CLINICAL PRESENTATION AND TREATMENT OUTCOMES OF CHILDREN AND ADOLESCENTS WITH LOW BACK PAIN IN PHYSICAL THERAPY

by

Shannon Nicole Clifford

BS, Exercise Science, University of Pittsburgh, 1999

MPT, Physical Therapy. University of Pittsburgh, 2002

Submitted to the Graduate Faculty of

School of Health and Rehabilitation Science in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy

University of Pittsburgh

2009

UNIVERSITY OF PITTSBURGH

SCHOOL OF HEALTH AND REHABILITATION SCIENCES

This dissertation was presented

by

Shannon Nicole Clifford

It was defended on

April 3rd, 2009

and approved by

Anthony Delitto, PhD, PT, FAPTA Professor and Chair, Department of Physical Therapy, School of Health and Rehabilitation Sciences, University of Pittsburgh

Julie M. Fritz, PhD, PT, ATC Associate Professor, Department of Physical Therapy, University of Utah

Patrick Sparto, PhD, PT Associate Professor, Department of Physical Therapy, School of Health and Rehabilitation Sciences, University of Pittsburgh

Tanya Hagen, MD Assistant Professor, Department of Orthopedic Surgery, School of Medicine, University of Pittsburgh

Chair of Dissertation Committee: Anthony Delitto, PhD, PT, FAPTA Professor and Chair,

CLINICAL PRESENTATION AND TREATMENT OUTCOMES OF CHILDREN AND ADOLESCENTS WITH LOW BACK PAIN IN PHYSICAL THERAPY

Shannon Nicole Clifford, PhD, MPT

University of Pittsburgh, 2009

ABSTRACT:

Purpose: Low back pain is a common condition in adolescents, and a specific pathoanatomical origin for the symptoms cannot always be determined. Physical activity level has been identified as a risk factor for the development of back pain in adolescents, but the influence of sports participation on the outcomes of treatment in adolescents has not been adequately examined. The purpose of this work was to examine the clinical outcomes of rehabilitation for adolescents with low back pain, and examine the influence of sports participation on outcomes.

Methods: This study was completed in three phases. Phase 1 was a retrospective review of 25 patients under the age of 18 who were seen in one physical therapy clinic for treatment of LBP. Information regarding the patients' medical diagnoses, subjective history, sports participation, clinical examination, and clinical outcomes were collected from chart review. Phase 2 was a retrospective review of 99 patients under the age of 18 with LBP tracked in a large clinical outcomes database. Individual responses and total score on the Numerical Pain Rating Scale (NPRS) and the Modified Oswestry Questionnaire (OSW) were recorded from the patient record. Phase 3 consisted of a prospective study of treatment-based classification of 34 adolescent patients seen in physical therapy for the treatment of their LBP. Treatment duration and content were at the clinician's discretion. Patients completed an OSW and NPRS before and after receiving physical therapy. Additional variables collected included subjective history and clinical examination findings, and sports participation and physical activity. Patients were then classified using a treatment-based classification (TBC) algorithm, and further analysis was performed to examine the effectiveness of classification on clinical outcome.

Results: In study 1, initial pain scores were lower if a specific pathology was present (P=.001). Initial pain and OSW scores were poorly correlated (r= 0.16). Forty-four percent (n=11) of patients scored under the floor value of 12% on OSW. A second examination of the OSW in 99 patients concluded that OSW was moderately correlated with NPRS (0.59). Chronbach's alpha was 0.86. All 10 items in OSW appeared to load onto two latent factors. When examining the effectiveness of TBC in adolescents with LBP, a classification decision was able to be made with a moderate degree of reliability ($0.53\ (0.28, 0.79) \le \kappa \le 0.89\ (.74, 1.0)$) in all of the 34 patients. Stabilization was the most commonly prescribed method of treatment by clinicians, while it appeared to only be indicated according to TBC. Those who were matched to their TBC classification experienced fewer numbers of visits than those who were not.

Conclusions: It appears the OSW is a valid and reliable tool for assessing clinical outcome of physical therapy intervention for adolescents with LBP. These results also suggest that a TBC approach to treatment of LBP in this population may be effective for improvements in clinical outcome.

Keywords: low back pain, outcome measurement, adolescence, Oswestry, treatment-based classification.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 CHAPTER 1- INTRODUCTION

1.1 STATEMENT OF THE PROBLEM AND OVERVIEW OF THE PROJECT

The growing number of adolescents reporting debilitating episodes of low back pain (LBP) is recently receiving increased attention. The majority of research studies on appropriate diagnostic techniques, important prognostic factors, conservative treatment ideas, and outcome measurements for individuals with LBP have been conducted, almost exclusively, in the adult population. The first phase of this study was to begin an investigation of the clinical presentation and management of children and adolescents with LBP by retrospective review.

In order to further study the effectiveness of treatment interventions for LBP in children and adolescents, there was an imminent need to ensure the availability of valid and responsive outcome measures for use with this population of patients. Although both the Oswestry (OSW) and Numerical Pain Rating Scale (NPRS) have been used as outcome measures in studies of treatments for LBP in older age groups, the validity of these measures in this younger population has not been specifically examined. The second phase of this project was aimed at the examination of the OSW and the NPRS as valid outcome measures for this population.

The final phase of this project consisted of a prospective, longitudinal, cohort study to examine the usefulness of a treatment-based classification approach in a group of adolescents with LBP. Previous research has described the potential benefits of a classification-based treatment system for adults with LBP. This system seeks to classify individuals with LBP into one of three primary categories based on the clinical characteristics of the patient at the initial assessment (mobilization, stabilization, or specific exercise (i.e., flexion or extension-oriented exercise)). The treatment most likely to be successful for the patient is then based on the classification category. While previous work shows that clinical outcomes are improved when treatment is based on this classification system in adults, its usefulness with children and adolescents is largely unknown.

1.2 AIMS AND HYPOTHESES

1.2.1 Study 1

1.2.1.1 Specific Aim 1

To describe the clinical presentation of a group of children and adolescents with LBP

Hypothesis 1

It is hypothesized that the subjective history, pathoanatomical diagnosis, clinical examination, and classification of children and adolescents with LBP will differ from that seen in adult populations.

1.2.1.2 Specific Aim 2

To examine the construct validity of the baseline OSW score in a sample of children and adolescents with LBP

Hypothesis 2

It is hypothesized that at least a moderate correlation ($r \geq 0.5$) will exist between baseline OSW and NPRS scores

1.2.2 Study 2

1.2.2.1 Specific Aim 1

Examine the distributional properties of baseline OSW and NPRS scores in a population of adolescents with LBP.

Hypothesis 1

It is hypothesized that the distribution of OSW and NPRS scores will approximate a normal distribution. It is further believed that fewer than 10% of the Oswestry scores obtained will experience a floor effect on the measure.

1.2.2.2 Specific Aim 2

Examine the construct validity of the OSW in a sample of adolescents with low back pain.

Hypothesis 2

It is hypothesized that at least a moderate correlation ($r \geq 0.5$) will exist between baseline OSW and NPRS scores, as well as between change scores on the two measures.

1.2.2.3 Specific Aim 3

Examine the responsiveness of the OSW and NPRS in a sample of adolescents with low back pain.

Hypothesis 3

It is hypothesized that the effect sizes in this population of adolescents with LBP receiving physical therapy treatment will be at least moderate (≥ 0.50)

1.2.3 Study 3

1.2.3.1 Specific Aim 1

To examine the interrater reliability of the TBC system in a sample of adolescents with LBP.

Hypothesis 1

It is hypothesized that paired raters will demonstrate at least moderate interrater reliability ($\kappa \geq 0.5$) when using the TBC System Algorithm to categorize adolescents patients based upon their baseline historical and examination findings.

1.2.3.2 Specific Aim 2

To examine the distribution of adolescents with LBP among classification categories using the TBC system.

Hypothesis 2

It is hypothesized that a significantly greater proportion of patients will be classified into the stabilization category in this sample of adolescents with LBP than in a similar sample of adults with LBP. In addition, it is hypothesized that a significantly smaller proportion of patients will classified into the specific exercise category (ie. flexion principle and extension principle) than in a similar sample of adults with LBP. Finally, it is expected that the proportion of patients classified into the mobilization/manipulation category will be similar to that which is seen in a similar sample of adults with LBP.

1.2.3.3 Specific Aim 3

Examine the clinical utility of the TBC-system.

Hypothesis 3

In a sample of adolescents with LBP, it is hypothesized that those patients who receive treatments that are defined as being "matched" to the appropriate classification category in the TBC schema will demonstrate greater improvements in the reduction of OSW and NPRS scores, than those patients who receive treatments that are defined as "unmatched." Specific criteria will be used to determine whether a patient's treatment was "matched" or "unmatched."

1.3 BACKGROUND OF LBP IN CHILDHOOD AND ADOLESCENCE

The presence of low back pain (LBP) in children and adolescents has reached a prevalence which closely resembles that of adult populations.[1-3] Most of the research that has been conducted in this area recognizes this steadily increasing trend, but falls short of providing any investigation of treatment options for these patients. Recognition that LBP among children and adolescents is a relatively common experience has led to increased attention from researchers. The predominance of this research has focused on examining the epidemiology of the condition, and identifying risk factors predicting the onset of LBP in these age groups. [4-8]

Although many episodes of LBP occurring in children and adolescents are likely to resolve quickly [5, 9, 10] the potential adverse consequences of the experience should be considered. Early reports of adolescent LBP cautioned practitioners that non-specific causes for LBP in this population were rare, with up to 50% of adolescent patients with LBP having a specific or serious underlying pathology. [10-12] Conversely, more recent literature has reported a higher prevalence of non-specific LBP in adolescents, [13, 14] and has even begun to assess interventional strategies for this population. [15]

One of the earliest, large epidemiological studies about adolescents with LBP by conducted by Olsen et. al in 1992. This large study was performed with school children in England and reported 23.1% of children and adolescents with LBP between the ages of 10-16 visited a medical practitioner for their condition, 30.8% experienced a reduction of physical activity or sports participation, and 26.2% had been absent from school because of LBP. [16] Other studies have also confirmed low rates for adolescent patients actually seeking medical attention for their LBP. [17, 18]

The relationship between LBP in adolescents and the quantity and intensity of physical activity is one which needs to continue to be explored.[19] Some research exists to suggest that onset of LBP may be positively correlated with physical inactivity as well as with extremely high levels of activity and intense sports participation.[19-22] Although the research concerning association between specific types of sports activities and risk of LBP development in adolescents is equivocal.[19, 20, 22-25]

The experience of LBP during childhood or adolescence also appears to have important consequences later in an individual's life. For example, a previous history of LBP has been reported to be the most predictive risk factor for new episodes of LBP among college-age athletes.[26, 27] Although research is beginning to clarify the epidemiological profiles and prevalent risk factors for LBP among children and adolescents, almost no information exists describing rehabilitation programs, or the clinical outcomes of such programs for this patient population.

1.3.1 Contributing Factors to the Development of LBP in Adolescents

Little guidance is available from the current body of literature to determine an evidence-based management strategy for the majority of children and adolescents with LBP of a non-specific, musculoskeletal origin. Several risk factors related to the development of LBP have been suggested including age, female sex, increased body mass index, smoking habits, activity level, including the frequency and type of activity, and sports participation.[3, 4, 28] However, it seems most of the reports in the literature that describe clinical rehabilitation are case studies, and it seems many are able only to report instances of operative rehabilitation, disc herniation, malignancy, fracture, infection, or other rare conditions.

A review of the literature will allow one to conclude that LBP is a common problem in adolescents, and many children and adolescents participating in athletics are affected. It is our experience that children and adolescents with LBP are more likely to present for treatment from health care providers when they are participants in an organized sporting activity. Among our previous review of children and adolescent patients with LBP seen at one facility over a one-year period, 92% reported the occurrence of LBP was related to participation in sports. [14] It is also apparent that LBP appears to depend on the particular sport in which a young athlete participates, and higher prevalence rates have reported in those sports requiring maneuvers with repetitive hyperextension of the lumbar spine, such as gymnastics, wrestling, rowing, diving, and football. [24, 29-32] Lundin and colleagues[33] found cases of severe LBP to be most common in wrestling athletes (54%), when compared with gymnastics, soccer, and tennis. Kolt et al [30] reported a one-week prevalence of LBP among elite gymnasts of 14.9%, and a study of rhythmic gymnastics reported a seven-week prevalence of 85.7%.[32] A recent study of high school football players reported a one-year prevalence of LBP of 54.1% among adolescents with at least one radiographic abnormality, and 37.1% among those without any radiographic abnormalities.[29]

1.3.2 Outcome Measurement in Adult Patients with LBP

Much of the work in the area of outcome measurement in patients with LBP has been focused on middle-aged adult populations among whom LBP is most prevalent and costly to society. One clinical outcome measure which has been employed in many clinical-trials is The Modified Oswestry Questionnaire (OSW).[34] The OSW is a ten-item, easily administered, disease specific measure used to indicate a patient's perceived level of disability from their LBP. The Numeric Pain Rating Scale (NPRS) is an 11-point pain intensity scale ranging from 0 (no pain) to 10 (worst imaginable pain). Studies involving adults with LBP have found the NPRS to be reliable and valid for the assessment of pain.[35] The OSW and NPRS are widely used in current practice in the assessment of adults with LBP undergoing treatment. Both the OSW and NPRS have been well validated and are recommended as components of a "core set" of outcome measures for use in the clinical management of adult patients with LBP.

1.3.3 Outcome Measurement for Adolescents with LBP

Similarly, to date there have been no studies conducted on appropriate outcome measurement for children and adolescents with low back pain. Two studies examining the use of the NPRS to assess post-operative pain in children age 7-18 have reported adequate reliability and concurrent validity.[36, 37] However, measures of disability have not been examined in this population. Our previous work in this area suggested that the OSW may not be suitable for use in children and adolescents.[14] Therefore the need for a more extensive exploration into the validation of an outcome measure for use in this population is apparent. The ability of researchers in the area of low back pain to examine effective clinical management and treatment of adolescents is greatly hindered by the lack of a validated outcome measure. The validation of such a measure should be conducted before further work in this area can be accomplished.

1.3.4 Treatment-Based Classification in Adults

The difficulty in identifying a pathoanatomical cause for most patients with LBP has prompted efforts to identify alternative methods of sub-grouping, or classifying, affected individuals.[38-40] Many have argued that classification methods are needed to more effectively direct management and improve research efficiency. The most common classification systems used in clinical practice are the system developed by McKenzie[41] and the system developed by Delitto and colleagues.[42] Delitto and his colleagues proposed a treatment-based classification system designed to guide the management of patients with LBP. The system has since been studied extensively and modified on the basis of new evidence. The classification system proposes to identify distinct and mutually exclusive categories of patients with LBP. Each category is described as having a distinct set of examination findings and associated intervention strategy thought to optimize outcomes for patients in the category (table 1).

Table 1- LBP sub-groups, signs and symptoms, and associated treatments from the work of Fritz and colleagues.[43-45]

Sub-group	Examination findings	Treatment
I. Mobilization/Manipulation	▪ More recent symptom onset of (<16days) ▪ Lumbar segmental hypomobility ▪ No symptoms distal to the knee ▪ Low FABQ scores (work scale <19) ▪ Greater hip internal rotation ROM (>35^0)	▪ Spinal manipulation/ mobilization techniques ▪ Spinal range of motion exercises
II. Stabilization	▪ Positive prone instability test ▪ Aberrant motions (e.g., instability catch) ▪ Younger age (<40) ▪ Greater SLR ROM (>91^0 bilateral)	▪ Trunk strengthening and stabilization exercises ▪ Avoidance of prolonged end-range positions
III. Specific Exercise	Preference for flexed or extended posture ▪ Centralization with lumbar movements	▪ Repeat exercise in direction of centralization ▪ Mobilization in direction of centralization
IV. Traction	▪ Leg pain > back pain ▪ Signs of nerve root compression (reflex, strength, sensory deficit, positive SLR) ▪ No centralization with lumbar movements	▪ Mechanical traction ▪ Progression to centralizing exercise

1.3.4.1 Impact of Treatment-Based Classification in Adults

Previous work in the area of classification systems has demonstrated the potential for improving outcomes from their implementation.[46] The most conclusive work in this area was published by Brennan et al. in 2006.[47] This study involved 123 patients with LBP randomized to receive one of three treatments; mobilization/manipulation, stabilization, or specific exercise. Comparisons were made between those patients who received a "matched" treatment based on their pre-treatment classification versus those receiving a treatment "unmatched" to their pre-treatment classification. Patients receiving matched treatment demonstrated greater improvements on the Oswestry after four weeks and one year, in both intention-to-treat and compliers-only analyses.

1.3.5 Treatment-Based Classification in Adolescents

Clinicians are increasingly faced with the necessity to utilize an evidence-based practice approach to treating their patients with LBP and support their interventional strategies with the current, best evidence.[48, 49] As mentioned previously, the usefulness and clinical effectiveness of classification systems to therapists treating adults with low back pain has been documented. However, there is presently little information on how adolescents with LBP may be classified in order to potentially impact outcome because these systems have not been examined for use in treating children and adolescents. For this reason, a prospective examination of a treatment-based classification system should provide valuable information as to the usefulness of this approach in guiding therapists their decision making.

2.0 CHAPTER 2- CHILDREN AND ADOLESCENTS WITH LOW BACK PAIN: A DESCRIPTIVE STUDY OF PHYSICAL EXAMINATION AND OUTCOME MEASUREMENT

2.1 INTRODUCTION

Once thought to be a rare occurrence almost always resulting from a serious etiology, recent studies suggest that low back pain (LBP) among children and adolescents is not uncommon.[2, 3, 5, 8, 50-54] This change in traditional thought has led to an increased emphasis on research into LBP in this population.[7] The predominance of this research has focused primarily on developing epidemiological profiles, examining prevalent risk factors, and identifying important prognostic indicators related to children and adolescents with LBP.[2, 7, 8, 12, 50, 55] Little research has been devoted to examining the management of these patients, and that which has been done appears to focus primarily on conditions such as spondylolisthesis and scoliosis.[56-58] Now that the occurrence of LBP in adolescents related to non-specific pathologies is recognized, what is currently lacking in the literature is information related to the appropriate sub-grouping and conservative clinical management of these patients.

