise for individuals with fibromyalgia. *Arthritis & Rheumatism-Arthritis Care & Research.* Dec 2004;51(6):890-898.

30. Grant PM, Ryan CG, Tigbe WW, Granat MH. The validation of a novel activity monitor in the measurement of posture and motion during everyday activities. *British Journal of Sports Medicine.* Dec 2006;40(12):992-997.

31. Guzman J, Esmail R, Karjalainen K, Malmivaara A, Irvin E, Bombardier C. Multidisciplinary rehabilitation for chronic low back pain: systematic review. *British Medical Journal.* Jun 2001;322(7301):1511-1516.

32. Hancock MJ, Maher CG, Latimer J, Herbert RD, McAuley JH. Independent evaluation of a clinical prediction rule for spinal manipulative therapy: a randomised controlled trial. *European Spine Journal.* Jul 2008;17(7):936-943.

33. Harold Merskey D. Classification of Chronic Pain, Description of Chronic Pain Syndromes and Definitions of Pain Terms. *International Association for the Study of Pain.* 1994.

34. Hazard RG, Haugh LD, Green PA, Jones PL. Chronic low back pain-The relationship between patient satisfaction and pain, impairment, and disability outcomes. *Spine.* Apr 1994;19(8):881-887.

35. Huijnen IPJ, Verbunt JA, Peters ML, et al. Do depression and pain intensity interfere with physical activity in daily life in patients with Chronic Low Back Pain? *Pain.* Jul;150(1):161-166.

36. Jacobsen S, Danneskioldsamsoe B. Inter-relations between clinical parameters and muscle function in patients with primary fibromyalgia. *Clinical and Experimental Rheumatology.* Sep-Oct 1989;7(5):493-498.

37. Janney CA, Fagiolini A, Swartz HA, Jakicic JM, Holleman RG, Richardson CR. Are adults with bipolar disorder active? Objectively measured physical activity and sedentary behavior using accelerometry. *Journal of Affective Disorders.* Jan;152:498-504.

38. JeanLouis G, vonGizycki H, Zizi F, Spielman A, Hauri P, Taub H. The actigraph data analysis software .1. A novel approach to scoring and interpreting sleep-wake activity. *Perceptual and Motor Skills.* Aug 1997;85(1):207-216.

39. JeanLouis G, vonGizycki H, Zizi F, Spielman A, Hauri P, Taub H. The actigraph data analysis software .2. A novel approach to scoring and interpreting sleep-wake activity. *Perceptual and Motor Skills.* Aug 1997;85(1):219-226.

40. King S, Wessel J, Bhambhani Y, Maikala R, Sholter D, Maksymowych W. Validity and reliability of the 6 minute walk in persons with fibromyalgia. *Journal of Rheumatology.* Oct 1999;26(10):2233-2237.

41. Kori SH, R.P. Miller, and D.D. Todd. Kinesiophobia: A new view of chronic pain behavior. Pain management. 1990: 35-43.

42. Korszun A, Young EA, Engleberg NC, Brucksch CB, Greden JF, Crofford LA. Use of actigraphy for monitoring sleep and activity levels in patients with fibromyalgia and depression. *Journal of Psychosomatic Research.* Jun 2002;52(6):439-443.

43. Kozey-Keadle S, Libertine A, Lyden K, Staudenmayer J, Freedson PS. Validation of Wearable Monitors for Assessing Sedentary Behavior. *Medicine and Science in Sports and Exercise.* Aug;43(8):1561-1567.

44. Kozey SL, Lyden K, Howe CA, Staudenmayer JW, Freedson PS. Accelerometer Output and MET Values of Common Physical Activities. *Medicine and Science in Sports and Exercise.* Sep;42(9):1776-1784.

45. Kundermann B. The effects of sleep deprivation on pain. *Pain Research & Management.* 2004;9(1):25-32.

46. Lavie P, Epstein R, Tzischinsky O, et al. Actigraphic measurements of sleep in rheumatoid-arthritis-Comparison of patients with low back pain and healthy controls. *Journal of Rheumatology.* Mar 1992;19(3):362-365.

