REVIEW ARTICLE

LOW-BACK PAIN IN ADOLESCENTS WITH AN OSTEOPATHIC COMPONENT

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Abstract

Low-back pain (LBP) is a common symptom presenting in adolescents. Most back pain in adolescents is benign and musculoskeletal in nature, due to trauma or congenital anomalies. Other less common causes include infection, inflammatory conditions or neoplasm. A comprehensive history and physical focusing on posture, muscle tenderness, range of motion, muscle strength and neurological function is essential in understanding the cause of low-back pain. Identification of risk factors for low-back pain will help the clinician in managing their patient. Treatment includes rest, avoiding activities that cause pain, physical therapy, osteopathic manipulative treatment, limited use of non-steroidal anti-inflammatory drugs and family and patient education. Assessing for warning signs or red flags of serious causes of LBP is a fundamental part of the clinical assessment. Pain that awakens from sleep, pain lasting longer than 4 weeks, sudden onset pain, systemic findings such as fever or weight loss and abnormal neurological findings should warrant immediate evaluation as these may suggest serious infectious conditions, malignancy or fracture. This article presents a comprehensive review of the epidemiology, relevant anatomy, biomechanics, causes and major risk factors for adolescent low-back pain. A diagnostic algorithm utilizing a step-by-step approach is also introduced to aid the clinician in management of the patient. Finally, the article presents guidelines for management of the adolescent with low-back pain including conservative, pharmacologic, as well as the osteopathic approach to treatment. Evidence-based recommendations on osteopathic approach to treatment has been reviewed from meta-analysis data and randomized controlled trials.

INTRODUCTION AND EPIDEMIOLOGY

Low-back pain (LBP) is a common complaint among children and adolescents. Most back pain in children and adolescents is benign in nature and caused by musculoskeletal conditions or trauma. Some adolescents have serious underlying congenital causes for LBP or acquired causes. Adolescent low-back pain has been as reported in the literature as common as the adult population.[1–3] Commonly, transient LBP presents in children and then into early adolescence.[4–6] It has been found that the risk for LBP increases with increasing age, pubertal development and linear growth.[7,8] A study within the Danish National Birth Cohort explored the differential nature of LBP and 7% of 12-year-olds had at least one episode of LBP.[8] The lifetime prevalence of LBP, by age 20, has been reported as high as 80%.[1] Prevalence increases with age, reaching a peak at the 6th decade of life. Based on the results of several large prospective trials, the best predictor of LBP is a previous history of LBP.[9]

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The prevalence of LBP in children and adolescents vary from 17%–26% based on several studies and is dependent on the age of a child and, in particular, the definition of LBP.[10–13] Similarly in adults, the prevalence of LBP is more common in females and increases with age.[14] There is a U-shaped relationship between physical activity and the prevalence of LBP in children. Low levels and high levels of physical activity contribute to a higher risk of LBP.[15,16] The etiology of LBP ranges from a sedentary lifestyle, prolonged screen time, sports injuries, psychosocial issues and a positive family history of LBP.[16-18] LBP may substantially restrict activities of daily living, in the adolescent population, such as school, sports or social activities. This paper presents an osteopathic approach to the diagnosis and treatment of adolescent LBP in the primary care setting with a focus on causes of LBP, biomechanics and relevant anatomy, risk factors, diagnostic strategies and treatment. A summary of evidenced based studies from the PubMed database of biomedical literature is reviewed and discussed. Search criteria were limited to studies in English and humans and key words were "adolescents" (aged 10–19), and "low-back pain". This summary also reviews the effectiveness of osteopathic manipulative treatment (OMT) and other treatments in the management of the adolescent with LBP.

CAUSES OF LOW-BACK PAIN

The differential diagnosis of LBP in adolescents is broader and more diverse than that seen in the adult population. In most children and adolescents with LBP, the etiology is benign, musculoskeletal in nature or due to trauma. Other, but less common causes, include infection, inflammatory conditions or neoplasm (Table 1).[17,19-23] In a large published series, of children and adolescents aged 10–19, 80% of adolescents had no identifiable diagnosis with their chief complaint of LBP. The most common diagnoses were lumbar strain/spasm (8.9%), scoliosis (4.7%), degenerative disk disease of lumbar area (1.7%) and lumbar disk herniation (1.3%). Less than 1% of complaints due to LBP were due to spondylolysis, spondylolisthesis, infection, neoplasm or fracture.[19]