The majority of research studies on appropriate diagnostic techniques, important prognostic factors, conservative treatment ideas, and outcome measurements for individuals with LBP have been conducted, almost exclusively, in the adult population. Although it may be tempting for clinicians to generalize the results of studies performed in adults to children and adolescents with LBP, doing so may lead to erroneous conclusions. Very little information is available regarding the clinical presentation and pertinent physical examination findings in children and adolescents with LBP. It is unknown if the conservative treatments developed and supported by research evidence in adults are necessarily effective in children and adolescents. Finally, outcome measures commonly used with adult patients have not been specifically tested in children and adolescents, and their validity in the population is not known. More information is needed in these areas to better inform both clinicians and researchers working with children and adolescents with LBP.

It is well known that the majority of adults with LBP cannot be given a specific diagnosis based purely on pathoanatomy.[59] This has lead to the development of classification systems based on clusters of clinical examination findings.[41, 42, 60, 61] These classification systems provide a method for sub-grouping patients and guiding the selection of interventions over the course of the patient's treatment. The most common classification systems used in adults are the McKenzie system[41] and the system developed by Delitto and colleagues.[42] Neither of these systems, nor any other LBP classification system has been studied or validated for use in children and adolescents. Thus, it remains unclear if the uses of these systems are effective in offering guidance to clinicians in the management of these patients.

Tools for measuring treatment outcomes developed for adults have generally not been used or validated with groups of children and adolescents with LBP. Patient self-report measures of disability due to LBP have been identified as an important outcome measure for both clinical practice and research involving patients with LBP[62] The Roland and Morris[63] and Oswestry[34] Disability Scales are the self-report measures most commonly reported on for adult patients[64] however, their applicability to children and adolescents is unknown.

The purpose of this study was to begin an investigation of the management of children and adolescents with LBP by describing a group of these patients, who were referred to one physical therapy sports medicine clinic over an 18-month period. Information on their initial clinical presentation, physical examination, pathoanatomical diagnosis, and clinical management were collected. The ability of each patient to be classified into a treatment group, using the Treatment-based Classification System developed by Delitto et al,[42] was also examined. Lastly, the validity of the Oswestry questionnaire was explored.

2.2 METHODS

2.2.1 Patients

Patient data were obtained for this study retrospectively from a large patient database maintained by the Centers for Rehab Services (CRS), a provider of out-patient physical therapy services in the Western Pennsylvania region. All CRS physical therapy clinics collect standardized baseline and outcomes data on all patients through a centralized database housed at the University of Pittsburgh clinical outcomes laboratory. The protocol for this study was approved by the Institutional Review Board at the University of Pittsburgh.

A one-and-a-half-year time span (*9/04/00 – 1/25/02)* was reviewed at one large Sports Medicine Clinic in the CRS system. Patient data were extracted for all new patients evaluated during this time frame with a presenting physician's diagnosis related to lumbar/pelvic dysfunction. Extracted patient records were then further reviewed to determine the age of the patient at the time of the initial evaluation. Patients who were under age 18 at the time of the initial evaluation were included in this study. Patients under the age of 18 were excluded only if their LBP was attributed to scoliosis, which is not normally managed with the same conservative forms of treatment.[65, 66]

2.2.2 Measurements

The following information was gathered from the patient's physical therapy treatment record.

2.2.2.1 Demographic Information

The patient's age at the time of the initial evaluation, gender, and regular involvement in organized sports activities (>2days per week, either through a scholastic or private institution) were recorded. The diagnosis provided by the referring physician was recorded and was further classified as representing a specific anatomical pathology (fracture, spondylolisthesis, disc herniation, etc), or a non-specific diagnosis (sprain, strain, dysfunction, etc.) Whether or not the patient was injured during sport participation was also recorded. A prior history of LBP was recorded as either; 1) no prior history of activity-limiting LBP, or 2) prior history of activity-limiting LBP. Frequency of prior LBP episodes was recorded.

2.2.2.2 Self-Report Measures

All patients with LBP evaluated at CRS clinics routinely complete a pain rating scale and a Modified Oswestry Disability Questionnaire (OSW)[67] at the baseline examination. The OSW is a ten-item scale that quantifies disability related to LBP. The scores range from 0-100 with higher numbers indicating greater disability. The clinic from which these data were collected used a version of the OSW that was modified from the original version by substituting an item regarding employment/ home-making ability for the item related to sex life. This modified version has been found to have high levels of reliability, validity, and responsiveness, similar to the original version.[67] Pain ratings were recorded on a 0-10 scale, a method of recording pain that has been shown to be reliable and valid.[68] Neither the OSW, nor the pain rating has been reported in samples of children and adolescents with LBP.

2.2.2.3 Physical Examination

Lumbar active range of motion (ROM) was performed in the examination of all patients, and available information was extracted from the chart. While standing, each patient was asked to perform flexion, extension, left and right side-bending as far as possible. While not all of the clinicians recorded actual ROM measurements, the following three judgments were made consistently for each motion, and used for this study; 1) pain provocation or exacerbation with the movement (recorded as yes, or no), 2) restriction of ROM based on the expectation of the therapist (recorded as restricted or not restricted), and 3) centralization or peripheralization of symptoms (the experience of each was recorded as yes or no). The judgments of pain provocation and ROM restriction with lumbar active ROM testing have been found to be reliable between examiners in previous studies.[60, 69, 70] Our previous work has also shown that in adults with LBP, judgments of centralization and peripheralization with movement testing (i.e., proximal or distal movement of symptoms respectively) can be made reliably.[71] Various special tests proposed to identify dysfunction of the sacroiliac (SI) region were also performed including the standing and seated flexion tests and palpation of symmetry of the pelvic landmarks.[72, 73]

Based on the results recorded from the patient demographics and the physical examination, we assigned a classification to each patient based on the presence of key signs and symptoms (table 1). Our previous work has demonstrated acceptable inter-rater reliability for making judgments of classification status using these key signs and symptoms.[43] For the purposes of this study, if a previous history of LBP was present, particularly if frequent episodes were encountered, or if the patient had diagnosis of spondylolisthesis, the patient was classified as immobilization. If an "opening" or "closing" pattern of ROM restrictions was noted, or positive findings related to SI region dysfunction, the patient was classified as mobilization. If a clear preference for flexion or extension postures were noted during the history or ROM examination, the patient was classified as specific exercise. Finally, if signs of nerve root compression were present and peripheralization of symptoms occurred during ROM, the patient was considered as a traction classification. Two different reviewers examined the patient data and independently assigned a classification. When disagreements in classification status were found, the case was discussed and a consensus reached regarding the most appropriate classification.

2.2.2.4 Data Analysis

Descriptive statistics were calculated for the measurement variables recorded at the initial evaluation including means, standard deviations, and range of scores for continuous variables, frequencies and percentages for categorical variables. Initial pain rating and Oswestry scores were compared for subgroups of patients based on the physical therapy classification (immobilization, mobilization, specific exercise, or traction) and the physician's diagnosis (specific or non-specific pathology). The concurrent validity of the initial Oswestry score was examined through correlation with the initial pain rating. The initial Oswestry score was also examined for floor or ceiling. Our previous work[43, 67, 74] has shown that adults with LBP referred to outpatient physical therapy typically have a mean Oswestry score of approximately 42% with a standard deviation of about 15%. We therefore considered individuals scoring at least 2 or more standard deviations above or below the adult mean value to be at the ceiling or floor respectively. In other words, a score of 12 or below was considered a score at the floor of the Oswestry scale, while a score of 72 or above was considered a score at the ceiling.

2.3 RESULTS

726 patients were seen with a diagnosis related to the lumbopelvic region, at the sports medicine clinic, during the 18-month time period defined for the study. Of these 726 patients, 691 were 18 years or older at the time of the initial evaluation. Of the remaining 35 patients, 3 were excluded for diagnoses of LBP resulting from scoliosis. Seven charts could not be located for review; therefore 25 cases were included in the study.

Demographic characteristics of the 25 patients are summarized in tables 2 and 3. A physician's diagnosis could be derived from a specific pathoanatomical cause in 11 cases (44%). Specific diagnoses were all related to spondylolitic lesions including acute spondylolisthesis, pseudo-spondylolisthesis, and occult spondylolisthesis. The remaining 14 patients (56%)

presented with non-specific physician's diagnoses including sprains, strains, and general dysfunction in the lumbar area. Twenty-one patients (83%) reported no previous history of LBP. The majority (92%) of patients reported being involved in a regular sporting activity, with 86% of those athletes being injured during participation in their sport.

Pain and OSW scores were not available for two patients (table 2). Lumbar extension ROM was problematic for a greater percentage of patients, with 78% reporting pain with lumbar extension and 61% observed to have extension ROM restrictions (table 3). Only 30% of patients were observed to have restrictions in lumbar flexion ROM and 22% experienced pain with flexion ROM. No patients were found to have signs of nerve root compression or were observed to experience centralization or peripheralization of symptoms with lumbar ROM.

Table 2- Continuous variable demographic and examination findings at intake.

Variable$_{units}$	**Mean (SD)**	**Range**
Age$_{years}$ (n=25)	14.4 (1.9)	9-17
Pain rating$_{0-10}$ (n=22)	4.4 (2.7)	0-9
Oswestry score$_{0-100}$ (n=21)	16.8 (12.9)	2-50
Number of visits (n=25)	6.5 (5.0)	1-21

Table 3- Categorical variable demographic and examination findings at intake.

Variable	Percentage $_{(N=25)}$
Gender (%female)	48
Physician Diagnosis Specific pathology (e.g. spondylolisthesis) Non-specific pathology (e.g. sprain, strain)	 44 56
Involvement in organized sports (%yes)	91.3
Mechanism of injury (% sport related)	86.4
Prior history of back pain (% yes)	16
Restricted lumbar flexion range of motion (ROM) (% yes)	30.4
Pain with lumbar flexion (% yes)	21.7
Restricted lumbar extension range of motion (ROM) (% yes)	60.8
Pain with lumbar extension (% yes)	78.2

The breakdown of the classification of patients is displayed in table 4. The two therapists reviewing the charts agreed on the classification status of the patient in 23 of the 25 patients. A consensus classification was reached for the other two patients. Immobilization was the most common classification (48%) with the next largest group of patients in the mobilization category (35%). Four patients (16%) were classified as specific exercise (two flexion and two extension). There were no patients classified as requiring traction (table 4).

Table 4- Initial pain and Oswestry scores by assigned classification

Classification	**Number of patients** N (%)	**Initial pain score** Mean (SD)	***Range of Pain Scores***	***Initial OSW score*** Mean (SD)	***Range of OSW Scores***
Immobilization	11 (47.8)	3.1 (2.7)	0-8	15.5 (15.7)	2.0-50.0
Mobilization	8 (34.8)	5.2 (2.5)*	2-8	13.0 (7.6)*	4.0-28.0
Specific Exercise Flexion Extension	4 (17.4) 2 (8.7) 2 (8.7)	7.0 (1.7)†	6-9	26.0 (12.2) †	18.0-40.0

(Scores from 2 patients were missing in the chart and are not included in analysis)
* n=7 † n=3

Table 5 shows initial pain rating and OSW scores when diagnoses were collapsed into specific or non-specific pathology groups. No statistically significant difference ($p<.05$) was found between the groups on the initial OSW score (t=-.86, P=0.40), however a significant difference was found between initial pain scores (t=-4.05, P=.001). The group with non-specific diagnoses was experiencing less pain than the specific diagnosis group.

The mean initial OSW score for the 25 patients was 16.8% (±12.9%). Eleven of the 25 patients (44%) had initial OSW scores that were at or below the floor level of 12%. The Pearson correlation coefficient calculated between the initial pain rating and OSW scores was low and not statistically significant (r= 0.16, p= 0.48).

Table 5- Initial pain and Oswestry scores by medical diagnosis

	Physician Diagnosis		
	Specific Diagnosis	**Non-specific Diagnosis**	**Significance**
	Mean ±SD (range)	***Mean ±SD (range)***	***P value***
Initial Pain Score n= 23	2.4±1.8 (0-5)	6.0±2.3 (2-9)	.001
Initial Oswestry Score n= 23	13.6±15.4 (2.0-50.0)	18.1±9.6 (4.0-40.0)	.402

(Scores from 2 patients were missing in the chart and are not included in analysis)

2.4 DISCUSSION

We reviewed referrals for LBP to one outpatient clinic over an 18-month period and found only 35 referrals of children and adolescents, representing 5% of the total referrals for LBP. This may appear to contradict recent epidemiological studies suggesting LBP is more common among children and adolescents than previously thought. For example, Burton et al [5] reported a lifetime prevalence of LBP of 50% in a group of 216, 15 year-old adolescents. Other studies have reported prevalence rates varying from 20% to 51%, indicating that the experience of LBP is relatively common among children and adolescents.[3, 28, 51, 75, 76] Further research suggests that LBP is not uncommon even among younger children. Gunzburg et al[77] reported a 36% lifetime prevalence of LBP in a group of children aged nine. The occurrence of LBP among children and adolescents may be relatively common, but in our experience, referral for physical therapy treatment appeared to be relatively rare.

Several reasons may exist for the low referral rate of children and adolescents with LBP to physical therapy. One possibility is that only a minority of children and adolescents with LBP seek medical intervention of any kind. Previous studies have shown that only 7-26% of children and adolescents pursue treatment for their LBP,[5, 18] compared with 20%-40% of adults.[78-80] Balague et al[7] in a recent systematic review reported only 4-16% of children and adolescents with LBP reported that they believed their condition necessitated medical consultation. Back pain in this age group may be viewed by society as a typical experience associated with growth and development, and not warranting extensive attention. Second, the majority of children and adolescents referred for treatment in our sample (92%) were involved in regular athletic activity. The high percentage of athletic participation in this sample could also be attributed to the nature of the sports medicine clinic, or it may indicate that children and adolescents with LBP related to athletic participation are more likely to seek out and be referred for treatment in order to return to sport. Further research is needed to determine if sports participation is a risk factor for the onset, or delay in recovery from an episode of LBP, and to clarify referral patterns for this population.

The evidence regarding the association between sports participation and LBP in children and adolescents has been equivocal. Studies by Salminen et al[81] and Troussier et al[54] did not find any correlation between the intensity of physical activity and prevalence of LBP in children and adolescents. On the contrary, Balague[8] identified sports participation as a risk factor for the development of LBP in this population. Both Balague and colleagues[7, 8, 50] and Burton et al[5] have reported an increased prevalence of LBP in individuals who participate in competitive sports. The findings of these latter studies could help explain the large percentage of athletes in our sample.

Although our sample size was small, our results suggest the clinical presentation of children and adolescents with LBP may differ from adults with respect to history, physician diagnosis, and physical examination findings. Regarding the history, our sample had an average age of 14.4 years, with 83% experiencing their first episode of LBP. This finding is in accordance with Salminen et al,[53] who reported that the first episode of LBP in children and adolescents often occurs between the ages of 13 and 14 years. In our sample, few patients (17%) reported any previous history of LBP. In studies examining adult clinical populations with LBP, a previous history of LBP is present in 50-75% of individuals.[82-84] A prior history of LBP has been identified as a negative prognostic factor for adults with LBP.[62, 85]

The pattern of diagnoses given to the children and adolescents by their physicians appears to reveal a different pattern than typically seen in adults. Specific pathoanatomical lesions cannot be identified in 85%-90% of adults with LBP.[59, 86] It has been assumed that specific pathoanatomical lesions are more likely to exist in a child or adolescent with LBP[87] however others have suggested that this may not be the case, and the pattern may be similar to adults.[5, 13] In our sample, almost half the patients (44%) were given a diagnosis related to a specific pathoanatomical cause, supporting the recommendation that "acute anatomical lesions," rather than non-specific, degenerative changes, should be sought when examining LBP in a child or adolescent.[12] Our results relied on a physician's diagnosis. Because the diagnostic process was not standardized, we cannot confirm the accuracy of the diagnoses of the subjects in this study.

All of the pathoanatomical lesions in our sample were spondylolitic-related. Spondylolysis stress fractures are reported to be the most common and potentially severe disorder causing LBP in athletic children and adolescents.[18, 57, 88] The three-year incidence of spondylolitic-related disorders has been reported as high as 47% in children and adolescents with LBP [18] and as low as 5%-8% in populations of adults with LBP.[89, 90] Our results support the high rate of these disorders in children and adolescents. Due to the retrospective nature of our study, additional patients may have had undiagnosed lesions, and we may have underestimated the number of specific lesions in our sample.

Finally, differences were noted in the physical examination findings. Children and adolescents with LBP appeared to have different characteristic ROM restrictions than adults. The largest majority of patients in this study had difficulty with lumbar extension. Reduced ROM in extension was identified in 61%, and pain with the movement was present in 78% of patients. Even though studies have found that extension ROM is decreased between the ages of 15 and 18 regardless of the presence of LBP[5] in our sample, 93% of our patients with reduced extension ROM also experienced pain. Conversely, only 30% of patients were observed to have restrictions in flexion ROM, and 22% had pain with lumbar flexion. Studies of adults with LBP reveal greater percentages of patients with painful and/or restricted lumbar flexion as opposed to extension ROM.[69, 91, 92]

The greater difficulty with extension as opposed to flexion motions in children and adolescents with LBP may be related to the diagnoses common in this population. Restricted ROM and pain with lumbar extension are characteristic of spondylolytic disorders. [93] Restricted and painful flexion, however, is more typical of lumbar disc herniation or discogenic LBP.[2, 94] The incidence of disc herniation in children and adolescents is much lower than adults.[90] Other clinical phenomena that have been described as common occurrence in adults with discogenic LBP are centralization and peripheralization of symptoms with active lumbar movements.[95] Previous studies have found 50%-75% of adults with LBP demonstrate centralization and/or peripheralization during lumbar movement testing.[95-97] Neither centralization nor peripheralization of symptoms was present in this group of patients.

If the general preference for flexion versus extension and the lack of centralization / peripheralization in children and adolescents with LBP is confirmed with additional research, these findings may have important implications for the management of these patients. The use of extension exercises and postures as treatments have been found to improve symptoms in many adults with LBP.[97-99] However, these treatments may not be useful for the majority of children and adolescents whose symptoms are likely to be exacerbated by these activities. Children and adolescents may be more likely to respond to flexion-oriented and/or spinal stabilization exercise programs because these interventions have been found to be more effective in individuals with spondylolytic conditions.[58, 100, 101] These studies however, have been conducted in adult populations with spondylolytic injuries and the generalizability of the results to younger individuals has yet to be investigated.