47. Lee CE, Simmonds MJ, Novy DM, Jones S. Self-reports and clinician-measured physical function among patients with low back pain: A comparison. *Archives of Physical Medicine and Rehabilitation.* Feb 2001;82(2):227-231.

48. Levendowski DJ, Zack N, Rao S, et al. Assessment of the test-retest reliability of laboratory polysomnography. *Sleep and Breathing.* May 2009;13(2):163-167.

49. Lichstein KL, Stone KC, Donaldson J, et al. Actigraphy validation with insomnia. *Sleep.* Feb 2006;29(2):232-239.

50. Long AC, Palermo TM, Manees AM. Brief report: Using actigraphy to compare physical activity levels in adolescents with chronic pain and healthy adolescents. *Journal of Pediatric Psychology.* Jul 2008;33(6):660-665.

51. Malec J CJ. Pain management: long term follow up of an inpatient program. *Archives of Physical Medicine and Rehabilitation.* 1981;62:369-372.

52. Marin R, Cyhan T, Miklos W. Sleep disturbance in patients with chronic low back pain. *American Journal of Physical Medicine & Rehabilitation.* May 2006;85(5):430-435.

53. Matthews CE, Chen KY, Freedson PS, et al. Amount of time spent in sedentary behaviors in the united states, 2003-2004. *American Journal of Epidemiology.* Apr 2008;167(7):875-881.

54. McGinn TG, Guyatt GH, Wyer PC, Naylor CD, Stiell IG, Richardson WS. Users' guides to the medical literature - XXII: How to use articles about clinical decision rules. *Jama-Journal of the American Medical Association.* Jul 2000;284(1):79-84.

55. Menefee LA, Frank ED, Doghramji K, et al. Self-reported sleep quality and quality of life for individuals with chronic pain conditions. *Clinical Journal of Pain.* Dec 2000;16(4):290-297.

56. Moldofsky H. Sleep and pain. *Sleep Medicine Reviews.* Oct 2001;5(5):387-398.

57. Moldofsky H, Lue FA, Smythe HA. ALpha-EEF sleep and morning symptoms in reheumatoid-arthritis. *Journal of Rheumatology.* 1983;10(3):373-379.

58. Monk TH, Reynolds CF, Kupfer DJ, et al. The Pittsburgh sleep diary. *Journal of Sleep Research.* Jun 1994;3(2):111-120.

59. Morin CM, Gibson D, Wade J. Self-reported sleep and mood disturbance in chronic pain patients. *Clinical Journal of Pain.* Dec 1998;14(4):311-314.

60. O'Donoghue GM, Fox N, Heneghan C, Hurley DA. Objective and subjective assessment of sleep in chronic low back pain patients compared with healthy age and gender matched controls: a pilot study. *Bmc Musculoskeletal Disorders.* Oct 2009;10.

61. Palermo TM, Fonareva I, Janosy NR. Sleep Quality and Efficiency in Adolescents With Chronic Pain: Relationship With Activity Limitations and Health-Related Quality of Life. *Behavioral Sleep Medicine.* 2008;6(4):234-250.

62. Peters JL LR. A randomised control trail evaluating in- and outpatient pain management programmes. *Pain.* 1990 1990;41:283-293.

63. Pfingsten M, Hildebrandt J, Leibing E, Franz C, Saur P. Effectiveness of a multimodal treatment program for chronic low-back pain. *Pain.* Oct 1997;73(1):77-85.

64. Pincus T, Swearingen C, Wolfe F. Toward a multidimensional Health Assessment Questionnaire (MDHAQ) - Assessment of advanced activities of daily living and psychological status in the patient-friendly health assessment questionnaire format. *Arthritis and Rheumatism.* Oct 1999;42(10):2220-2230.

65. Sadeh A, Hauri PJ, Kripke DF, Lavie P. The role of actigraphy in the evaluation of sleep disorders. *Sleep.* May 1995;18(4):288-302.

66. Sayar K, Arikan M, Yontem T. Sleep quality in chronic pain patients. *Canadian Journal of Psychiatry-Revue Canadienne De Psychiatrie.* Nov 2002;47(9):844-848.