Back pain is an uncommon complaint in the pediatric emergency department (ED) setting. A study at an urban pediatric ED looked at the chief complaint of back pain over the course of one year and found that only 0.4% of ED visits accounted for LBP. Of the children who complained of LBP, 90% had pain fewer than 4 weeks and the most common diagnoses were direct trauma (25%), musculoskeletal strain (24%), sickle cell crisis (13%), idiopathic (13%) and infections such as a urinary tract infection or viral infection (9%). Imaging was rarely helpful in this setting.20 Reassuringly, LBP resolves in children. In several longitudinal cohorts, only 7% of the entire studied population reported persistent pain at follow up assessments and most pain was non-specific and self-limiting.[5,21,22]

Nonspecific musculoskeletal pain and muscle strain appear to the most common causes of LBP in adolescents and account for nearly 50% of cases depending on the study population.[8,19,22–25] These patients usually do not present with any warning signs to suggest other pathology. The most common factors associated with non-specific LBP include older age and sports participation,[6,20] soft mattress usage,[26] sports equipment such as poorly cushioned running shoes or improper bicycle seat position,[27] increased thoracic kyphosis[28] and underlying mental health issues and psychosocial stressors.[29,30] A large systematic review looked at whether LBP was associated with heavy shoulder backpack usage and there was no correlation.[31] Muscle strain is usually related to overuse or overstrain and worsened by twisting or lifting. Other common and less common causes of LBP in adolescents are described in more detail in Table 1.

TABLE 1:

Differential diagnosis of low-back pain in adolescents

CONDITION	TYPICAL AGE GROUP	RISK FACTORS	HISTORY AND PHYSICAL EXAM FINDINGS	DIAGNOSTIC TOOLS
Non-specific musculoskeletal pain and muscle strain				
Non-specific musculoskeletal pain	All ages	Older age group Sports participation Co-morbid medical conditions Psychosocial stressors Sleep environment	Warning signs or red flags are usually absent	History and physical
Muscle pain	All ages	Inciting activity Trauma Overuse injury	Pain with activity Pain with lifting or twisting Muscle tenderness but no radiation Pain relieved with rest	History and physical
Thoracic pain				
Scheuermann Kyphosis	Early adolescence	Tall stature Boys > girls	Sharp angulation when bending over Pain with flexion, activity and at the end of the day	AP and lateral spine radiographs
Thoracic or lumbar pain				
Scoliosis	Adolescents	Idiopathic or congenital spinal anomalies	Lateral curvature of the spine with ADAMS test	Forward bend test Scoliometer Cobb angle more than 10o Standing PA or lateral views of the spine
Osteoid osteoma	Adolescents	Second decade of life	Nocturnal pain Relieved by NSAIDs Can be associated with scoliosis	CT

TABLE 1 CONT'D:

Malignancy - Primary tumor (Ewing sarcoma, osteochondroma) - Secondary malignancy leukemia, lymphoma, neuroblastoma, metastatic disease	Any age	May have a history of malignancy	Fever, weight loss, malaise, nocturnal pain, abnormal neurological findings, bowel or bladdery dysfunction	Blood work (CRP, ESR, CBC), CT scan
Spinal epidural abscess	Any age	Untreated can go from LBP to root pain ("shooting pains" to neurological deficits)	Fever, spinal pain, neurological deficits	Blood work (CRP, ESR, CBC) MRI
Vertebral osteomyelitis (including TB spondylitis, Pott disease)	Adolescents	History of infection	History of infection Systemic symptoms, constant pain, localized pain with percussion, ill appearing, nocturnal pain, exposure to TB limping	Blood work (CRP, ESR, CBC), blood culture, bone scan, MRI
Vasoocclusive crisis	All ages	History of sickle cell disease	Severe pain	Abnormal UA (concentrated, hematuria, proteinuria)
Tethered cord	All ages	Recent onset of scoliosis with severe pain	Younger children: refusal to do certain activities Older children: back pain exacerbated by exercise Neurological findings	MRI
Syringomyelia	All ages	Can be associated with congenital anomalies (eg, Arnold-Chiari malformation type 1), spinal infection, inflammation, malignancy	Clinical presentation is variable Recent onset scoliosis with severe pain Progressive central spinal cord deficits	MRI
Transverse myelitis	All ages	Associated with infection or systemic autoimmune disorder (eg, Lupus, ankylosing spondylitis)	Abnormal motor, sensory and/or autonomic findings	MRI
Chronic nonbacterial osteomyelitis	Between ages 7 and 12 years	Can affect the thoracic or lumbar spine Can be associated with psoriasis, palmoplantar pustulosis, acne, inflammatory bowel disease and spondyloarthropathy	Low grade fever, localized low back pain	Blood work (CRP, ESR, CBC), blood and bone cultures are usually negative
Lumbar or lumbosacral pain				
Hyperlordodic back pain	Any age	Weak core	Weak core muscles Increased lumbar lordosis	Clinical examination, imaging negative, Positive Trendelenburg sign, increased lumbar lordosis with thoracic kyphosis
Lumbosacral transitional vertebra (Bertolotti syndrome)	All ages	None	Nonspecific LBP Poorly localized unilateral LBP Insidious onset Increased lumbar lordosis	Physical exam Radiographs will demonstrate sacralization of last lumbar vertebrae CT scan