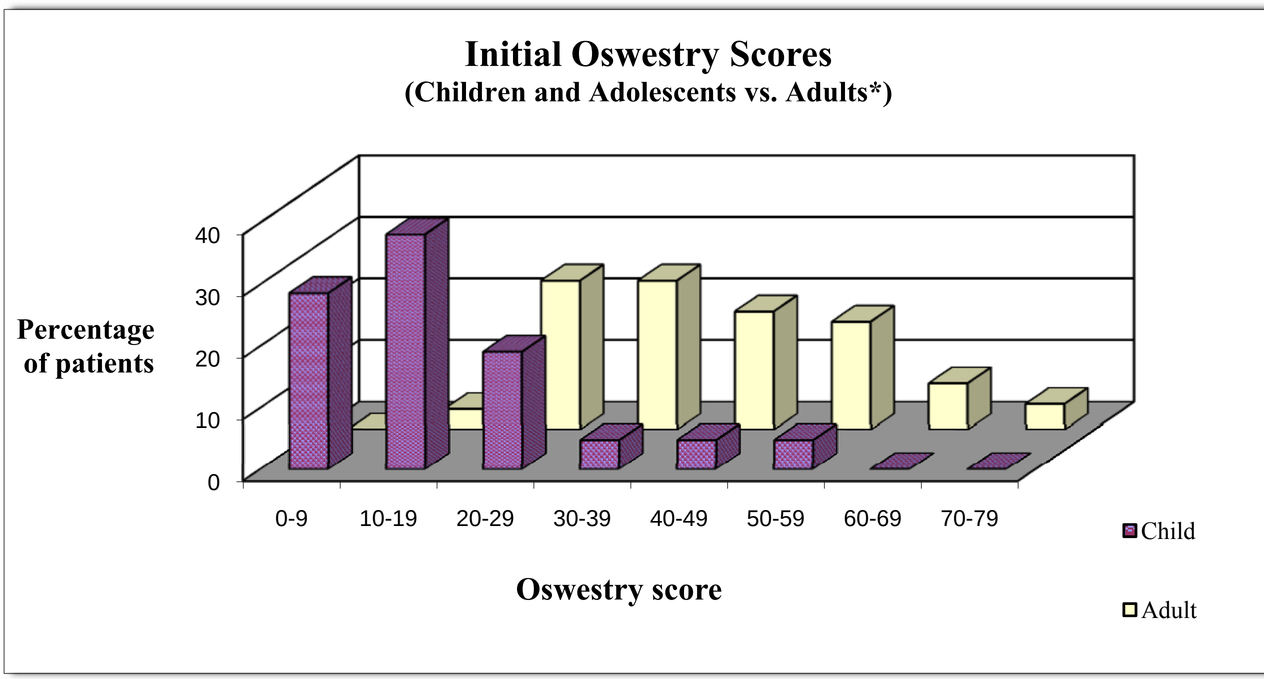
We found differences in the classification pattern of this sample of children and adolescents with LBP, when compared to our previous research in adult populations. We were able to classify the patients in this study using a previously-described treatment-based classification system.[42, 43] In our previous work examining adults referred to physical therapy with LBP,[43] the most common classification was specific exercise (42% of subjects with an equal distribution of flexion and extension exercise patients). Second most common was mobilization (35%), followed by immobilization (18%) and finally traction (6%). In the current study involving children and adolescents, the most common classification was immobilization (48%), followed by mobilization (35%), and finally specific exercise (17%). No patient was classified in the traction category. Patients classified in the immobilization category are treated with a program of trunk strengthening and stabilization exercises. The increased rate of immobilization classification among children and adolescents is consistent with the increased incidence of spondylolytic disorders in this population. Previous research has found a stabilization exercise approach to be effective in treating adults with these types of injuries.[58, 100] Further research on the effectiveness of stabilization exercises in children and adolescents is required, however it appears this approach may be useful for a large number of younger individuals with LBP. Manual therapy approaches may also have a role, and to a lesser extent, specific exercise programs (i.e., flexion or extension-oriented exercises).

In adults, emphasis has been placed on the use of patient-reported, back pain-specific functional scales, such as the OSW disability questionnaire, to assess treatment outcomes.[102] The OSW, in both original and modified forms, has been studied extensively in adults with LBP and found to be a reliable, valid, and responsive measure of patient-reported disability.[7, 64, 67, 79, 103] The measurement properties of the OSW have not been investigated previously in children and adolescents with LBP. We began an examination of the construct validity by correlating baseline OSW scores with concurrent ratings of pain intensity. We found a low and statistically insignificant correlation between pain and disability in our sample (r=0.16). Studies of adults with LBP have reported moderate correlation coefficients between pain and disability, ranging between 0.35 and 0.60 depending on the characteristics of the patients and the particular disability scale studied. [86, 92, 104, 105] In our previous work involving adults with LBP we have found correlations of 0.47 and 0.58 between concurrent measures of pain and the modified OSW scale. [74, 83]

The low correlation between the OSW and pain scores in this group of children and adolescents with LBP may indicate a lack of concurrent validity for the OSW as a tool to measure disability due to LBP in this population. Previous research in adults with LBP tends to show moderate correlations between concurrent measures of pain and disability (r values ranging between 0.37-0.55). [74, 86] In this group, the mean and standard deviation of pain scores (mean = 4.4, SD = 2.7) were slightly less than, but similar to values typically reported in adults with LBP. Most studies of adults with LBP from general practice or physical therapy populations have reported mean pain rating ranging between 5 and 6. [71, 94, 106] However, the children and adolescents with LBP in this group scored considerably lower on their initial OSW (mean = 16.8, SD = 12.9) than has been reported for adults. Studies of adults with LBP have generally reported mean baseline values on the OSW ranging between 35-45.[79, 106-108] In our previous work in adults receiving physical therapy, we have found baseline OSW values ranging between 40-45 with SD of about 15. [43, 67, 74, 83] The low baseline scores in this group of children and adolescents present concerns about the responsiveness of the OSW in this population.

In this sample, 48% of the patients scored at least two standard deviations below the typical adult mean values, creating a floor effect that would make it difficult to document improvement in many patients. A graph of the distribution of the baseline OSW scores in this sample of children and adolescents compared with scores in an adult population[43] (figure 1) illustrates the distributional difficulties that may be encountered if the OSW were to be used as a treatment outcome measure in a study involving children and adolescents with LBP. We believe the individual items of the OSW may not be relevant to the functional difficulties experienced by children and adolescents with LBP. Further research is needed to identify appropriate outcome measures for studies involving individuals under age 18 who are treated for LBP. This research is necessary prior to conducting intervention studies involving this population.

Figure 1- Distribution of Oswestry scores in children and adolescents versus adults with low back pain.



***Data on distributional Oswestry scores in adults from Fritz JM and George S, *Spine* 2000.**

2.5 CONCLUSION

Although the retrospective nature of this descriptive study prevents any strong conclusions, this study provides a foundation and identifies several areas for further research. It appears that children and adolescents with LBP differ from their adult counterparts with respect to history, physical examination, and physician diagnosis. Our results indicate that further research is needed to examine referral patterns, optimal treatment programs, and appropriate outcome measures for children and adolescents with LBP. In our experience, few children and adolescents with LBP were referred to physical therapy. Children and adolescents appear more likely to have a specific pathoanatomical diagnosis, and are more likely to experience difficulties with extension movements than adults. Stabilization appeared to be the most common classification; however more research is needed to examine the use of a classification approach in this population. Lastly, the Oswestry Questionnaire, a commonly utilized measure of disability in adults, may not be useful as a clinical outcome measure in this population. More research is crucial to uncover the information needed to connect all of these findings. Doing so could lead to the development of a more responsive outcome measure for children and adolescents with LBP, and specific treatment patterns that need to be identified and tested in prospective, controlled studies.

3.0 CHAPTER 3- VALIDATION OF THE MODIFIED OSWESTRY QUESTIONNAIRE AS AN OUTCOME MEASURE IN THE TREATMENT OF ADOLESCENTS WITH LOW BACK PAIN

3.1 INTRODUCTION

Much of the work in the area of outcome measurement in patients with LBP has been focused on middle-aged adult populations among whom LBP is most prevalent and costly to society. One clinical outcome measure which has been employed in many clinical-trials is The Modified Oswestry Questionnaire (OSW). The OSW is a ten-item, easily administered, disease specific measure used to indicate a patient's perceived level of disability from their LBP. Another commonly used outcome measure, the Numeric Pain Rating Scale (NPRS), is an 11-point pain intensity scale ranging from 0 (no pain) to 10 (worst imaginable pain). Studies involving adults with LBP have found the NPRS to be reliable and valid for the assessment of pain[35] and moderately correlated with self-reported disability on the OSW.[109] The OSW and NPRS are widely used in current clinical practice in the assessment of adults with LBP who are undergoing treatment.

To date, there have been no studies conducted on appropriate outcome measurement for children and adolescents with low back pain. Two studies examining the use of the NPRS to assess post-operative pain in children age 7-18 have reported adequate reliability and concurrent validity.[36] However, measures of disability from low back pain have not been examined in this population. Our previous work in this area suggested that the OSW may not be suitable for use in children and adolescents. Therefore the need for a more extensive exploration into the validation of an outcome measure for use in this population is apparent. The ability of researchers in the area of low back pain to examine effective clinical management and treatment of adolescents is greatly hindered by the lack of a validated outcome measure. The validation of such a measure is needed before any further work in this area can be accomplished.

The growing number of pediatric and adolescents reporting debilitating episodes of low back pain is recently receiving increased attention. Thus, there is an imminent need to ensure the availability of valid and responsive outcome measures for use with this population of patients. Although both the Oswestry and NPRS have been used as outcome measures in studies of treatments for LBP in older age groups, the validity of these measures in this younger population has not been specifically examined. The overall purpose of this project is to examine the construct validity and responsiveness of the Oswestry and NPRS in adolescents with low back pain. The purposes of this paper are to: (1) examine the distributional properties of baseline OSW and NPRS scores in a population of adolescents with LBP; (2) examine the construct validity of the OSW in a sample of adolescents with LBP; and to (3) examine the responsiveness of the OSW and NPRS in a sample of adolescents with LBP.

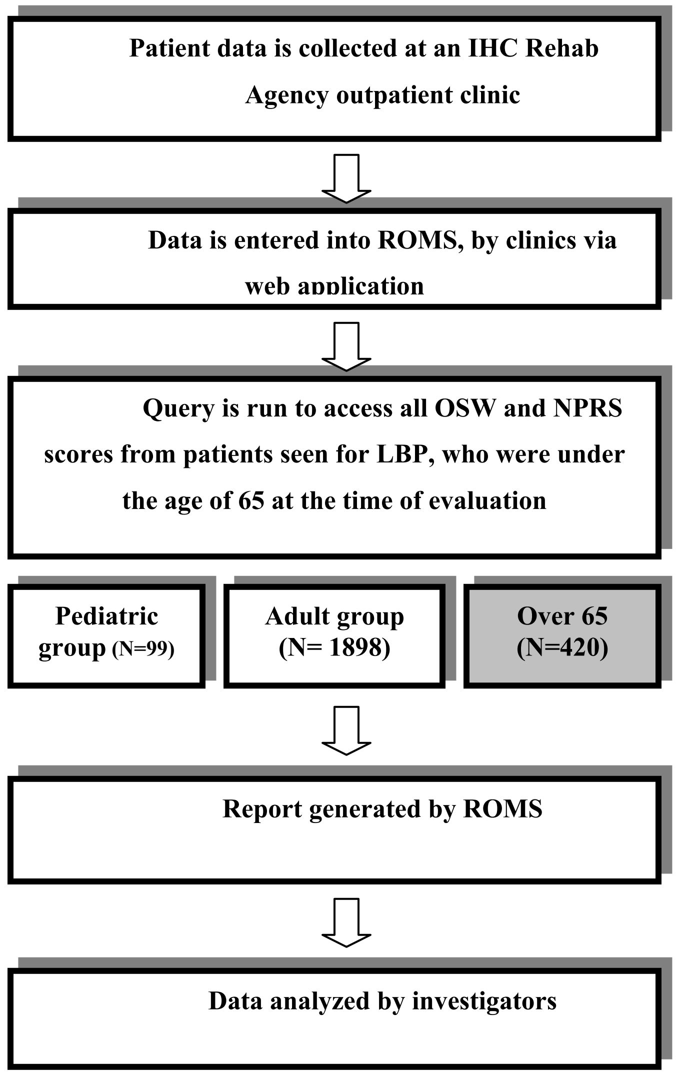
3.2 METHODS

Data for this study was collected at outpatient physical therapy clinics of Intermountain Health Care (IHC), an integrated, non-profit health care system with clinics throughout Utah and Southern Idaho. Since 2002, IHC physical therapy clinics have collected outcomes data on all patients using a web-based electronic database. A region-specific measure of disability and 0-10 numeric pain rating scale (NPRS) are entered into the database for each patient at each physical therapy visit. This data is then stored along with other informative data (date of birth, sex, etc.) and made available for query. During the time of this study, outcomes data were successfully collected on 93% of patients.

This project was a retrospective review using the electronic database to query six outpatient physical therapy clinics in the greater Salt Lake City, Utah region. All patients entered into the database from the participating clinics with an initial and at least one follow-up OSW score from January 1, 2003 until December 31, 2005 were considered for inclusion in this review. For all patients under age 65 at the time of the initial evaluation, the initial and final OSW and NPRS scores were recorded along with the patient's date of birth, sex, and number of therapy visits (figure 2).

Patient data was then divided into two age-related sub-groups by comparing the patient's date of birth with the date of the initial physical therapy visit. Those less than 18 years of age at the initial visit were categorized as "adolescent" and those aged 18-64 were categorized as "adult." Individual item scores on the OSW were recorded for those patients in the "adolescent" group. Data were then entered into Excel and SPSS from the ROMS output.

Figure 2- Layout of research design



3.2.1 Sample Size

Understanding the natural history of LBP, one expects a responsive outcome measure to detect at least a moderate effect size (0.5).[42] Subsequently, a power analysis yielded a minimum N=35 patients would need to be recruited for this study in order to detect an effect size of at least 0.50 with 80% power and an alpha level of 0.05, assuming a two-sided alternative hypothesis. A standard adjustment (*d*') for dependent samples was made to Cohen's *d* assuming a correlation of 0.5 between baseline and follow-up OSW scores. The review of the ROMS database for the period of the study yielded a total of 99 patients under the age of 18 that were treated for LBP. Thus, it was concluded that a sufficient number of cases would be present in the database to ensure adequate power to complete the aims of the study.

3.2.2 Data Analysis

Descriptive statistics, including frequency counts for categorical variables and measures of central tendency and dispersion for continuous variables were calculated to summarize the data. Descriptive statistics including mean, median, and standard deviation for initial OSW and NPRS were calculated and compared using ANOVA for each age category. Histograms were constructed for visual comparison of baseline scores for each group. The proportion of patients experiencing a floor effect on each scale was calculated for each age category. A "floor effect" was defined as an initial score that was sufficiently low to make the demonstration of any improvement problematic.[42] A patient's OSW score was defined as reaching the "floor" when the baseline OSW was 10% or less. The baseline score defining a floor effect for the NPRS was 1 or less. These scores indicate that only 10% or less of the scale would be available for demonstrating improvement between baselines and follow-up. One-sample Kolmogrov-Smirnov (K-S) tests were utilized to test the normality of the baseline distributions of the OSW and NPRS within each age category.

Pearson correlation coefficients with associated 95% confidence intervals were computed and compared between baseline OSW and NPRS scores for each age category to assess construct validity. Change scores for both outcome measures were then computed by subtracting the final score from the initial score for each patient. Standardized effect sizes and associated 95% confidence intervals for both the OSW and NPRS in both age categories were calculated. The standardized effect size was calculated for each age category for the OSW and NPRS by dividing the mean change score on the variable of interest by the standard deviation of the initial score for that age category. A significant difference was said to exist if the observed 95% confidence intervals did not overlap.

Lastly, construct and convergent validity of the OSW in this population was further examined. Internal consistency reliability (how the components of the measure moved together) was examined by computation of Chronbach's alpha. Since the OSW has never been validated previously in this population, item appropriateness was also considered. In order to determine the appropriateness of the items included in the OSW for use in adolescents with LBP factor analysis was performed. Individual items were examined in order to assure similar loading characteristics of the OSW items in adolescents with LBP as compared with adults. Principal components analysis was performed with varimax rotation with Eigen values ≥ 1.0. Items were only included which displayed a loading of at least 0.35 onto one latent factor.[110]

3.3 RESULTS

During the designated time period a total of 2417 patients with at least one initial and follow-up OSW, were treated in the six participating clinics. Ninety-nine patients (4.1%) were under age 18, 1898 patients were between the ages of 18 and 64 (78.5%), leaving 420 (17.4%) over the age of 65 (figure 2). Those patients over the age of 65 were excluded from further analysis. The baseline OSW score of the "pediatric" group (mean= 30.97±13.12) was lower than the "adult" group (mean 40.64±15.98) groups ($p < 0.001$). There was no difference between the baseline pain scores of the two groups (table 6).

Table 6- Descriptive statistics for adolescent and adult age categories.

	Variable	Minimum	Maximum	Mean	St. Deviation
Adolescent	Initial OSW Score	2	66	30.97	13.18
	Change in OSW	-22	54	12.48	14.25
	Initial NPRS Score	0	10	5.14	2.18
	Change in NPRS	-4	7	1.92	2.37
	Number of PT Visits	1	15	5.00	2.53
	Duration of symptoms*	0	1851	189.18	385.65
	Age	10	17	15.51	1.46
Adult (under 65)	Initial OSW Score	0	100	40.64	15.98
	Change in OSW	-74	88	13.33	15.84
	Initial NPRS Score	0	10	5.58	2.38
	Change in NPRS	-5	10	2.02	2.47
	Number of PT Visits	1	42	5.10	3.59
	Duration of symptoms†	0	8581	213.92	744.48
	Age	18	64	41.64	12.46

The histogram of the baseline OSW scores for the pediatric group (figure 3) showed nine patients (9.0%) experienced a floor effect on the OSW, and six (6.1%) experienced a floor effect on the NPRS (data not pictured). The K-S tests revealed no significant skewness was present for the OSW ($p=0.80$) or the NPRS ($p=0.16$) in the pediatric group. In the adult group, 30 (1.6%)

and 80 (4.2%) patients experienced floor effects on the OSW and NPRS respectively. Also, in the adult group significant positive skewness was present for the initial OSW scores ($p<0.001$) (figure 4), and negative skewness for the initial NPRS ($p<0.001$).