67. Smith M, Wegener S. Measures of sleep: The insomnia Severity Index, Medical Outcomes Study (MOS) Sleep Scale, Pittsburgh Sleep Doary, and Pittsburgh Sleep Quality Index. *Arthritis Care and Research.* 1993 1993;49:184- 196.

68. Smith MT, Haythornthwaite JA. How do sleep disturbance and chronic pain inter-relate? Insights from the longitudinal and cognitive-behavioral clinical trials literature. *Sleep Medicine Reviews.* Apr 2004;8(2):119-132.

69. Smith MT, Perlis ML, Smith MS, Giles DE, Carmody TP. Sleep quality and presleep arousal in chronic pain. *Journal of Behavioral Medicine.* Feb 2000;23(1):1-13.

70. Spinhoven P, Terkuile MM, Linssen ACG, Gazendam B. Pain coping strategies in a Dutch population of chronic low-back pain patients. *Pain.* Apr 1989;37(1):77-83.

71. Stanos S. Focused Review of Interdisciplinary Pain Rehabilitation Programs for Chronic Pain Management. *Current Pain and Headache Reports.* Apr;16(2):147-152.

72. Stiell IG, Lesiuk H, Wells GA, et al. The Canadian CT head rule study for patients with minor head injury: Rationale, objectives, and methodology for phase I (derivation). *Annals of Emergency Medicine.* Aug 2001;38(2):160-169.

73. Stiell IG, McKnight RD, Greenberg GH, et al. Implementation of the Ottawa ankle rules. *Jama-Journal of the American Medical Association.* Mar 1994;271(11):827-832.

74. Stiell IG, Wells GA, Hoag RH, et al. Implementation of the Ottawa Knee Rule for the use of radiography in acute knee injuries. *Jama-Journal of the American Medical Association.* Dec 1997;278(23):2075-2079.

75. Sullivan MJL. The role of perceived injustice in the experience of chronic and disability: Scale Development and Validation. *Journal of Occupation Rehabiliation* 2008;18(3):249-261.

76. Sullivan MJL, Bishop SR, Pivik J. The Pain Catastrophizing Scale: Development and validation. *Psychological Assessment.* Dec 1995;7(4):524-532.

77. Tait RC, Pollard CA, Margolis RB, Duckro PN, Krause SJ. The pain disability index-psychometric and validity data. *Archives of Physical Medicine and Rehabilitation.* Jul 1987;68(7):438-441.

78. Thorpy M, Chesson A, Derderian S, et al. Practice parameters for the use of actigraphy in the clinical-assessment of sleep disorders. *Sleep.* May 1995;18(4):285-287.

79. Townsend CO, Kerkvliet JL, Bruce BK, et al. A longitudinal study of the efficacy of a comprehensive pain rehabilitation program with opioid withdrawal: Comparison of treatment outcomes based on opioid use status at admission. *Pain.* Nov 2008;140(1):177-189.

80. Turk D. Clinical effectiveness and cost-effectiveness of treatment for patients with chronic pain. *Clinical Journal of Pain.* 2002;18(6):355-365.

81. Turk DC, Stanos, S. P, et al. Interdisciplinary Pain Management. *American Pain Society.*

82. van de Water ATM, Eadie J, Hurley DA. Investigation of sleep disturbance in chronic low back pain: An age- and gender-matched case-control study over a 7-night period. *Manual Therapy.* Dec;16(6):550-556.

83. Wand BM, Chiffelle LA, O'Connell NE, McAuley JH, DeSouza LH. Self-reported assessment of disability and performance-based assessment of disability are influenced by different patient characteristics in acute low back pain. *European Spine Journal.* Apr;19(4):633-640.

84. Wilson AC, Palermo TM. Physical Activity and Function in Adolescents With Chronic Pain: A Controlled Study Using Actigraphy. *Journal of Pain.* Feb;13(2):121-130.