TABLE 1 CONT'D:

Intervertebral disc disease and herniated nucleus pulposus	Adolescents	Uncommon cause of LBP Acute trauma and axial load Scheuermann kyphosis Family history Obesity/overweight Associated with weightlifting, gymnastics, wrestling and collision sports	Pain radiating to buttocks or lower extremities Pain worse with flexion Limited Spinal flexibility Positive SLR test Leg pain is worse than back pain Severe herniation can lead to cauda equina syndrome	MRI
Spondylolysis	Early adolescence	More common in boys than girls Associated with: Scheuermann kyphosis, repetitive trauma	Pain extending into buttocks and thighs Pain worse with extension, improved with rest Hamstring tightness Positive SLR	Physical exam Radiographs CT scan
Spondylolisthesis	Early adolescence	More common in boys than girls Associated with Scheuermann kyphosis, certain sports and repetitive trauma	Pain extends into buttocks and posterior thighs Pain with extension Hamstring tightness Prominent spinous process Flattening of the normal lumbar lordosis Knee-flexed, hip-flexed gait	Physical exam Radiographs CT scan
Apophyseal ring fracture	Adolescents	Boys more than girls Associated with activities that require lumbar hyperflexion Associated also with Scheuermann kyphosis, and intervertebral disc herniation Associated with weightlifting, wrestling and gymnastics	Pain radiating to buttocks or lower extremities Pain worse with flexion Positive SLR test Leg pain is worse than back pain	Radiographs CT scan
Inflammatory arthritis: - Ankylosing spondylitis - Psoriatic arthritis - Arthritis of inflammatory bowel disease - Reactive arthritis	All ages	Family history of inflammatory spondylitis	Nocturnal pain Morning stiffness Chronic pain SI joint tenderness (positive FABER test) Flattening of the lumbar curve on flexion Involvement of other joints	HLA-B27 although not specific Plain radiographs MRI detects early disease

TABLE 1 CONT'D:

Discitis	Younger children	Rare case of LBP Low grade infection on spectrum of vertebral osteomyelitis Due to mild presentation may be underdiagnosed	Nocturnal pain Generally, affects lower lumbar spine Gradual onset of irritability and LBP, lip or refusal to bear weight No systemic toxicity Fever is absent or low-grade Examination findings: refusal in flexion, percussion tenderness over involved spine, hip pain, stiffness, loss of lumbar lordosis	Blood cultures are sterile ESR MRI Antibiotics
Paraspinal muscle pain				
Pyomyositis	Young children Young adults	Predisposing factors include immunodeficiency, trauma, injection drug use, concurrent infection and malnutrition	Fever and muscle tenderness localized to a single muscle group More common in the tropics, but has been reported in temperate climates	Blood work (CRP, ESR, CBC) CT
Viral myalgia	All ages	Prodrome or early phase of acute viral infections	Preceding viral illness (eg, rhinitis, pharyngitis, cough) LBP common	History and physical
Referred back pain				
Pain amplification/ chronic pain syndromes	Adolescents	Family history Pain at multiple sites	Chronic pain Discordance between reported symptoms and physical exam findings Repeated school absences	Lab work and imaging findings are not useful
Pyelonephritis	All ages	Ascending UTI	Dysuria Fever Abnormal UA	History and physical UA
Pneumonia	All ages	Younger age Prematurity Underlying pulmonary or cardiac disease	Fever Cough Tachypnea Abnormal pulmonary exam	History and physical CXR
Pelvic inflammatory disease	Sexually active adolescent females	Multiple sexual partners Unprotected sex	Fever Abdominal pain/pelvic pain	History and physical STI labs
Pancreatitis	All ages	Associated with trauma, infection, structural anomalies, some medications	Fever Acute, consistent mid to upper abdominal pain that radiates to the back Nausea and vomiting	History and physical Labs (CRP, ESR, CBC, amylase, lipase) Imaging
Nephrolithiasis	All ages	Diet Obesity Certain medical conditions	Severe back pain	Abnormal UA