Figure 3- Initial OSW scores in "adolescent"

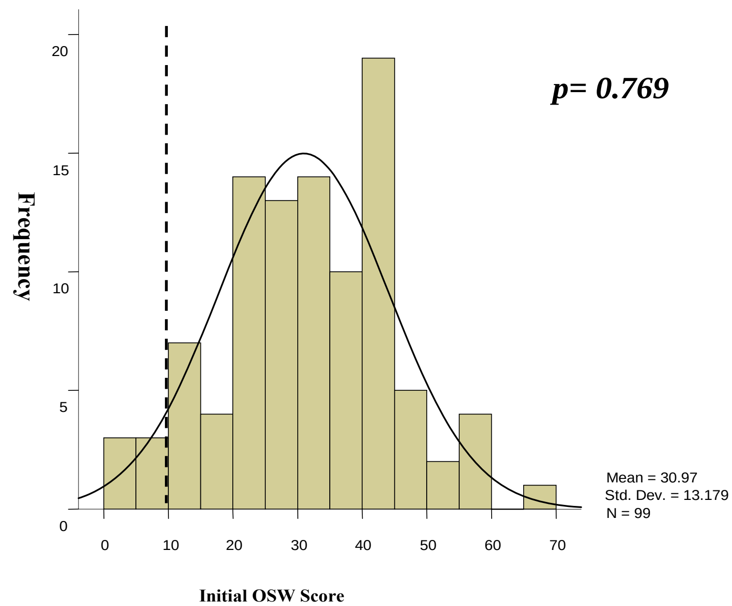
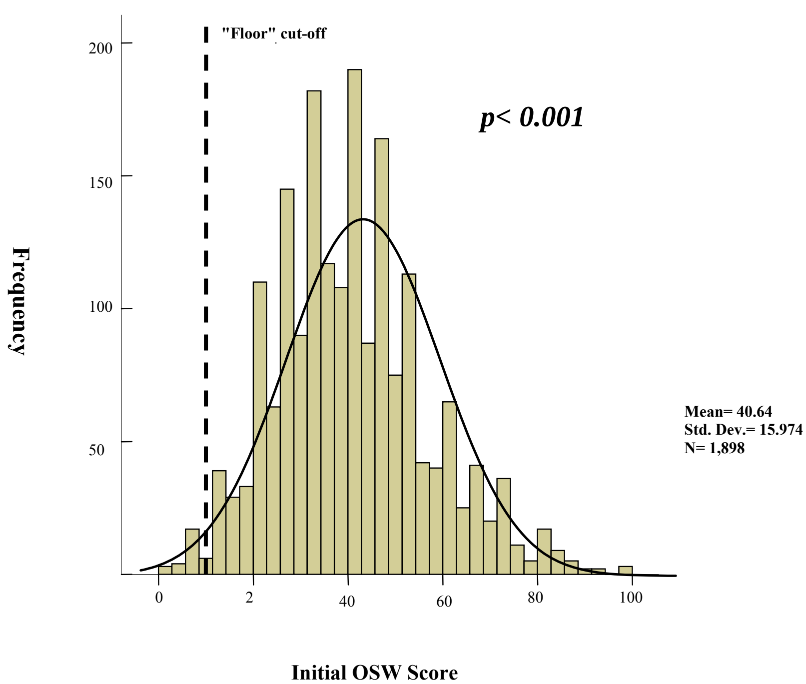


Figure 4- Initial OSW scores in "adults"



Descriptive statistics for the number of visits as well as the final and change scores for the OSW and NPRS are shown in table 6. Change scores for the OSW between the groups were compared with an analysis of covariance (ANCOVA) using the baseline OSW as the covariate based on significant differences in the initial scores between the groups. The difference in change scores on the OSW between the pediatric and adult groups did not reach significance (p=0.07). Changes in pain were also compared between the groups using ANCOVA. No significant main effect for group (pediatric vs. adult) was found (p=0.69). Correlation coefficients between initial NPRS and OSW scores and the change scores for the two measures did not differ between the groups (table 7). Effect sizes for OSW and NPRS for each age category are given in table 8. A comparison of the 95% confidence intervals associated with effects sizes in each age category indicated no significant differences between effect sizes based upon age group.

Table 7- Correlations and confidence intervals between baseline and change scores on OSW and NPRS

	Pediatric	Adult	P-value
Baseline scores	**0.59** (0.34, 0.65)	**0.63** (0.61, 0.64)	**0.71**
Change scores	**0.59** (0.42, 0.70)	**0.68** (0.65, 0.71)	**0.19**

Table 8- Effect Sizes with Associated 95% Confidence Intervals

Variable	Mean Δ score / σ_{initial}	Effect Size	95% Confidence Interval
OSW_{adoles}	(12.48 / 13.18)	0.95	(0.65,1.24)
OSW_{adult}	(13.33 / 15.97)	0.84	(0.77,0.90)
$NPRS_{adoles}$	(1.92 / 2.18)	0.88	(0.59,1.17)
$NPRS_{adult}$	(2.02 / 2.38)	0.85	(0.78, 0.91)

A factor analysis of the individual OSW items for the adolescent group revealed that two latent factors (figure 5) emerge from the data. Seven of the items: personal care, walking, sitting, standing, sleeping, travel and school activities loaded onto one factor, while the remainder of the OSW items: pain intensity, lifting and social life loaded onto a second latent factor (table 9). Approximately sixty percent (59.7%) of the variance in the data was explained by the convergence upon these two factors. The cumulative Eigen values for factors 1 and 2 were 4.79 and 1.18 respectively (figure 6). Moderate to good internal consistency was demonstrated by a Chronbach's alpha of 0.86.

Table 9- Rotated component matrix of OSW in adolescent group (N=99)

	FACTOR	
	1	**2**
% variance explained	47.9%	11.8%
Eigen value	4.79	1.18
Item 1- Pain	.039	**.791**
Item 2- Personal Care	.449	**.543**
Item 3- Lifting	.185	**.818**
Item 4- Walking	**.660**	.372
Item 5- Sitting	**.791**	-.045
Item 6- Standing	**.574**	.429
Item 7- Sleeping	**.752**	.213
Item 8- Social Life	.521	**.608**
Item 9- Traveling	**.831**	.221
Item 10- Work/school	**.555**	.351

Bold type indicates primary factor loading for each item

Figure 5- Two factor structure of individual OSW items in adolescent patients with LBP

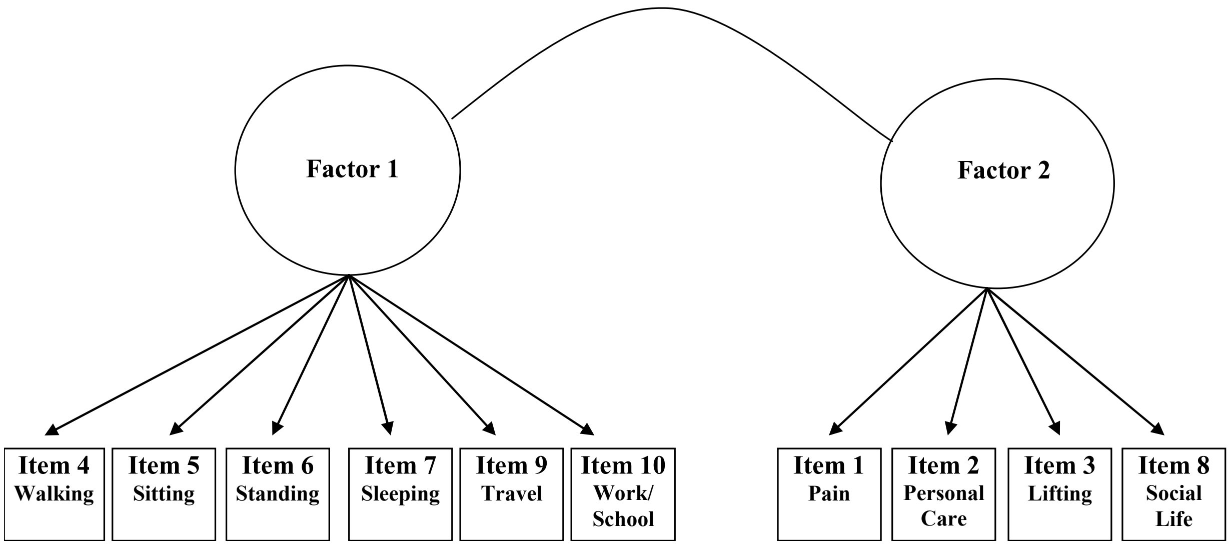
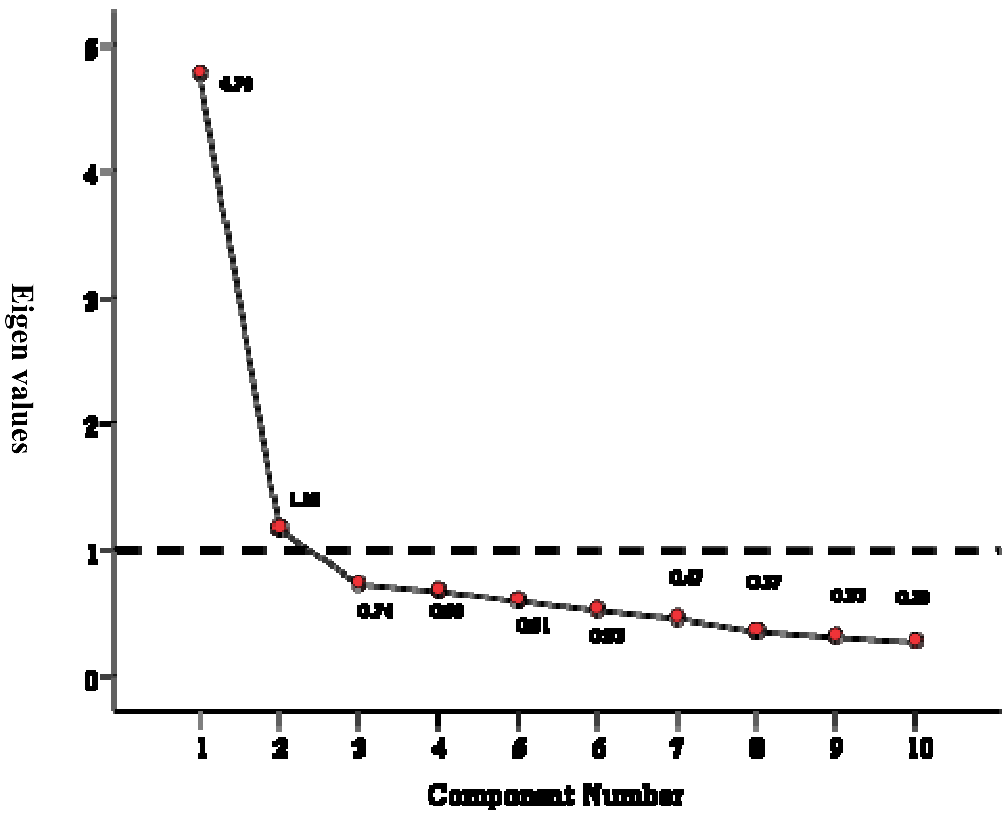


Figure 6- Scree plot for Eigen values from OSW "adolescent"



3.4 DISCUSSION

Based upon the results of this review, it appears as though the Modified Oswestry Disability Questionnaire can be utilized as an outcome measure in adolescent patients (18 years of age and younger) with LBP. The change scores and effect sizes seen here were large and also similar to those seen in adults.[111] Similarly, the magnitude of change experienced by the adolescent patients in this review also appears to be detectable with use of the OSW, suggesting good responsiveness of the measure to detect clinical change in this population. As has been done with adult populations, good construct validity of the measure was demonstrated here by the high correlation of OSW change scores to NPRS ($r=0.59$, 95% CI= 0.42, 0.70).

The underlying distribution of scores on OSW and NPRS did differ slightly from those reported by adults with LBP. The distributions of scores for the OSW and NPRS in the adult group were both skewed. Although the initial subjective pain ratings did not appear to differ significantly between the two groups, it does appear that in this sample of adults with LBP, patients tended to report slightly higher percentages of disability from LBP. Conversely, it has been reported previously that patients under the age of 18 with low back pain tend to report lower levels of disability on the OSW.[112] The average mean OSW score in the adolescent group was approximately 10% less than the mean score in the adult group. Considering the minimal clinically important difference (MCID) for the OSW is approximately 6 percentage points, the difference in means seen here could suggest a significant difference in clinical presentation for these two groups of patients.[67] Further research and analysis would need to be conducted in order to confirm this observation.

Our previous work suggested a lack of concurrent validity for the OSW as a tool to measure disability due to LBP in the adolescent population. Previously, a low correlation between the OSW and NPRS scores in children and adolescents with LBP was reported to be 0.16.[112] In this sample of adolescents, construct validity appears to be demonstrated through a moderate correlation of NPRS and OSW scores = 0.59. Other studies in adult populations have demonstrated correlations between concurrent measures of pain and disability ranging between 0.37 and 0.61.[74, 86, 113]

Although controversial among researchers, retrospective analysis of responsiveness is an approach which is widely conducted.[67, 114, 115] Calculation of effect size is an approach to assess responsiveness that has been used in OSW analysis, and allows for group variability to be taken into account.[103, 116] Since effect size is not affected by sample size, but rather baseline variability it was believed to be a good indicator of responsiveness in this study. In our sample, large effect sizes (as defined by Cohen) were demonstrated on the OSW in both adolescents (0.95, 95% CI= 0.65, 1.24) and adults (0.84, 95% CI= 0.77, 0.90).[117] Effect size estimates for the OSW in adult samples of the same magnitude have been reported.[118] Thus, it appears the OSW has the ability to detect meaningful change in adolescent patients with LBP to the same magnitude as it does in adult patients with LBP.

The results of the factor analysis for the OSW in the adolescent group suggest that the disability reported in adolescents with low back pain cannot be viewed as a one-dimensional construct. This finding is similar to what has been reported in the adult literature.[109, 110, 119] In reported adult samples, typically two latent factors have been identified which seem to relate to the location or nature of the activity.[110, 119] In this study, factor one consisted mostly of physical activities performed over a certain distance or period of time. Factor two consisted primarily of activities performed at home, work or in social settings (figure 5). Individual item characteristics of the OSW in adult samples have varied from study to study. Similarly, the individual item characteristics in this sample of adolescents differ as well from what has been reported previously in adult literature. However, the two factor structure of the measure in both adults and adolescents is similar.[110, 119]

After close review of the factor structure of the OSW in this sample of adolescents, the authors feel as though the second latent factor may be a result of a misunderstanding of terminology by younger patients. For example, the concept of "lifting" in adolescent populations may be more typically associated with specific exercises performed in a fitness/weightlifting setting. Thus these patients may have a very different associated disability for lifting tasks if they do not participate in this specific activity. Similarly, patients in this age group may not completely comprehend what their experienced disability in their "social life" may be, given the possible age-specific understanding of the concept and what it encompasses. Therefore, the differences seen in factor loading may not be a direct reflection of the OSW instrument itself, but rather the wording used within the questionnaire. Further validation with the inclusion of age-sensitive examples or descriptions for each of the 10 items included within the OSW may be a plausible solution.

One of the largest limitations of this study was the presence of a large disparity in sample sizes between groups. Although we were powered sufficiently to meet the aims of the study, such a large difference in number of subjects raises concerns regarding analysis and generalizability of the results. Efforts were made through statistical analysis and careful interpretation to ensure homogeneity of variances between samples. In addition, the retrospective nature of the review via computerized database precluded the gathering of information related to subjective history, clinical presentation, or another measure such as the global rating of change in order to further assess responsiveness of the OSW.

3.5 CONCLUSION

In conclusion, it appears that based upon the results of this review the OSW is most likely an appropriate outcome measure for use with patients with LBP under the age of 18. Clinicians should feel confident when using the measure that the basic constructs of the measure are upheld in their younger patients, and that it is able to detect clinical change in this population. However, it is also important to remember that it may be useful to review each item of the OSW with the patient prior to completion in order to assure a complete understanding of the activity each item is measuring.

4.0 CHAPTER 4- TREATMENT BASED CLASSIFICATION OF ADOLESCENT PATIENTS WITH LOW BACK PAIN

4.1 INTRODUCTION

Non-specific low back pain in adolescents is a common problem, and is beginning to receive attention from researchers.[75] Treatment intervention strategies for adult patients with low back pain have been extensively studied, and clinicians now have evidence-based tools such as clinical prediction rules[120-122] and classification schemas[41, 42, 123-125] to assist in their decision making for adult patients with LBP. However, estimates of the prevalence of low back pain in adolescents are quickly approaching that which has been documented in adults.[126] Therefore, research efforts have begun to focus on the evidence that exists to guide treatment intervention in adolescent patients with LBP seeking physical therapy services. Unfortunately, little evidence exists for therapists to base treatment decisions upon.

Previous research has described a classification-based treatment system for adults with LBP.[42, 43] This system seeks to classify individuals with LBP into one of three primary categories based on the clinical characteristics of the patient at the initial assessment (mobilization, stabilization, or specific directional exercise (i.e., flexion or extension-oriented exercise)). The treatment most likely to be successful for the patient is then based on the classification category. While previous work shows that clinical outcomes are improved when treatment is based on this classification system in adults[47, 125] its usefulness with children and adolescents is largely unknown.

The need to develop methods of "classification" or sub-grouping of adult patients with LBP grew largely from the difficulty in identifying a known pathoanatomical cause for LBP.[59, 127] Previously it was believed that the identification of a pathoanatomical cause for low back pain in adolescent patients was necessary and characteristic of the population.[10, 128, 129] However, recent literature suggests an increasing tendency for adolescent patients to report complaints of disabling low back pain for which no specific cause can be found.[4, 13, 75] Thus it seems reasonable that the effectiveness of classification systems in adolescents with LBP should be investigated. The purposes of this study were to 1) examine the interrater reliability of the treatment-based classification (TBC) system in a sample of adolescents with LBP; 2) determine the appropriateness of a 3-category system by examining the distribution of adolescents with LBP among classification categories using the TBC system; 3) examine the clinical utility of the TBC-system by comparing treatment outcomes.