Appendix

As mentioned previously, participants' sleep was analyzed across five nights instead of seven due some participants not being compliant with wearing the watch. Sleep on-set latency (SOL) is the fourth variable the actigraphy is capable of calculating. Each groups' sleep quality was averaged over the five nights then a 2X5 ANOVA was performed, comparing the groups to nights of sleep. Along-side SE, WASO, and TST, sleep onset latency is objectively derived from the actigraphy. Sleep onset latency is defined as the length of time, measured in minutes, the patient takes to accomplish the transition from full wakefulness to sleep.[2] The time period measure from "lights out" to the beginning of sleep is SOL.[1] Each groups' sleep quality was averaged over the five nights then a 2X5 ANOVA was performed, comparing the groups to nights of sleep. There was so statistical difference for SOL between the SP and S group (See figure 11 and 12). The SP group SOL was 18.9±25.5 and S group SOL was 25.1±32.9 (F (1, 11) =.321, p= .572).

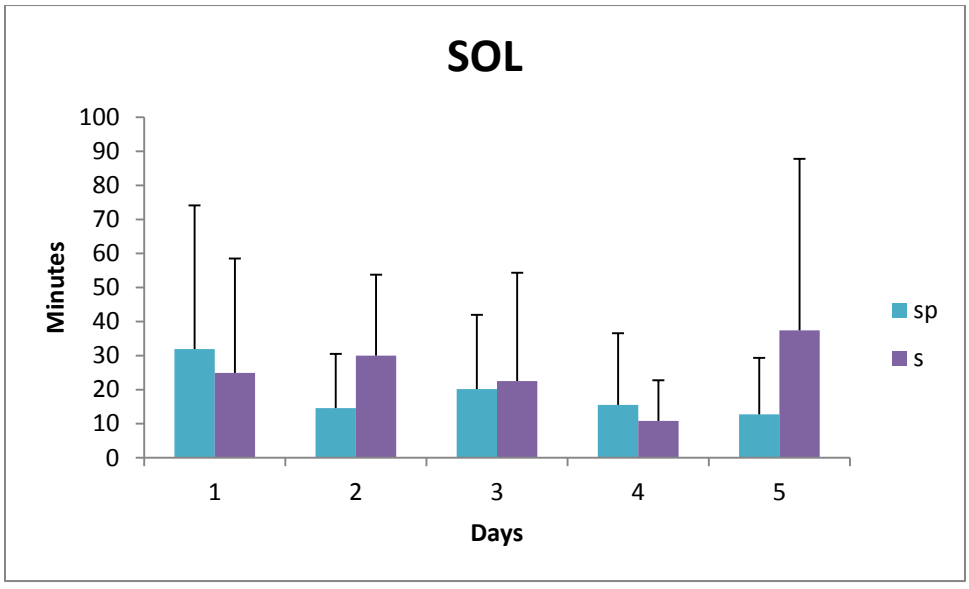

Figure 1: Average SOL for each group across five nights.