4.2 METHODS

4.2.1 Research Design Overview

This project was a prospective, longitudinal, cohort study to examine the usefulness of treatment-based classification in a group of adolescents with LBP. Patients who fit the inclusion criteria and consented to participate in the study completed a battery of self-report measures related to activity level, pain, disability and symptom onset and behavior. Patients then underwent a standardized history assessment and clinical examination. Upon completion of the clinical examination, patients were then returned to the care of their treating therapist. Based on the results of the study examination, patients were classified by the researchers into one of the three possible classification categories (stabilization, mobilization/manipulation, or specific exercise). Treating therapists were blinded to classification assignment made by the researchers and were free to determine the most appropriate treatment for the patient. All treatment procedures, including frequency and duration were recorded.

4.2.2 Patient Recruitment

All subjects were recruited from multiple sources within the greater Salt Lake City region and Pittsburgh, PA; including the clinical facilities of the Rehabilitation Agency of Intermountain Health Care, and the clinical facilities of Allegheny and Chesapeake Physical Therapy and Children's Hospital of Pittsburgh. These facilities were selected as clinics that routinely manage children and adolescents with low back pain. All consecutive patients, ages 12-17, referred to either a physical therapist for the treatment of their LBP were considered for inclusion in this study. This study was approved by the Institutional Review Board at Intermountain Health Care, the University of Utah, and the University of Pittsburgh before any patients were recruited and data collection began in their respective areas.

4.2.3 Description of Patients

The study included patients with both acute and chronic LBP from both known and unknown pathoanatomical causes. Patients were seen initially by their treating therapist and underwent a routine clinical examination. All individuals fitting the criteria listed below were offered the opportunity to participate in this study by the treating clinician initially evaluating the patient. If the both the parent and adolescent were interested in participation, study personnel were contacted and a meeting was arranged prior to the second physical therapy treatment session. The study personnel explained all procedures to the individual patient and his or her guardian, and both provided informed consent prior to the patient's participation in this study. Once appropriate parental consent and adolescent assent were obtained, the research baseline examination was conducted.

4.2.4 Inclusion Criteria

The following inclusion criteria were used to determine a patient's eligibility for this study:

1. Chief complaint of pain and/or paresthesias in the lumbar spine, with or without symptoms extending into the lower extremities; that is reproduced or exacerbated by movements of the lumbar spine.
2. Age at the time of the baseline examination between 12-17 years old.

Most of the research in this area to date shows that the prevalence of low back pain in adolescents is the higher than in younger age groups. There is research to suggest that the prevalence of LBP declines at ages less than 12[54, 130] and children younger than 12 with LBP may have a greater likelihood of a non-musculoskeletal etiology such as spinal malignancies.[16]

Studies of adults with LBP frequently use a lower age limit of 18 years old. Similarly, studies of adolescent medicine frequently utilize and age group of 12-17. For these reasons, individuals between the ages of 12 and 17 were recruited for participation in this study. Reproduction of symptoms with lumbar movements was required in an attempt to limit recruitment to individuals with mechanical LBP.

4.2.5 Exclusion Criteria

Individuals were ineligible for participation in this study if *any one* of the following exclusion criteria was present:

1. Red flags noted in the patient's general medical screening questionnaire that may indicate a high likelihood of non-mechanical LBP (e.g., history of cancer, night pain, recent unexplained weight loss, history of severe trauma without imaging, etc.)
2. Evidence of central nervous system involvement, (symptoms of cauda equina syndrome (i.e. loss of bowel/bladder control or saddle region paresthesia) or presence of pathological reflexes (i.e. positive Babinski))
3. Any prior surgery to the lumbar spine or buttocks.

These criteria were designed to exclude individuals with non-mechanical LBP attributable to conditions that may require traditional medical management. Red flags were screened in the medical history questionnaire completed by the adolescent with his or her guardian. Signs of central nervous system involvement were screened during the physical examination. Individuals with any previous history of surgery to the lumbopelvic region were excluded because these procedures may constrain treatment decision-making due to possible post-operative restrictions. No individuals were excluded on the basis of gender, race, color, national and/or ethnic origin.

4.2.6 Therapists

Each of the therapists involved in the recruitment of study patients underwent a specific training session prior to initiating recruitment. Each training session was conducted by one of the study investigators and consisted of instruction on the administrative aspects of the study, appropriate recruitment procedures, HIPAA compliance, and the study outline and protocol.

4.2.7 Examination Procedures

4.2.7.1 Baseline Examination Procedures

Individuals meeting the criteria for participation and providing informed consent first underwent a standardized baseline assessment performed by one of the investigators. The baseline examination was performed for three primary purposes; 1) collect information needed to make a classification assignment, and 2) obtain baseline values for the main dependent variables in the study. The baseline examination included the use of self-report measures and a history/physical examination.

4.2.7.2 Self-Report Measures

1. <u>Demographic Information</u> – Demographic information including age, gender, height, weight, race, school status, past medical history, Body Mass Index (BMI), and expectation of treatment. Other questions that were asked related to the mechanism of onset, location and nature of the patient's symptoms, symptom severity, and previous

treatment for symptoms. This information was only collected during the baseline examination.

2. Numeric Pain Rating Scale (NPRS) – An 11-point NPRS ranging from 0 (no pain) to 10 (worst imaginable pain) was used to assess current pain intensity. Studies involving adults with LBP have found NPRS to be reliable and valid for the assessment of pain.[35] The psychometric properties of pain ratings in children and adolescents have not been extensively studied.[131] Two studies examining the use of pain scales to assess post-operative pain in children age 7-18 have reported adequate reliability and concurrent validity.[36, 37] Luffin and Grove[132] reported increased reliability and acceptability of an NPRS when facial expressions were added to the scale. Given that our study focused on adolescents and the age range for inclusion in this study extended from 12-17, it was believed that facial expressions were not necessary to assess pain intensity in this sample of patients.

3. Modified Oswestry Disability Questionnaire (OSW) – The OSW is as a region-specific disability scale for patients with LBP.[109, 133, 134] The questionnaire consists of 10 items addressing different aspects of function, each scored from 0-5 with higher values representing greater disability, and has been demonstrated to have high levels of reliability, validity and responsiveness in studies of adults with LBP.[64] The OSW used in this study was modified by replacing an item on sex life with an item related to homemaking/ employment to improve compliance. Our previous research has demonstrated the modified version to have equally high levels of reliability, validity and responsiveness.[67] Our pilot data collected on the use of this modified OSW in children and adolescents suggested adequate concurrent validity and responsiveness for use in this

age group. For this study we used the modified version with the homemaking/employment item re-worded to refer to sports/ recreation activities.

4. Modifiable Activity Questionnaire for Adolescents (MAQA) – The MAQA was used to assess past-year participation in leisure/sports activities. The MAQA includes a list of 26 common leisure/sports activities. Patients were asked to indicate all activities they have participated in at least 10 times in the past year. Information regarding the frequency and duration of participation in each activity was collected and scored to determine the total past-year hours per week of each activity, and the MET-hours per week using published equations.[135] The MAQA has been shown to be reliable and valid in samples of adolescents ranging from age 12-18.[136, 137] We added an additional question to assess the extent to which the subject believes his or her participation is limited by LBP (0% - 100%).

4.2.7.3 History and Physical Examination

The history and physical examination consisted primarily of variables needed to make a classification decision. The following variables were collected:

1. History questions regarding prior episodes of LBP, frequency of prior episodes, anatomical distribution of current symptoms, and aggravating/relieving factors.

2. Single and repeated lumbar active ROM was performed. AROM was measured with the patient standing using a single inclinometer with techniques we have found to have good inter-rater reliability.[111] The impact of each movement on symptoms was judged as

status quo, centralizing, or peripheralizing using definitions described by McKenzie[41] We have examined these judgments previously in adults with LBP and found them to have high levels of inter-rater reliability.[138]

3. Hip flexion and rotation passive ROM, and straight leg raise passive ROM was measured using single inclinometer techniques. Straight leg raise ROM was measured with the patient supine and the examiner passively lifting the extended leg. We have found excellent inter-rater reliability in adults for the measurement of straight leg raise ROM using a single inclinometer.[111] Hip flexion was measured with the patient supine and the knee flexed. Hip rotation passive ROM was measured with the patient prone and the knee of the tested leg flexed to about 90^0. Excellent inter-rater reliability has been reported for hip flexion and rotation measurements made in this manner using similar devices in adults.[139, 140]

4. Lumbar segmental mobility was assessed with posterior-to-anterior spring testing performed with the patient prone. The examiner contacted the spinous process of the lumbar segment being tested with his or her hypothenar eminence and applied a posterior-to-anterior force. Mobility judgments for each lumbar level were made on a 3-point scale (normal, hypo-, or hypermobile) based on the examiner's expectation of mobility and the mobility of the surrounding segments. The presence or absence of pain with spring testing at each lumbar vertebral level was also noted. We have found fair to moderate inter-rater reliability for judgments of mobility and pain made in this manner during spring testing in adults with LBP.[71, 138]

5. The prone instability test was performed by re-testing lumbar vertebral segments identified as painful during the mobility testing procedures described previously. Segmental mobility testing was then re-assessed with a posterior-to-anterior force applied while the patient is prone and extending the hips, causing contraction of the lumbar extensor muscles. If all previously painful lumbar vertebral segments are no longer painful, the test is considered positive. Our previous research has found the prone instability test to have good inter-rater reliability in adults.[138]

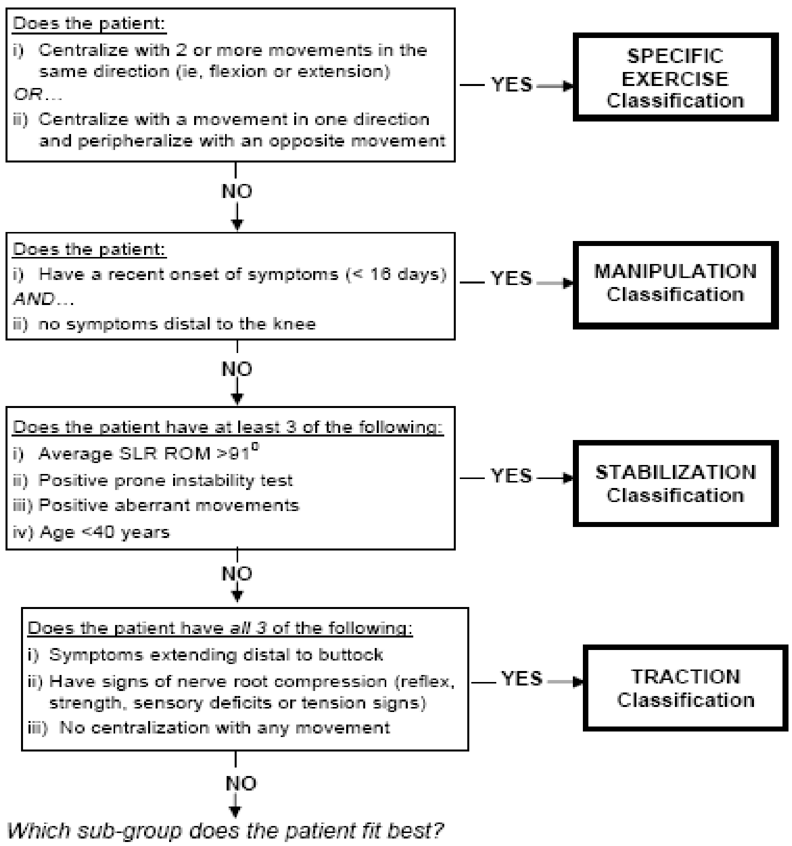
4.2.8 *Blinding*

The treating therapists who were responsible for the physical therapy management of the patients were completely blinded to the investigators' classification following the initial evaluation.

4.2.9 Classification Determination Procedures

Following completion of the baseline examination, the variables collected were reviewed and case summaries were generated. These were then used to test the reliability of the classification decision-making process utilizing a treatment-based classification algorithm (figure 7). The reliability and validity of this algorithm for treatment decision-making in adults has been studied extensively.[46, 124, 141] Our previous work in adults demonstrated that clinicians using this treatment-based classification algorithm can make a reliable classification determination (κ=0.6), regardless of clinician experience level. Classification decisions were made by the principal investigator and two independent examiners. Each examiner was a licensed physical therapist experienced in treating patients with LBP in outpatient physical therapy settings. The primary investigator reviewed and classified all case summaries. Each independent examiner then reviewed each case and made a classification decision, using the decision-making algorithm. In the case of a tie, the principal investigator's decision for that case was referred to as the tie-breaker to establish a classification category for each patient.

Figure 7- Treatment-based classification decision making algorithm



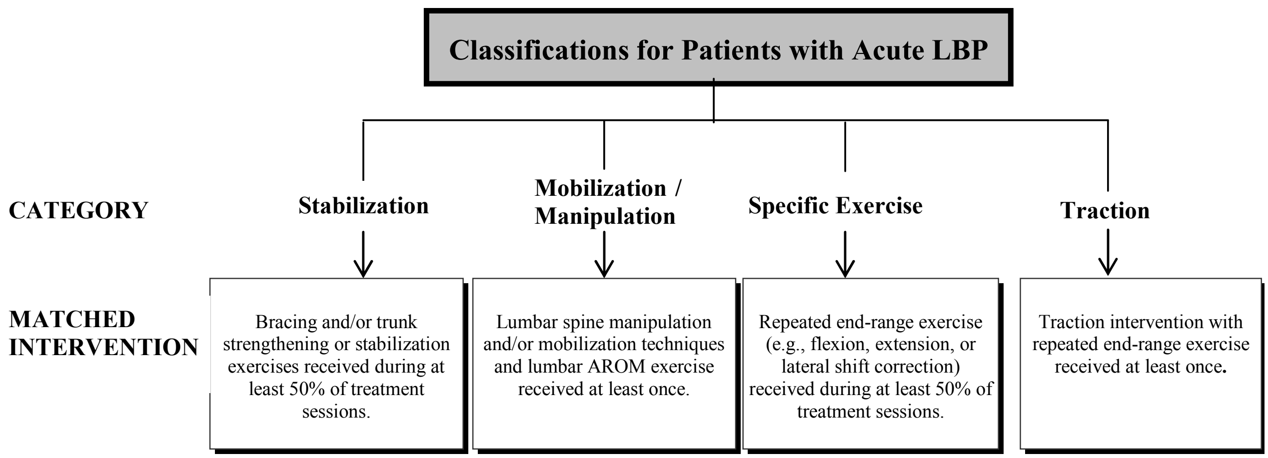
MANIPULATION		STABILIZATION		SPECIFIC EXERCISE	
Factors favoring	Factors against	Factors favoring	Factors against	Factors favoring	Factors against
▪ More recent onset of symptoms ▪ Hypomobility with spring testing ▪ LBP only (no distal symptoms) ▪ Low FABQ scores (FABQW <19)	▪ Symptoms below the knee ▪ Increasing episode frequency ▪ Peripheralization with motion testing ▪ No pain with spring testing	▪ Younger age ▪ Positive prone instability test ▪ Aberrant motions present ▪ Greater SLR ROM ▪ Hypermobility with spring testing ▪ Increasing episode frequency ▪ 3 or more prior episodes	▪ Discrepancy in SLR ROM (>10°) ▪ Low FABQ scores (FABQPA < 9)	▪ Strong preference for sitting or walking ▪ Centralization with motion testing ▪ Peripheralization in direction opposite centralization	▪ Low back pain only (no distal sx) ▪ Status Quo with all movements

Fig. 3 – Revised Classification Decision-Making Algorithm to be used in this study

4.2.9.1 Criteria for "Matched" and "Unmatched" Treatments

Once each patient was classified, the interventions received by each subject during the first three treatment sessions after evaluation were reviewed via chart review. Interventions received were categorized based on the intent of the activity. Based upon the criteria listed in figure 7, each subject was categorized as receiving either an intervention approach that was either "matched" or "unmatched" to their classification.

Figure 8- Criteria for determining if interventions were matched to a subject's classification assigned by researchers



4.2.10 Data Analysis

The interrater reliability of the overall classification decision was examined with percent agreement and an unweighted kappa coefficient with 95% CI for the pair of raters. We qualitatively compared the reliability coefficients calculated in this cohort of adolescents with our previous publications reporting reliability of the same variables in adults with LBP. Frequency distributions were then examined for each classification category within the sample of adolescents with LBP.

Each patient was classified as receiving an intervention that was either "matched" or "unmatched" based upon the previously-described criteria. Descriptive statistics for the matched and unmatched groups were calculated to examine baseline equivalency on the groups. Next, the number of visits, OSW and NPRS scores of each group were compared using either parametric (repeated measures ANOVA/ANCOVA) or nonparametric tests (Kruskal-Wallis) to compare the outcome measures.

4.2.11 *Sample Size and Power*

The sample size estimation was based upon on a comparison of classification distribution between an adolescent and adult distributions previously reported in the literature. Previous studies of adults with LBP have reported the proportion of patients classified as stabilization to be about 20%.[43, 46] Our previous work with adolescents with LBP has suggested the proportion of patients classified as stabilization to be about 50%.[14] Therefore, in order to detect a difference between a percentage of 20% vs. 50% with 90% power and an alpha level of 0.05, it was estimated that approximately 33 patients would need to be recruited.

4.3 RESULTS

Thirty-four consecutive patients who presented to physical therapy with a primary complaint of LBP and consented to participate were included in this study. Demographic characteristics of the subjects are presented in tables 10 and 11. On average, adolescent patients in this sample were approximately 15 years of age, were physically active and were of normal BMI. The average number of visits to the physical therapy clinic for the episode of care was 4 visits. At baseline, patients reported an average NPRS and OSW score of 4.8 and 24.7% respectively. Only 4 patients scored below 10% on their initial OSW indicating no significant "floor effect" for the measure in these patients. 84% (n=26) of the patients reported a non-specific diagnosis for their LBP from their referring physician (i.e. LBP, sprain, strain).