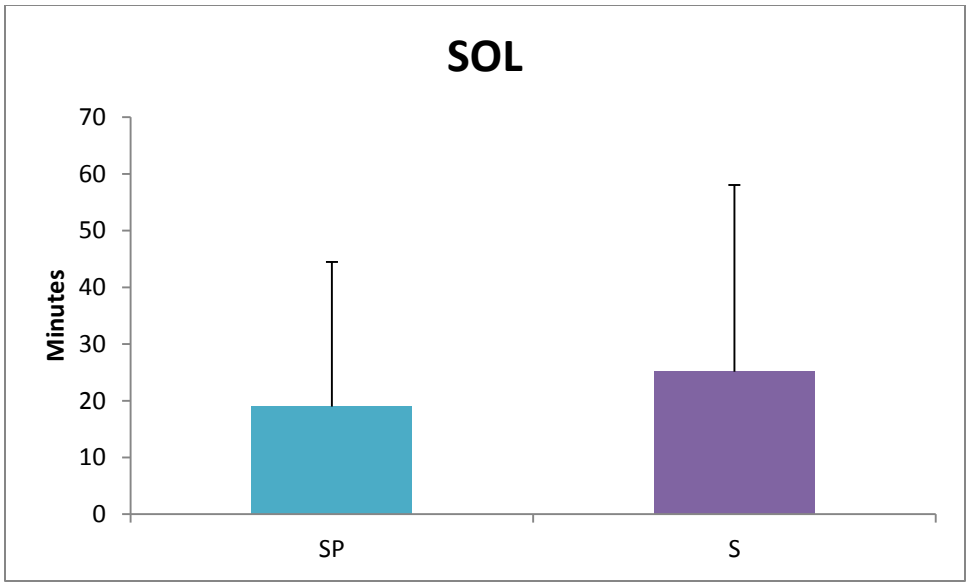

Figure 2: No difference between the groups for the average five day SOL

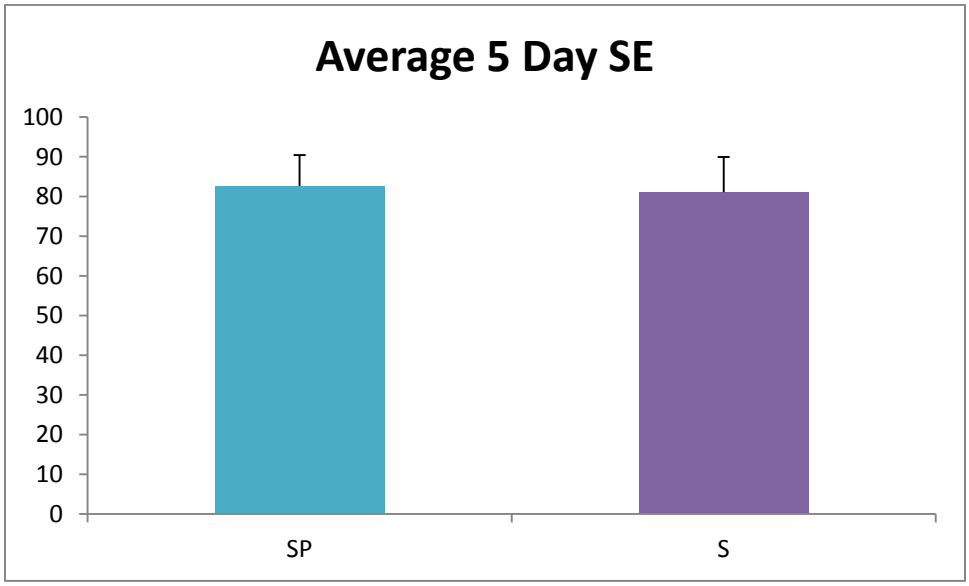

Figure 3: No difference between the groups for the average five day sleep efficiency.

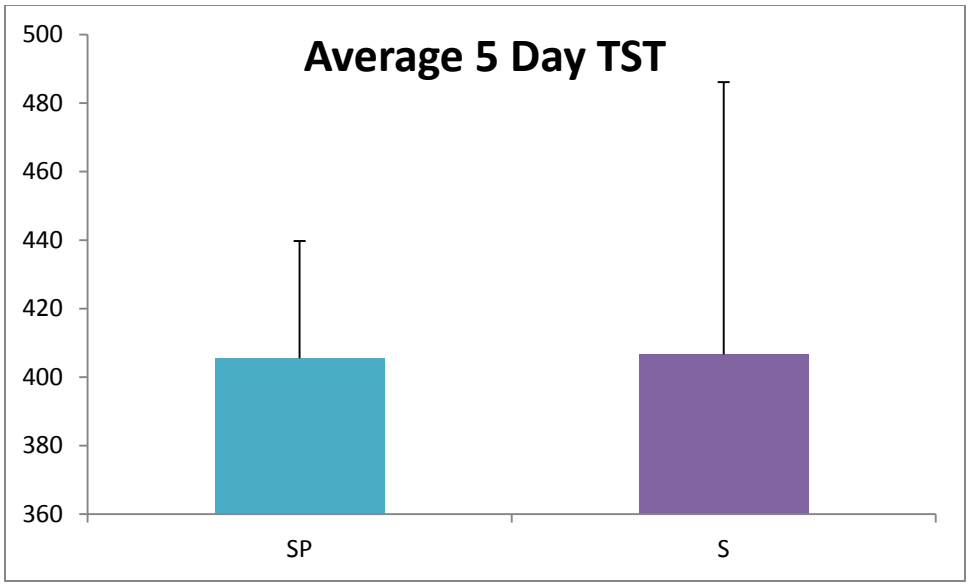

Figure 4: No difference between groups for the average five day total sleep time.