Table 10- Continuous variable demographic and exam findings at baseline

Variable$_{units}$	**Mean (SD)**	**Range**
Age$_{years\ (n=34)}$	14.9 (1.45)	12-17
Number of visits $_{(n=34)}$	4.10 (1.93)	1-9
Hours per week of activity$_{MAQA}$	9.28 (7.19)	0-24
Pain rating$_{0\text{-}10\ (n=34)}$	4.88 (2.28)	0-9
Oswestry score$_{0\text{-}100\ (n=33)}$	24.7 (11.6)	4-58
FABQPA$_{0\text{-}24\ (n=32)}$	14.6 (5.25)	4-24

Table 11- Categorical variable demographic and exam findings at baseline

Variable$_{units}$	**Percentage**
Gender (% female)	50
Race n=33	91 White/Caucasian 3 Hispanic 3 African American 3 Asian
BMI category As per NIH standards for adolescents n=33	3 underweight 85 normal 6 overweight 6 obese
Physician Diagnosis n=31	
Specific pathology (e.g. spondylolisthesis)	16
Non-specific pathology (e.g. LBP, sprain, strain)	84
Involvement in organized sports? (% yes) n=33	67
Previous history of LBP? (% yes) n=33	27
Currently taking meds for pain? (% yes)	62

All 34 patients (100%) in this sample of adolescents with LBP were able to be classified to one of the 3 independent categories (stabilization, mobilization, specific exercise) within the TBC-system. The interrater reliability of the pair of independent examiners was found to be Kappa = 0.53 ($p < .0.001$), 95% CI (0.28, 0.79). Kappa statistics were also calculated for each independent examiner and the PI, and these are summarized in table 12. A tie-breaker classification assignment had to be assigned according to the PI's classification of the patient in 9 of the cases.

Table 12- Computed Kappa statistics (95% C) for TBC classification for each examiner pair

	PI	Examiner A	Examiner B
PI	1.0	0.89 (.74, 1.0)	0.53 (0.28, 0.78)
Examiner A		1.0	0.53 (0.28, 0.79)
Examiner B			1.0

Classification of the initial intervention approach utilized by the treating physical therapist and breakdown of classification as assigned by the researchers after reviewing the initial examination summary is summarized in table 13. The most frequently utilized treatment strategy by clinicians was a stabilization approach (55.9%), followed by mobilization (32.4%) and then by specific directional exercises (11.8%). The most frequently assigned classification by the researchers was mobilization (55.9%), followed by stabilization (38.2%) and then by specific exercise (5.9%). Table 13 also shows a breakdown of initial and final NPRS and OSW scores between assigned classification groups. Table 14 also shows similar comparisons of initial and final NPRS and OSW scores by the classification of the treatment approach utilized by the treating physical therapist. Outcome scores were compared across treatment groups using repeated measures ANOVA ($p \leq 0.05$).

Table 13- Initial and final NPRS and OSW scores by assigned classification groups

Classification	Number of patients (%)	Initial Pain Score (SD)	Final Pain Score (SD)	Initial OSW N=31	Final OSW N=31
Stabilization	13 (38%)	4.2 (3.5)	3.5 (1.9)	28.3 (11.1)	16.6 (11.5)†
Mobilization	19 (56%)	5.8 (1.8)	3.5 (2.5)	22.0 (12.6)	16.3 (13.3)†
Specific Exercise **Flexion** **Extension**	 0 2 (6%)	3.5 (3.5)	4.0 (4.2)	26.0 (2.83)	23.0 (26.9)

†= p<0.05 for within-group comparison

Table 14- Initial and final NPRS and OSW scores by classification of treatment approach by the physical therapist.

Classification	Number of patients (%)	Initial Pain Score (SD)	Final Pain Score (SD)	Initial OSW N=31	Final OSW N=31
Stabilization	19 (56%)	4.5 (2.6)	3.4 (1.8)	27.3 (10.7)	17.1 (11.1)†
Mobilization	11 (32%)	5.2 (1.7)	3.3 (2.7)†	22.6 (10.6)	15.0 (14.0)†
Specific Exercise					
Flexion	2 (6%)	5.8 (2.5)	4.8 (2.9)	20.5 (19.1)	20.5 (20.5)
Extension	2 (6%)				

†= p<0.05 for within-group comparison

Patients who received an initial treatment approach which was in accordance with the researcher's TBC classification for that patient were then further categorized as receiving a "matched" treatment. 21 patients (60%) were considered to have received a "matched" intervention, and each patient in the sample was re-categorized as either "matched" or "unmatched" for further analysis. No significant differences in any baseline characteristics were seen between the matched and unmatched groups ($p \geq 0.05$).

A significant difference was seen between the two groups in number of visits utilized by adolescents patients with LBP ($p=0.04$). When comparing initial TBC-classification by the researchers to those who were "matched" and "unmatched," a significant difference was found ($p=0.02$). 10 (77%) of the 13 patients in the "unmatched" group were classified by the researchers a requiring a mobilization treatment strategy according to the TBC-system. Conversely, only 9 (47%) of the 19 patients classified as being appropriate for an initial mobilization intervention received this intervention from their treating therapist (table 15).

Table 15- Breakdown of those patients "matched" and "unmatched" to their TBC classification across categories.

Treatment by Physical Therapist "matched" or "unmatched"	Overall Study Classification by Researchers			
	Stabilization	**Mobilization**	**Specific Exercise**	**Total**
Matched	**11**	**9**	**1**	21
Unmatched	**2**	**10**	**1**	13
Total	13	19	2	34

4.4 DISCUSSION

In order to assess the clinical utility of the TBC-system is adolescents with LBP, it seems reasonable to first assess the appropriateness of the structure of the classification system by ensuring that all adolescent patients can reliably be fit in one of the three available categories. In our sample of adolescents with LBP all 34 patients were able to be classified to either a stabilization, mobilization or a specific exercise category with a moderate degree of reliability (κ=0.53). In 2000, Fritz and George[43] also reported a similar degree of reliability when classifying adult patients with LBP (κ=0.56). A recent study by Fritz et al. also demonstrated a moderate degree of reliability among expert clinicians, well versed in TBC, who classified adult patients with LBP from one-page case summaries ($0.52 \leq \kappa \geq 0.87$).[46] The same study by Fritz et al. also concluded that experience level was not a factor in making a reliable classification determination, when using the classification decision-making algorithm utilized in our study.[46] Thus it can be concluded that clinicians of varying experience levels should be able to make reliable determinations of initial treatment strategies, in their adolescent patients with LBP, by using the TBC-system and a classification decision-making algorithm.

It appears as though the present three-category classification system utilized in this study is able to capture the varying clinical presentations among adolescents with LBP. The initial version of the TBC-system included seven independent treatment categories, and has since been streamlined into the present day form.[42, 43, 46] As stated earlier, all 34 adolescent patients in this study were able to be classified by the researchers into three categories based upon their initial clinical exam findings: stabilization, mobilization and specific exercise (flexion or extension oriented exercises). Similarly, the clinicians treating the patients included in our study utilized intervention strategies which were consistent with those included in the streamlined, 3-category TBC-system. The traction category[42, 43], a fourth category reserved for those who do not fit the inclusion criteria for any other main category was not utilized by any treating therapist nor was is believed to be indicated for any of the participants. It is possible that traction intervention may not be appropriate for adolescents with LBP. However, future research aimed specifically at treatment interventions in this population will be needed to confirm or disconfirm that notion.

The proportion of adolescent patients with LBP in each category differed significantly from what has been reported in adult samples. Fritz and George (2000)[43] reported that in a sample of 120 adult patients with LBP, the proportion of those categorized to a stabilization classification was 0.18. Our results demonstrated a statistically greater proportion, 0.56 ($p \leq 0.03$, power=.9821) of adolescent patients being classified to a stabilization category based upon clinical exam findings.

The proportion of adolescents with LBP classified to a mobilization category was much higher than anticipated by comparison with adult samples. Our results suggest that as many as 56% of the patients who present to physical therapy with a primary complaint of LBP fit a mobilization classification. Fritz and George[43] found that approximately 35% of adult patients with LBP were classified as needing mobilization. This 21% difference could be somewhat problematic to clinicians who are faced with the reality of needing to provide scientific rationale for their treatment interventions. Very little research has been published on the use of spinal mobilization techniques in adolescents with LBP.[15, 142] It is possible that this mismatch between clinical presentation and the available literature to guide treatment decision-making could help explain the discrepancy seen here between those who were classified as potentially benefiting from spinal mobilization and those who actually received it.

It has already been demonstrated in the literature that adults with LBP who are appropriately "matched" to an intervention according to the TBC-system have greater short-term and long-term improvements in self-reported pain and disability.[47] In our sample of adolescents with LBP, we saw a significant decrease in the number of visits required with a physical therapist. A few reasons may exist for the lack of significant change in NPRS and OSW in this group. The first reason is that post-hoc power analysis of between-group comparisons yielded inadequate power to detect a change for those comparisons (0.1-0.3). The sample size selected for this study was based upon the ability to detect a difference in classification proportions between adults and adolescents with LBP. A more clinical rationale for the lack of significant change in NPRS and OSW may surround the relatively low average number of visits seen here (4.1, range 1-9). Previous reports in adults with LBP have demonstrated an average number of visits ranging from 5.5-7.7.[43, 47] It has also been suggested that adolescents who report having episodes of LBP tend to not seek professional attention for their symptoms from either physicians or physical therapists.[5, 77, 143] This last notion may have a role in the low number of visits utilized in this sample of adolescents with LBP. Therefore, these adolescents may not have completed the most effective length of treatment required to see significant changes in subjective ratings of pain and disability.

Several limitations are present in this study which should be considered. First, the adolescents in this study were all recruited while receiving physical therapy, which may create a selection bias. Second, we did not have a long-term follow-up beyond NPRS and OSW scores at discharge available for the subjects. Future research should include complete clinical follow-up in order to better understand the clinical progression and treatment effectiveness in this population. In this study we were precluded from making strong conclusions regarding changes in subjective pain and disability ratings. The primary aims of this study were not focused on within-group comparisons following categorization. Lastly, we utilized the OSW as the primary outcome measure for determining to disability related to LBP in a sample of adolescents. While this questionnaire has been well-validated for use in adults, its applicability and validity for use in adolescents with LBP is still largely unknown.

4.5 CONCLUSION

It appears as though the TBC-system and classification decision-making algorithm have the potential to be valuable tools to guide clinicians in the treatment of adolescents with LBP. Although the proportion of adolescents distributed among the 3 treatment categories differ significantly from what has been reported in adults, it appears clinicians can make reliable classification decisions. Although the results of this study suggest a high percentage of adolescents with LBP may require mobilization interventions, the effectiveness of these interventions in adolescents is largely unknown. Future research should be guided at examination of effective treatment interventions for this population, and continued efforts to discover the potential benefits of the TBC-system in adolescents with LBP.

APPENDIX A

BASELINE PHYSICAL EXAMINATION FORM

Study ID: ____________________________ Date:______________________
Age: ___________ Sex: ☐ Male ☐ Female
Sports Status: ☐ Full play
☐ Playing with restrictions
☐ Practice only
☐ Not currently playing

Sports subject participates in:
____
____

Diagnosis: _________________________________ Date of Onset/Injury/: _____________
Height:__________ (inches) Weight:__________ (lbs)

BMI: _________________

1. SUBJECTIVE HISTORY

Mode of Onset **Comments**

Gradual ☐ ____
Sudden (Minimal/No Perturbation) ☐ ____
Traumatic ☐ ____

Sports Participation

Sport	Frequency of Participation (times/week)	Hours per week of participation

Nature of Symptoms

a. Low Back/Buttock Symptoms: ☐ no ☐ yes

b. Symptoms Distal to Buttock: ☐ no ☐ yes (☐ right ☐ left ☐ bilateral)
(☐ posterior ☐ anterior ☐ both A/P)

c. Symptoms Distal to Knee: ☐ no ☐ yes (☐ right ☐ left ☐ bilateral)
(☐ pain ☐ numbness ☐ pain/numb)

Ordering of Symptoms

BEST: ☐ sitting ☐ standing ☐ walking ☐ indeterminate
Relieving Factors:____

WORST: ☐ sitting ☐ standing ☐ walking ☐ indeterminate
Aggravating Factors:____

Diagnostic Tests / Results: ____

Patient Expectations/Goals:____

PHYSICAL EXAMINATION
Neurological Screening (□ not applicable – proceed to standing examination)

1. Sensory Examination:

LEVEL	RIGHT			LEFT		
	Absent	Dim.	WNL	Absent	Dim.	WNL
L1 (inguinal area)						
L2 (anterior mid-thigh)						
L3 (distal anterior thigh)						
L4 (medial lower leg/foot)						
L5 (lateral leg/ foot)						
S1 (lateral side of foot)						

2. Motor Examination:

MUSCLE TEST	RIGHT			LEFT		
	WNL	Dim.	Pain	WNL	Dim.	Pain
Hip Flexion (L2-L3)						
Knee Extension (L3-L4)						
Dorsiflexion (L4)						
Hallux Extension (L5)						
Ankle Eversion (S1-S2)						

3. Deep Tendon Reflexes:

	WNL	Dim.	Absent
Right-Quad			
Left-Quad			
Right-Ankle			
Left-Ankle			

4. Tension Signs:

	Positive	Negative
Right - SLR		
Left - SLR		
Right - FNS		
Left - FNS		

STANDING EXAMINATION

Observation: ☐ Normal ☐ Acute Kyphosis

☐ Lateral Shift (☐ Left, ☐ Right)

☐ Other______________________

Range of Motion

Movement	AROM	Effect on Pain Intensity: No Effect	Effect on Pain Intensity: Increased Pain	Effect on Pain Intensity: Decreased Pain	Effect on Symptom Location: No Effect	Effect on Symptom Location: Centralization	Effect on Symptom Location: Peripheralization
Flexion	________^{0}	☐	☐	☐	☐	☐	☐
Extension	________^{0}	☐	☐	☐	☐	☐	☐
Repeated Extension		☐	☐	☐	☐	☐	☐
R Side-Bending	________^{0}	☐	☐	☐	☐	☐	☐
L Side-Bending	________^{0}	☐	☐	☐	☐	☐	☐
R Pelvic Translation		☐	☐	☐	☐	☐	☐
L Pelvic Translation		☐	☐	☐	☐	☐	☐

Aberrant Movements:

Painful Arc: ☐ yes ☐ no

"Instability Catch": ☐ yes ☐ no

Difficult return from flexion ("thigh climbing, etc): ☐ yes ☐ no

Beighton Scale:

	RIGHT SIDE		LEFT SIDE	
	Present	Absent	Present	Absent
Knee hyperextension $>10^0$	☐	☐	☐	☐
Elbow hyperextension$>10^0$	☐	☐	☐	☐
5^{th} finger hyperextension $>90^0$	☐	☐	☐	☐
Abduction of thumb to forearm	☐	☐	☐	☐
Can place palms flat on floor w/ no knee flexion in forward bending	☐ Present		☐ Absent	

SUPINE EXAMINATION

Hip Screening:

	RIGHT HIP					LEFT HIP				
	RANGE OF MOTION			PAIN		RANGE OF MOTION			PAIN	
	Normal	**Hypo**	**Hyper**	**Yes**	**No**	**Normal**	**Hypo**	**Hyper**	**Yes**	**No**
Flexion										
Abduction										
FABER test										

Straight Leg Raise ROM: __________° Right __________° Left

Bilateral SLR: ☐ Negative (can perform) ☐ Positive (cannot perform)

Active Sit-Up: ☐ Negative (can perform) ☐ Positive (cannot perform)

PRONE EXAMINATION

Hip Rotation Range of Motion:

	Right	**Left**
Hip Internal Rotation	_____°	_____°
Hip External Rotation	_____°	_____°
Hip Extension	_____°	_____°

Spring Test:

Level	**Normal mobility**	**Hypo-mobile**	**Hyper-mobile**	**No Pain**	**Pain-Local**	**Pain-Distant**
L1						
L2						
L3						
L4						
L5						
Sacrum						

Spinal Tenderness: ☐ Negative (no tenderness) ☐ Positive (tenderness present)

Sustained Extension Prone: ☐ N/A ☐ Centralizes ☐ Peripheralizes ☐ ISQ

Segmental Instability Test: ☐ N/A (no pain w/ spring) ☐ Negative ☐ Positive

APPENDIX B

MODIFIABLE ACTIVITY QUESTIONNAIRE FOR ADOLESCENTS (MAQA)

DATE________ NAME____________________ ID __ __ __ __

SCHOOL _______________ CLASS

1. How many times in the past 14 days have you done at least 20 minutes of exercise hard enough to make you breathe heavily and make your heart beat fast? (Hard exercise includes, for example, playing basketball, jogging, or fast bicycling; include time in physical education class)

   ( ) None
   ( ) 1 to 2 days
   ( ) 3 to 5 days
   ( ) 6 to 8 days
   ( ) 9 or more days

2. How many times in the past 14 days have you done at least 20 minutes of light exercise that was not hard enough to make you breathe heavily and make your heart beat fast? (Light exercise includes playing basketball, walking or slow bicycling; include time in physical education class)

   ( ) None
   ( ) 1 to 2 days
   ( ) 3 to 5 days
   ( ) 6 to 8 days
   ( ) 9 or more days

3. During a normal week how many hours a day do you watch television and videos, or play computer or video games before or after school?

   ( ) None
   ( ) 1 hour or less
   ( ) 2 to 3 hours
   ( ) 4 to 5 hours
   ( ) 6 or more hours

4. During the past 12 months, how many team or individual sports or activities did you participate in on a competitive level, such as varsity or junior varsity sports, intramurals, or out-of-school programs.

   ( ) None
   ( ) 1 activity
   ( ) 2 activities
   ( ) 3 activities
   ( ) 4 or more activities

   What activities did you compete in?

   ____
   ____
   ____
   ____
   ____
   ____

Aerobics
Band/Drill Team
Baseball
Basketball
Bicycling
Bowling
Cheerleading
Dance Class
Football
Garden/Yard Work

Gymnastics
Hiking
Ice Skating
Roller Skating
Running for Exercise
Skateboarding
Snow Skiing
Soccer
Softball
Street Hockey

Swimming (Laps)
Tennis
Volleyball
Water Skiing
Weight Training (Competitive)
Wrestling
Others:
____
____
____

List each activity that you checked above in the "Activity" box below.
Check the months you did each activity and then estimate the amount of time spent in each activity.