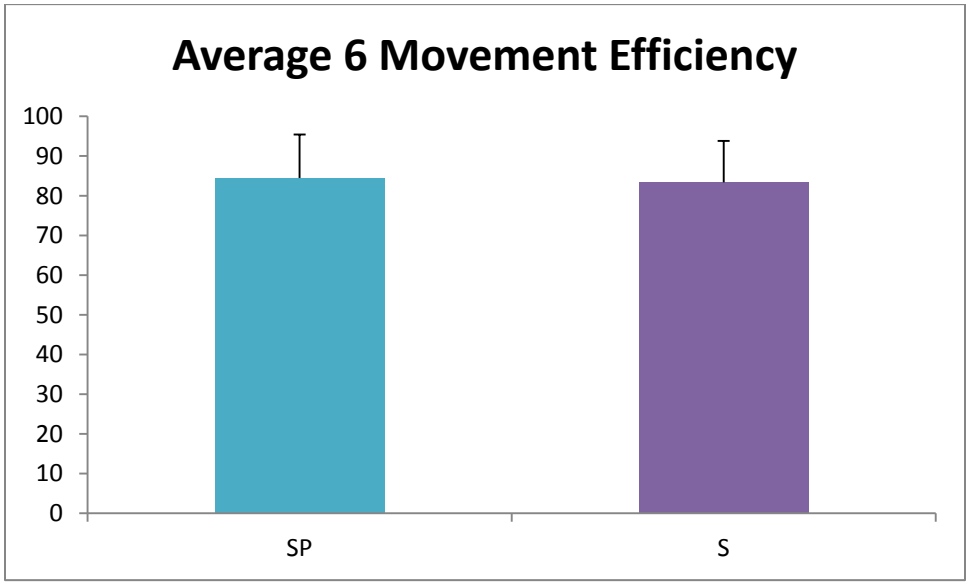

Figure 5: There was no significance of average six day movement efficiency between groups. The mean six day movement efficiency for both groups was 84%.

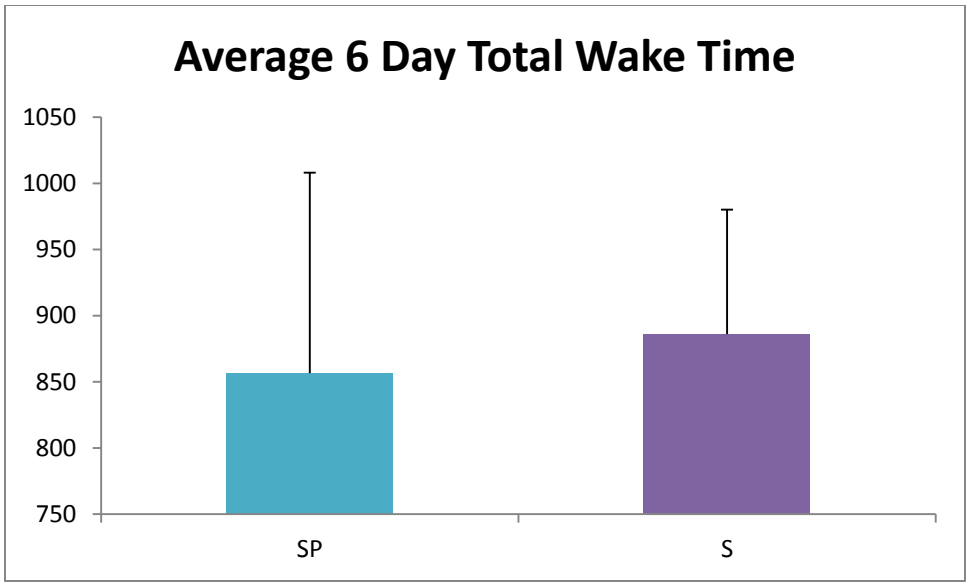

Figure 6: There was not statistical difference between groups for average six day total wake time.