Activity	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec	Months per Year	Days Per Week	Minutes Per Day

If your ability to play sports and activities before you hurt your back is considered 100%, how would you rate your current ability to participate in sports or activities?

∋	∋	∋	∋	∋	∋	∋	∋	∋	∋	∋
0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

(Unable to participate) (Fully able to participate)

APPENDIX C

FEAR AVOIDANCE BELIEFS- PHYSICAL ACTIVTY SUBSCALE (FABQPA)

For each statement below please mark the number from 0 to 6 to indicate how much physical activities such as bending, lifting, or sports affect or would affect your back pain.

	Completely Disagree			Unsure			Completely Agree
1. Physical activity makes my pain worse	0	1	2	3	4	5	6
2. Physical activity might harm my back	0	1	2	3	4	5	6
3. I should not do physical activities which (might) make my pain worse	0	1	2	3	4	5	6
4. I cannot do physical activities which (might) make my pain worse	0	1	2	3	4	5	6

APPENDIX D

NUMERICAL PAIN RATING SCALE (NPRS)

1. Please rate your level of pain in your back based on the following three definitions.

a. Please rate your **current level of pain** on the following scale (check one):

϶	϶	϶	϶	϶	϶	϶	϶	϶	϶	϶
0	1	2	3	4	5	6	7	8	9	10
(no pain)									(worst imaginable pain)	

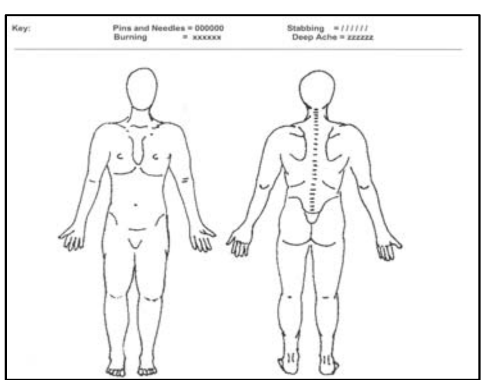
b. Please rate your **worst level of pain in the last 24 hours** on the following scale (check one):

϶	϶	϶	϶	϶	϶	϶	϶	϶	϶	϶
0	1	2	3	4	5	6	7	8	9	10
(no pain)									(worst imaginable pain)	

c. Please rate your **best level of pain in the last 24 hours** on the following scale (check one):

϶	϶	϶	϶	϶	϶	϶	϶	϶	϶	϶
0	1	2	3	4	5	6	7	8	9	10
(no pain)									(worst imaginable pain)	

Please use the diagram below to indicate the symptoms you have experienced over the past 24 hours. **Be VERY precise when drawing the location of your buttock and/or leg pain.** Use the key to indicate the type of symptoms.



APPENDIX E

MODIFIED OSWESTRY LOW BACK PAIN DISABILITY QUESTIONNAIRE

This questionnaire has been designed to give your therapist information as to how your back pain has affected your ability to manage in everyday life. Please answer every question by placing a mark in the **one** box that best describes your condition today. We realize you may feel that 2 of the statements may describe your condition, but **please mark only the box that most closely describes your current condition.**

Pain Intensity

- ☐ I can tolerate the pain I have without having to use pain medication.
- ☐ The pain is bad, but I can manage without having to take pain medication.
- ☐ Pain medication provides me with complete relief from pain.
- ☐ Pain medication provides me with moderate relief from pain.
- ☐ Pain medication provides me with little relief from pain.
- ☐ Pain medication has no effect on my pain.

Personal Care (e.g., Washing, Dressing)

- ☐ I can take care of myself normally without causing increased pain.
- ☐ I can take care of myself normally, but it increases my pain.
- ☐ It is painful to take care of myself, and I am slow and careful.
- ☐ I need help, but I am able to manage most of my personal care.
- ☐ I need help every day in most aspects of my care.
- ☐ I do not get dressed, I wash with difficulty, and I stay in bed.

Lifting

- ☐ I can lift heavy weights without increased pain.
- ☐ I can lift heavy weights, but it causes increased pain.
- ☐ Pain prevents me from lifting heavy weights off the floor, but I can manage if the weights are conveniently positioned (e.g., on a table).
- ☐ Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conveniently positioned.
- ☐ I can lift only very light weights.
- ☐ I cannot lift or carry anything at all.

Walking

- ☐ Pain does not prevent me from walking any distance.
- ☐ Pain prevents me from walking more than 1 mile. (1 mile).
- ☐ Pain prevents me from walking more than 1/2 mile.
- ☐ Pain prevents me from walking more than 1/4 mile.
- ☐ I can walk only with crutches or a cane.
- ☐ I am in bed most of the time and have to crawl to the toilet.

Sitting

- ☐ I can sit in any chair as long as I like.
- ☐ I can only sit in my favorite chair as long as I like.
- ☐ Pain prevents me from sitting for more than 1 hour.
- ☐ Pain prevents me from sitting for more than 1/2 hour.
- ☐ Pain prevents me from sitting for more than 10 minutes.
- ☐ Pain prevents me from sitting at all.

Standing

- ☐ I can stand as long as I want without increased pain.
- ☐ I can stand as long as I want, but it increases my pain.
- ☐ Pain prevents me from standing for more than 1 hour.
- ☐ Pain prevents me from standing for more than 1/2 hour.
- ☐ Pain prevents me from standing for more than 10 minutes.
- ☐ Pain prevents me from standing at all.

Sleeping

- ☐ Pain does not prevent me from sleeping well.
- ☐ I can sleep well only by using pain medication.
- ☐ Even when I take medication, I sleep less than 6 hours.
- ☐ Even when I take medication, I sleep less than 4 hours.
- ☐ Even when I take medication, I sleep less than 2 hours.
- ☐ Pain prevents me from sleeping at all.

Social Life

- ☐ My social life is normal and does not increase my pain.
- ☐ My social life is normal, but it increases my level of pain.
- ☐ Pain prevents me from participating in more energetic activities (e.g., sports, dancing).
- ☐ Pain prevents me form going out very often.
- ☐ Pain has restricted my social life to my home.
- ☐ I have hardly any social life because of my pain.

Traveling

- ☐ I can travel anywhere without increased pain.
- ☐ I can travel anywhere, but it increases my pain.
- ☐ My pain restricts my travel over 2 hours.
- ☐ My pain restricts my travel over 1 hour.
- ☐ My pain restricts my travel to short necessary journeys under 1/2 hour.
- ☐ My pain prevents all travel except for visits to the physician / therapist or hospital.

Employment / School

- ☐ My normal school/ job activities do not cause pain.
- ☐ My normal school/ job activities increase my pain, but I can still perform all that is required of me.
- ☐ I can perform most of my school / job duties, but pain prevents me from performing more physically stressful activities (e.g., lifting, running, etc.).
- ☐ Pain prevents me from doing anything but light activities.
- ☐ Pain prevents me from doing even light activities.
- ☐ Pain prevents me from performing any job or school activities.

For Investigator's Use Only

Score:___________ Number missed:___________

Items:____

APPENDIX F

BASELINE DEMOGRAPHIC QUESTIONNAIRE]

(to be completed with a parent or guardian)

Today's Date: _________ Height:__________ Weight:___________
mm / dd / yy

Race: White ☐ Hispanic ☐ African-American ☐ Asian ☐ Native American ☐ Other ☐

1. **What is your current year in school? (please check one).**
   - ☐ Middle School (5^{th} – 8^{th} grade)
   - ☐ High School (9^{th} – 12^{th} grade)
   - ☐ College
   - ☐ Out of school

2. **Have you experienced any low back pain within the past year?**
   - ☐ No
   - ☐ Yes (If Yes, briefly describe) ____)

3. **If the Answer to #3 was YES, how long have you had your MOST RECENT back pain?**
   - ☐ Less than 1 month ☐ 6 – 12 months
   - ☐ 1 – 3 months ☐ 1 – 2 years
   - ☐ 4 – 6 months ☐ 3 – 5 years
   - ☐ ☐ More than 5 years

4. **How did you injure your back again?** (accident, fall, trauma, gradual, etc) Please describe in the space provided below.

____

5. **How many times have you experienced low back pain within the past year?**
   - ☐ None
   - ☐ 1 time
   - ☐ 2-4 times
   - ☐ 5 or more

6. **Are you currently participating regularly in any sport?**
   - ☐ No
   - ☐ Yes (If Yes, which one(s) ____)

7. **Are you currently taking any medications for your back pain (over the counter and/or prescribed)?**
   - ☐ No
   - ☐ Yes (If Yes, please list the medications that you are currently taking in the table below.)

me of Medicine	Dose (Milligrams)	How many pills?	How many times per day?

8. **Before now, have you tried any other treatment for your back pain within the past year (other than physical therapy)?**
   - ☐ No
   - ☐ Yes (If Yes, please describe the treatment in the space provided below.)

____

1. **Did the treatment help?**
   - ☐ No
   - ☐ Yes
   - ☐ N/A (I have not received any treatment during the last year.)

2. **If you had to spend the rest of your life with the back pain you have right now, how would you feel about it?**
   - ☐ Very dissatisfied
   - ☐ Somewhat dissatisfied
   - ☐ Neutral- OK
   - ☐ Somewhat satisfied
   - ☐ Very satisfied

3. **Please rate your activity level in each one of the following circumstances. Check only one answer in each row:**

	Jumping, pivoting, hard cutting, football, soccer	Heavy lifting, skiing, tennis	Light manual work, jogging, running	Regular activities, nothing beyond daily routine
1. Before starting to have back pain, I performed activities such as:	∍	∍	∍	∍
2. Before seeing my trainer, I performed activities such as:	∍	∍	∍	∍
3. At the present time I am able to perform activities such as:	∍	∍	∍	∍

BIBLIOGRAPHY

1. Leboeuf-Yde C, Kyvik KO. At what age does low back pain become a common problem? A study of 29,424 individuals aged 12-41 years. *Spine.* 1998;23(2):228.
2. Balague F, Nordin M. Back pain in children and teenagers. *Baillieres Clin.Rheumatol.* 1992;6(3):575.
3. Wedderkopp N, Leboeuf-Yde C, Andersen LB, Froberg K, Hansen HS. Back pain reporting patterns in a Danish population-based sample of children and adolescents. *Spine.* 2001;26(17):1879.
4. Feldman DS, Hedden DM, Wright JG. The use of bone scan to investigate back pain in children and adolescents. *J Pediatr Orthop.* 2000;20(6):790.
5. Burton AK, Clarke RD, McClune TD, Tillotson KM. The natural history of low back pain in adolescents. *Spine.* 1996;21(20):2323.
6. Jones MA, Stratton G, Reilly T, Unnithan VB. A school-based survey of recurrent non-specific low-back pain prevalence and consequences in children. *Health Ed Res.* Jun 2004;19(3):284-289.
7. Balague F, Troussier B, Salminen JJ. Non-specific low back pain in children and adolescents: risk factors. *Eur Spine J.* 1999;8:429.
8. Balague F, Nordin M, Skovron ML, Dutoit G, Yee A, Waldburger M. Non-specific low-back pain among schoolchildren: a field survey with analysis of some associated factors. *J Spinal Disord.* 1994;7(5):374.
9. Hayden JA, Mior SA, Verhoef MJ. Evaluation of chriopractic management of pediatric patients with low back pain: a prospective cohort study. *J Manipulative Physiol Ther.* 2003;26:1-8.
10. Hollingworth P. Back pain in children. *Br.J Rheumatol.* 1996;35(10):1022.
11. Roncevic N, Vilotijevic G, Savic K. Backache in children. *Med Pregl.* 1994;47(7-8):254.
12. Kujala UM, Taimela S, Oksanen A, Salminen JJ. Lumbar mobility and low back pain during adolescence. A longitudinal three-year follow-up study in athletes and controls. *Am.J Sports Med.* 1997;25(3):363.
13. Combs JA, Caskey PM. Back pain in children and adolescents: a retrospective review of 648 patients. *South Med J.* 1997.
14. Clifford SN, Fritz JM. Children and adolescents with low back pain: a descriptive study of physical examination and outcome measurement. *J Orthop Sports Phys Ther.* Sep 2003;33(9):513-522.

15. Kosseim M, Rein R, McShane C. Implementing evidence-based physiotherapy practice for treating children with low back pain: are we there yet? *Pediatric Physical Therapy.* 2008;20(2):179-184.
16. Selbst SM, Lavelle JM, Soyupak SK, Markowitz RI. Back pain in children who present to the emergency department. *Clin Pediatr.* Jul 1999;38(7):401-406.
17. Viry P, Creveuil C, Marcelli C. Nonspecific back pain in children. A search for associated factors in 14-year-old schoolchildren. *Rev.Rhum.Engl.Ed.* 1999;66(7-9):381.
18. Olsen TL, Anderson RL, Dearwater SR, et al. The epidemiology of low back pain in an adolescent population. *Am.J Public Health.* 1992;82(4):606.
19. Skoffer B, Foldspang A. Physical activity and low-back pain in schoolchildren. *Eur Spine J.* Mar 2008;17(3):373-379.
20. Newcomer K, Sinaki M. Low back pain and its relationship to back strength and physical activity in children. *Acta Paediatr.* 1996;85(12):1433.
21. Kujala UM, Taimela S, Viljanen T. Leisure physical activity and various pain symptoms among adolescents. *Br.J Sports Med.* 1999;33(5):325.
22. Auvinen J, Tammelin T, Taimela S, Zitting P, Karppinen J. Associations of physical activity and inactivity with low back pain in adolescents. *Scand J Med Sci Sports.* Apr 2008;18(2):188-194.
23. Korovessis P, Koureas G, Papzisis Z. Correlation between backpack weight and way of carrying, sagittal and frontal spinal curvatures, athletic activity, and dorsal and low back pain in schoolchildren and adolescents *J Spin Dis.* 2004;17:33-40.
24. Powell JW, Barber-Foss KD. Injury patterns in selected high school sports: a review of the 1995-1997 seasons. *J Athl Train.* Jul-Sep 1999;34(3):277-284.
25. Sallis JF, Patrick K. Physical activity guidelines for adolescents: a consensus statement. *Pediatric Exercise Science.* 1994;6:302-314.
26. Jones GT, Watson KD, Silman AJ, Symmons DP, Macfarlane GJ. Predictors of low back pain in British schoolchildren: a population-based prospective cohort study. *Pediatrics.* Apr 2003;111(4 Pt 1):822-828.
27. Watson KD, Papageorgiou AC, Jones GT, et al. Low back pain in schoolchildren: occurrence and characteristics. *Pain.* May 2002;97(1-2):87-92.
28. Balague F, Skovron ML, Nordin M, Dutoit G, Pol LR, Waldburger M. Low back pain in schoolchildren. A study of familial and psychological factors. *Spine.* 1995;20(11):1265.
29. Iwamoto J, Abe H, Tsukimura Y, Wakano K. Relationship between radiographic abnormalities of lumbar spine and incidence of low back pain in high school and college football players: a prospective study. *Am J Sports Med.* Apr-May 2004;32(3):781-786.
30. Kolt GS, Kirkby RJ. Epidemiology of injury in elite and subelite female gymnasts: a comparison of retrospective and prospective findings. *Br J Sports Med.* Oct 1999;33(5):312-318.
31. Rubin BD. The basics of competitive diving and its injuries. *Clin Sports Med.* Apr 1999;18(2):293-303.
32. Hutchinson MR. Low back pain in elite rhythmic gymnasts. *Med Sci.Sports Exerc.* 1999;31(11):1686.
33. Lundin O, Hellstrom M, Nilsson I, Sward L. Back pain and radiological changes in the thoraco-lumbar spine of athletes. *Scand J Med Sci Sports.* 2001;11:103-109.
34. Fairbank JC, Couper J, Davies JB, O'Brien JP. The Oswestry low back pain disability questionnaire. *Physiotherapy.* Aug 1980;66(8):271-273.

35. Childs JD, Piva SR, Fritz JM. Responsiveness of the numeric pain rating scale in patients with low back pain. *Spine*. Jun 1 2005;30(11):1331-1334.

36. LaMontagne LL, Johnson BD, Hepworth JT. Children's ratings of postoperative pain compared to ratings by nurses and physicians. *Issues Compr Pediatr Nurs*. 1991;14:241-247.

37. O'Hara M, McGrath PJ, D'Astous J, al e. Oral morphine versus injected meperidine (demerol) for pain relief in children after orthopedic surgery. *J Pediatr Orthop*. 1987;7:78-82.

38. Kent P, Keating JL. Do primary-care clinicians think that nonspecific low back pain is one condition? *Spine*. 2004;29(9):1022-1031.

39. Abenhaim L, Rossignol M, Gobeille D, Bonvalot Y, Fines P, Scott S. The prognostic consequences in the making of the initial medical diagnosis of work-related back injuries. *Spine*. 1995/// 1995;20(7):791-795.

40. Hart LG, Deyo RA, Cherkin DC. Physician office visits for low back pain: frequency, clinical evaluation, and treatment patterns from a national survey. *Spine*. 1995/// 1995;20:11-19.

41. McKenzie RA. *The Lumbar Spine: Mechanical Diagnosis and Therapy*. Waikanae, New Zealand: Spinal Publications Limited; 1989.

42. Delitto A, Erhard RE, Bowling RW. A treatment-based classification approach to low back syndrome: identifying and staging patients for conservative treatment.[see comment]. *Phys Ther*. Jun 1995;75(6):470-485; discussion 485-479.

43. Fritz JM, George S. The use of a classification approach to identify subgroups of patients with acute low back pain. Interrater reliability and short-term treatment outcomes. *Spine*. Jan 2000;25(1):106-114.

44. Fritz JM. Use of a classification approach to the treatment of 3 patients with low back syndrome. *Phys Ther*. Jul 1998;78(7):766-777.

45. Fritz JM. Low back rehabilitation. In: Andrews JR, Wilk.K.E., Harrelson GL, eds. *Rehabilitation of the Injured Athlete*. 3rd ed. Philadelphia: W.B. Saunders Co.; 2004.

46. Fritz JM, Brennan GP, Clifford SN, Hunter SJ, Thackeray A. An examination of the reliability of a classification algorithm for subgrouping patients with low back pain. *Spine*. Jan 1 2006;31(1):77-82.