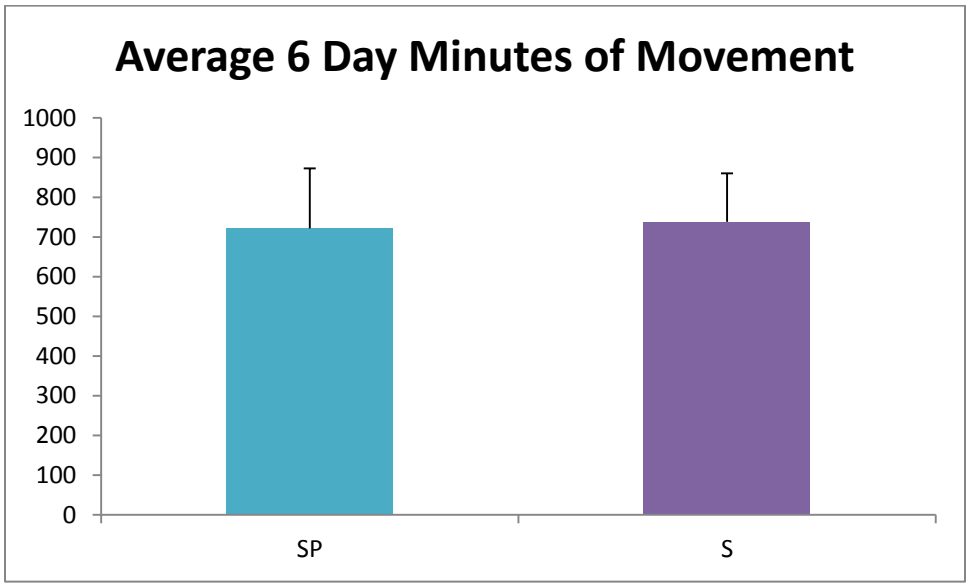

Figure 7: No significance between the S and SP for the average six day minutes of movement.

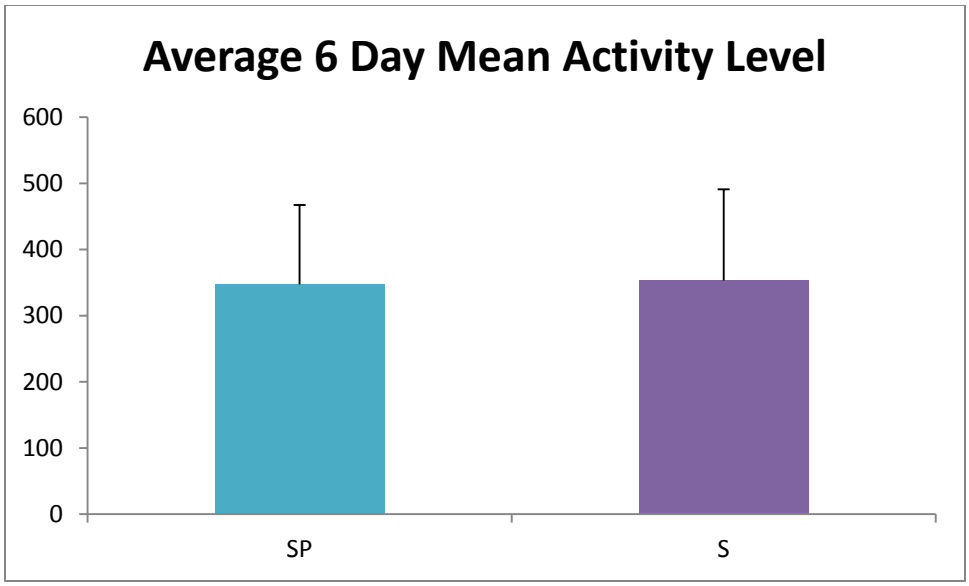

Figure 8: No difference between groups for the average six day mean activity level.

Appendix Reference

1. O'Donoghue GM, Fox N, Heneghan C, Hurley DA. Objective and subjective assessment of sleep in chronic low back pain patients compared with healthy age and gender matched controls: a pilot study. *Bmc Musculoskeletal Disorders.* Oct 2009;10.

2. Smith M, Wegener S. Measures of sleep: The insomnia Severity Index, Medical Outcomes Study (MOS) Sleep Scale, Pittsburgh Sleep Diary, and Pittsburgh Sleep Quality Index. *Arthritis Care and Research.* 1993 1993;49:184- 196.