47. Brennan GP, Fritz JM, Hunter SJ, Thackeray A, Delitto A, Erhard RE. Identifying subgroups of patients with acute/subacute "nonspecific" low back pain: results of a randomized clinical trial. *Spine*. Mar 15 2006;31(6):623-631.

48. Glanville J. Where's the evidence? How to find clinical-effectiveness information. *Clin Perform Qual Health Care*. Jan-Mar 1998;6(1):44-48.

49. Sharon E. Strauss WSR, Paul Glasziou, R. Brian Haynes. *Evidence-based Medicine: How to Practice and Teach EBM*. 3rd. ed. New York, NY: Churchill Livingstone; 2005.

50. Balague F, Dutoit G, Waldburger M. Low back pain in schoolchildren. An epidemiological study. *Scand J Rehabil Med*. 1988;20(4):175-179.

51. Hart LG, Deyo RA, Cherkin DC. Physician office visits for low back pain: frequency, clinical evaluation, and treatment patterns from a U.S. national sruvey. *Spine*. 1995;20:11.

52. Kujala UM, Kinnunen J, Helenius P, Orava S, Taavitsainen M, Karaharju E. Prolonged low-back pain in young athletes: a prospective case series study of findings and prognosis. *Eur Spine J*. 1999;8:480.

53. Salminen JJ, Erkintalo MO, Pentti JB, Oksanen A, Kormano MJ. Recurrent low back pain and early disc degeneration in the young. *Spine.* 1999;24(13).

54. Troussier B, Davoine B, de Gaudemaris R, Foconni J, Phelip X. Back pain in schoolchildren; a study among 1178 poeple. *Scand J Rehabil Med.* 1994;26:143.

55. Taimela S, Kujala UM, Salminen JJ, Viljanen T. The prevalence of low back pain among children and adolescents. A nationwide, cohort-based questionnaire survey in Finland. *Spine.* 1997;22(10):1132.

56. Cassella MC, Hall JE. Current treatment approaches in the nonoperative and operative management of adolescent idiopathic scoliosis. *Phys.Ther.* 1991;71(12):897.

57. Logroscino G, Mazza O, Aulisa G, Pitta L, Pola E, Aulisa L. Spondylolysis and spondylolisthesis in the pediatric and adolescent population. *Childs Nerv.Syst.* 2001;17(11):644.

58. O'Sullivan PB, Phyty GD, Twomey LT, Allison GT. Evaluation of specific stabilizing exercise in the treatment of chronic low back pain with radiologic diagnosis of spondylolysis or spondylolisthesis. *Spine.* 1997;22(24):2959.

59. Abenhaim L, Rossignol M, Gobeille D, Bonvalot Y, Fines P, Scott S. The prognostic consequences in the making of the initial medical diagnosis of work-related back injuries. *Spine.* 1995;20(7):791.

60. Van Dillen LR, Sahrmann SA, Norton BJ, et al. Reliability of physical examination items used for classification of patients with low back pain. *Phys Ther.* Sep 1998;78(9):979-988.

61. Wilson L, Hall H, McIntosh G, Melles T. Intertester reliability of a low back pain classification system. *Spine.* Feb 1 1999;24(3):248-254.

62. Deyo RA, Diehl AK. Psychosocial predictors of disability in patients with low back pain. *J Rheumatol.* 1988;15:1557.

63. Roland M, Morris R. A study of the natural history of back pain. Part I: development of a reliable and sensitive measure of disability in low-back pain. *Spine.* Mar 1983;8(2):141-144.

64. Beurskens AJ, de Vet HC, Koke AJ, van der Heijden GJ, Knipschild PG. Measuring the functional status of patients with low back pain. Assessment of the quality of four disease-specific questionnaire. *Spine.* 1995;20(9):1017.

65. Casella MC HJ. Current treatment approaches in the nonoperative and operative management of adolescent idiopathic scoliosis. *Phys Ther.* 1991;71:897-909.

66. Robinson CM, McMaster MJ. Juvenile idiopathic scoliosis: curve patterns and prognosis in one hundred and nine patients. *J Bone Joint Surg.* 1996;78-A(8):1140.

67. Fritz JM, Irrgang JJ. A Comparison of a Modified Oswestry Disability Questionnaire and the Quebec Back Pain Disability Scale. *Phys Ther.* 2001;81(2):776.

68. Jensen MP, Turner JA, Romano JM, Fisher LD. Comparative reliability and validity of chronic pain intensity measures. *Pain.* Nov 1999;83(2):157-162.

69. Strender LE, Sjoblom A, Sundell K, Ludwig R, Taube A. Interexaminer reliability in physical examination of patients with low back pain. *Spine.* 1997;22(7):814.

70. Viikari-Juntura E, Takala EP, Riihimaki H, Malmivaara A, Martikainen R, J„ppinen P. Standardized physical examination protocol for low back disorders: feasibility of use and validity of symptoms and signs. *J Clin Epidemiol.* 1998;51(3):245.

71. Fritz JM, Delitto A, Vignovic M, Busse RG. Inter-rater reliability of judgments of the centralization phenomenon and status change during movement testing in patients with low back pain. *Arch Phys Med Rehabil.* 2000;81(1):57.

72. Cibulka MT, Delitto A, Koldehoff R. Changes in inominate tilt after manipulation of the sacroiliac joint in patients with low back pain: An experimental study. *Phys.Ther.* 1988;68:1359.

73. Cibulka MT, Koldehoff R. Clinical usefulness of a cluster of sacroiliac joint tests in patients with and without low back pain. *J Orthop Sports Phys Ther.* 1999;29(2):83.

74. George SZ, Fritz JM, Erhard RE. The comparison of fear avoidance beliefs in patients with lumbar and cervical spine pain. *Spine.* 2001;26:2139.

75. Duggleby T, Kumar S. Epidemiology of juvenile low back pain: a review. *Disabil.Rehabil.* 1997;19(12):505.

76. Kristjandottir G. Prevalence of self-reported back pain in school children: a study of sociodemographic differences. *Eur J Pediatr.* 1996;155(11):984.

77. Gunzburg R, Balagu, F, Nordin M, et al. Low back pain in a population of school children. *Eur Spine J.* 1999;8(6):439.

78. Carey TS, Evans AT, Hadler NM, et al. Acute severe low back pain. A population-based study of prevalence and care-seeking. *Spine.* Feb 1 1996;21(3):339-344.

79. Cote P, Cassidy JD, Carroll L. The treatment of neck and low back pain: who seeks care? who goes where? *Med Care.* Sep 2001;39(9):956-967.

80. Hurwitz EL, Morgenstern H. Cross-sectional associations of asthma, hay fever, and other allergies with major depression and low-back pain among adults aged 20-39 years in the United States. *Am J Epidemiol.* Nov 15 1999;150(10):1107-1116.

81. Salminen JJ, Pentti J, Terho P. Low back pain and disability in 14-year-old schoolchildren. *Acta Paediatr.* 1992;81(12):1035.

82. Cherkin DC, Deyo RA, Battie M, Street J, Barlow W. A comparison of physical therapy, chiropractic manipulation, and provision of an educational booklet for the treatment of patients with low back pain.[see comment]. *N Engl J Med.* Oct 8 1998;339(15):1021-1029.

83. Fritz JM, George SZ, Delitto A. The role of fear avoidance beliefs in acute low back pain: relationships with current and future disability and work status. *Pain.* 2001;94(1):7.

84. Stratford PW, Binkley J. Assessing change over time in patients with low back pain. *Phys.Ther.* 1994;74(6):528.

85. Coste J, Delecoeuillerie G, Cohen de Lara A, Le Parc JM, Paolaggi JB. Clinical course and prognostic factors in acute low back pain: an inception cohort study in primary care practice. *BMJ.* 1994;308:577.

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

87. Kujala UM, Oksanen A, Taimela S, Salminen JJ. Training does not increase maximal lumbar extension in healthy adolescents. *Clin.Biomech.(Bristol., Avon.).* 1997;12(3):181.

88. Kujala UM, Taimela S, Erkintalo M, Salminen JJ, Kaprio J. Low-back pain in adolescent athletes. *Med Sci.Sports Exerc.* 1996;28(2):165.

89. Malmivaara A, Hakkinen U, Aro T, et al. The treatment of acute low back pain--bed rest, exercises, or ordinary activity? *New Eng J Med.* 1995;332(6):351.

90. Micheli LJ, Wood R. Back pain in young athletes: significant differences from adults in causes and patterns. *Archives of Pediatrics and Adolescent Medicine.* 1995;149(1):15.

91. Donelson R, Grant W, Kamp C, Medcalf R. Pain response to sagittal end-range spinal motion. *Spine.* 1991;16(suppl):s206.

92. Waddell G. Clinical assessment of lumbar impairment. *Clin Orthop.* 1987;221:110.

93. McGregor AH, Cattermole HR, Hughes SPF. Global spinal motion in subjects with lumbar spondylolysis and spondylolisthesis. *Spine.* 2001;26(3):282.

94. Vocetic N, Svensson O. Physical signs in lumbar disc hernia. *Clin Orthop Rel Res.* 1996;333:192.

95. Donelson R, Aprill C, Medcalf R, Grant W. A prospective study of centralization of lumbar and referred pain. A predictor of symptomatic discs and anular competence. *Spine.* 1997;22(10):1115.

96. Karas R, McIntosh G, Hall H, Wilson L, Melles T. The relationship between nonorganic signs and centralization of symptoms in the prediction of return to work for patients with low back pain.[see comment]. *Phys Ther.* Apr 1997;77(4):354-360; discussion 361-359.

97. Williams MW, Hawley JA, McKenzie RA, Van Wijmen PM. A comparison of the effects of two sitting postures on back and referred pain. *Spine.* 1991;16:1185.

98. Nwuga G, Nwuga V. Relative therapeutic efficacy of the Williams and McKenzie protocols in back pain management. *Physiotherapy Practice.* 1985;1:99.

99. Pontes DL, Jensen GL, Kent BE. A preliminary report on the use of the McKenzie protocol versus Williams protocol in the treatment of low back pain. *J.Orthop.Sports Phys.Ther.* 1984;6:130.

100. Hides JA, Jull GA, Richardson CA. Long term effects of specific stabilizing exercises for first-episode low back pain. *Spine.* 2001;26(11):E243.

101. Sinaki M, Lutness MP, Ilstrup DM, Chu C, Gramse R. Lumbar spondylolisthesis: Retrospective comparison and three year follow up of two conservative treatment programs. *Archives of Phys.Med.Rehab.* 1989;70(8):594.

102. Bombardier C. Outcome assessment in the evaluation of treatment of spinal disorders: summary and general recommendations. *Spine.* 2000;25(24):3100.

103. Taylor SJ, Taylor AE, Foy MA, Fogg AJ. Responsiveness of common outcome measures for patients with low back pain. *Spine.* Sep 1 1999;24(17):1805-1812.

104. Jacob T, Baras M, Zeev A, Epstein L. Low back pain: reliability of a set of pain measurement tools. *Arch Phys Med Rehabil.* 2001;82:735.

105. Kopec JA, Esdaile JM, Abrahamowicz M, et al. The Quebec Back Pain Disability Scale. Measurement properties. *Spine.* 1995;20(3):341.

106. Leclaire R, Blier F, Fortin L, Proulx R. A cross-sectional study comparing the Oswestry and Roland-Morris functional disability scales in two populations of patients with low back pain of different levels of severity. *Spine.* 1997;22(1):68.

107. Suarez-Almazor ME, Kendall C, Johnson JA, Skeith K, Vincent D. Use of health status measures in patients with low back pain in clinical settings. Comparison of specific, generic and preference-based instruments. *Rheumatol.* 2000;39:783.

108. Von Korff M, Moore JE, Lorig K, et al. A randomized trial of a lay person-led self-management group intervention for back pain in primary care. *Spine.* 1998;23(23):2608.

109. Fairbank JC, Pynsent PB. The Oswestry Disability Index. *Spine.* 2000;25:2940-2953.

110. Fisher K, Johnston, M. Validation of the oswestry low back pain disability questionnaire, its sensitivity as a measure of change following treatment and its relationship with other aspects of the chronic pain experience. *Physiother.* 1997;13:67-80.

111. Fritz JM, Piva SR. Physical impairment index: reliability, validity, and responsiveness in patients with acute low back pain. *Spine.* 2003/// 2003;28:1189-1194.

112. Clifford SN, Fritz JM. Children and adolescents with low back pain: a descriptive study of physical examination and outcome measurement. *J Orthop Sports Phys Ther.* 2003;33:513-522.

113. Gronblad M, Hupli M, Wennerstrand P, et al. Intercorrelation and test-retest reliability of the Pain Disability Index (PDI) and the Oswestry Disability Questionnaire (ODQ) and their correlation with pain intensity in low back pain patients. *Clin J Pain.* Sep 1993;9(3):189-195.

114. Guyatt GH, Deyo RA, Charlson M, Levine MN, Mitchell A. Responsiveness and validity in health status measurement: a clarification. *J Clin Epidemiol.* 1989;42(5):403-408.

115. Norman GR, Stratford P, Regehr G. Methodological problems in the retrospective computation of responsiveness to change: the lesson of Cronbach. *J Clin Epidemiol.* Aug 1997;50(8):869-879.

116. Portney LG WM. *Foundations of Clinical Research: Applications to Practice.* Vol 1. 3rd edition ed. Upper Saddle River, NJ: Pearson Education, Inc; 2009.

117. Cohen J. *Statistical Power Analysis for the Behavioral Sciences.* 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates; 1988.

118. Beurskens AJ, de Vet HC, Koke AJ. Responsiveness of functional status in low back pain: a comparison of different instruments. *Pain.* Apr 1996;65(1):71-76.

119. Tait RC, Chibnall JT, Krause S. The Pain Disability Index: psychometric properties. *Pain.* Feb 1990;40(2):171-182.

120. Childs JD, Fritz JM, Flynn TW, et al. Validation of a clinical prediction rule to identify patients with low back pain likely to benefit from spinal manipulation. *Ann Intern Med.* 2004;141:920-928.

121. Hicks GE, Fritz JM, Delitto A, McGill SM. Preliminary development of a clinical prediction rule for determining which patients with low back pain will respond to a stabilization exercise program. *Arch Phys Med Rehabil.* Sep 2005;86(9):1753-1762.

122. Fritz JM, Childs JD, Flynn TW. Pragmatic application of a clinical prediction rule in primary care to identify patients with low back pain with a good prognosis following a brief spinal manipulation intervention. *BMC Fam Pract.* Jul 14 2005;6(1):29.

123. Riddle DL. Classification and low back pain: a review of the literature and critical analysis of selected systems.[see comment]. *Phys Ther.* Jul 1998;78(7):708-737.

124. Fritz JM, George S. The use of a classification approach to identify subgroups of patients with acute low back pain: Inter-rater reliability and short-term treatment outcomes. *Spine.* 2000;25(1):106.

125. Fritz JM, Delitto A, Erhard RE. Comparison of classification-based physical therapy with therapy based on clinical practice guidelines for patients with acute low back pain: a randomized clinical trial. *Spine.* Jul 1 2003;28(13):1363-1371; discussion 1372.

126. Jeffries LJ, Milanese SF, Grimmer-Somers KA. Epidemiology of adolescent spinal pain: a systematic overview of the research literature. *Spine.* Nov 1 2007;32(23):2630-2637.

127. Kent P, Keating J. Do primary-care clinicians think that nonspecific low back pain is one condition? *Spine.* May 1 2004;29(9):1022-1031.

128. King HA. Evaluating the child with back pain. *Pediatr Clin North Am.* 1986;33:1489-1493.
129. Turner PG, Green JH, Galasko CS. Back pain in childhood. *Spine.* 1989;14(8):812.
130. Hakala P, Rimpela A, Salminen JJ, Virtanen SM, Rimpela M. Back, neck, and shoulder pain in Finnish adolescents: national cross sectional surveys. *BMJ.* 2002;325:723-726.
131. van Dijk M, Koot HM, Abu Saad HH, Tibboel D, Passchier J. Observational visual analog scale in pediatric pain assessment: useful tool or good riddance? *Clin J Pain.* 2002;18:310-316.
132. Luffin R, Grove SK. Examining the validity, reliability, and preference of three pediatric pain measurement tools in African-American school children. *Pediatr Nurs.* 2003;29:54-59.
133. Fairbank JC. Use of Oswestry Disability Index (ODI). *Spine.* 1995;20:1535-1537.
134. Fairbank JC, Davies JB, O'Brien JP. The Oswestry low back pain disability questionnaire. *Physiotherapy.* 1980;66:271-273.
135. Aaron DJ, Kriska AM. Modifiable Activity Questionnaire for adolescents. *Med Sci Sports Exerc.* 1997;29(6):79-82.
136. Aaron DJ, Kriska AM, Dearwater SR, et al. The epidemiology of leisure physical activity in an adolescent population. *Med Sci Sports Exerc.* Jul 1993;25(7):847-853.
137. Aaron DJ, Kriska AM, Dearwater SR, Cauley JA, Metz KF, LaPorte RE. Reproducibility and validity of an epidemiologic questionnaire to assess past year physical activity in adolescents. *Am J Epidemiol.* Jul 15 1995;142(2):191-201.
138. Hicks GE, Fritz JM, Delitto A, Mishock J. The reliability of clinical examination measures used for patients with suspected lumbar segmental instability. *Arch Phys Med Rehabil.* 2003 2003;84:1858-1864.
139. Ellison JB, Rose SJ, Sahrmann SA. Patterns of hip rotation range of motion: a comparison between healthy subjects and patients with low back pain. *Phys Ther.* Sep 1990;70(9):537-541.
140. Waddell G, Somerville D, Henderson I, Newton M. Objective clinical evaluation of physical impairment in chronic low back pain. *Spine.* 1992/06// 1992;17(6):617-628.
141. Heiss DG, Fitch DS, Fritz JM, Sanchez WJ, Roberts KE, Buford JA. The interrater reliability among physical therapists newly trained in a classification system for acute low back pain. *J Orthop Sports Phys Ther.* Aug 2004;34(8):430-439.
142. Vohra S, Johnston BC, Cramer K, Humphreys K. Adverse events associated with pediatric spinal manipulation: a systematic review. *Pediatrics.* Jan 2007;119(1):e275-283.
143. Burton AK. Low back pain in children and adolescents: to treat or not? *Bull Hosp Jt Dis.* 1996;55(3):127.