BIOMECHANICS AND RELEVANT ANATOMY

In order to understand the etiology of LBP, clinicians need a complete understanding of the biomechanics and relevant anatomy of the spine, intervertebral discs and surrounding soft tissues. LBP is usually localized to the lower thoracic, lumbar or lumbosacral spine. The primary function of the spine is to protect the spinal cord and the nerve roots, while also allowing for full range of motion and to support and balance the entire body. The axial spine has 3 planes of motion: flexion and extension, lateral flexion and lateral rotation.[23] The thoracic spine consists of 12 vertebrae (T1–T12) and lumbar spine consists of 5 vertebrae (L1–L5). The sacrum (S1–S5) is a fused bone at the base of the spine and articulates with the ilium, and the upper part connects with L5 and its lower part connects with the coccyx. The sacral plexus is derived from the anterior rami of spinal nerves: L4, L5, S1, S2, S3 and S4. Subsequently, each of these anterior rami supply the anterior and posterior branches. The anterior branches innervate the flexor muscles of the lower extremity and the posterior branches innervate the extensor and abductor muscles of the lower extremity. The sacroiliac (SI) joint has numerous ridges and depressions, and its function is more for stability than movement. There is an intervertebral disc between each thoracic and lumbar vertebra. Between L5 and the sacrum there consists of a diarthrodial joint with limited range of motion. The spinal nerves exit posteriorly and bilaterally from the foramina of the thoracic and lumbar vertebral body. The complex anatomy of the lumbar region also consists of flexible ligaments, tendons and large muscles.

RISK FACTORS

Recognizing risk factors is important when assessing an adolescent with LBP. During the history, the clinician should ask questions regarding family history of low-back pain, any significant past medical history, time spent being sedentary, posture when doing schoolwork or using a computer and their physical activity level as well as the hours, type and intensity of this activity.[32–34] A physical exam should always obtain a height and a weight to determine BMI. A large cohort study did a survey of LBP in 13- to 16-year-old adolescents regarding their sedentary activities, sports participation, employment and smoking. The risk for developing LBP appears to be multi-factorial such as female gender, BMI > 25kg/m2, tightness of hamstring muscles, hypermobility, competitive sports participation, daily smoking, prolonged sedentary activities such as screen time, jobs that require heavy lifting as well as social and psychological factors.[34] The risk of LBP also increases with age.[21,33,34] A larger, more recent systematic review suggested that the association between LBP and risk factors were inconsistent but did note that older age and participation in competitive sports demonstrated a consistent association with LBP.[21] It does appear that more studies are needed to fully determine the prevalent risk factors of LBP in adolescents.

OSTEOPATHIC STRUCTURAL EXAM/ CLINICAL APPROACH

The osteopathic philosophy to patient care is characterized by a holistic and whole-body approach. It places an emphasis on the relationship and connection between physiological and anatomic structures. This approach also emphasizes the psychosocial and environmental influences that can cause pain. Previously, there used to be a paucity of medical literature on the effectiveness of osteopathic manipulative medicine for low-back pain, but growing evidence suggests that isolated manual techniques and patient education can improve lower back pain.[35–36]

Similar to other medical complaints, a complete and accurate history and comprehensive physical examination are key to proper diagnosis and management of LBP. The provider should ask the adolescent and their parent regarding the onset of pain, location of symptoms, duration of symptoms, description of the pain characteristics, presence or lack of radiation, aggravating or alleviating factors as well as any other associated symptoms. Acute onset pain is usually caused by trauma, while pain that is slower to present is usually caused by muscular, inflammatory, bony or biomechanical issues. Clinicians should also ask about the adolescent's participation in sports and other activities to see how much their pain is limiting their participation. In order to elucidate whether the adolescent is having inflammatory pain or mechanical pain, the provider should ask if they have morning stiffness or reduction of pain with movement or activity. Inflammatory pain decreases with physical activity and increases with prolonged rest. Mechanical pain increases with physical activity. In addition, family history is important, in particular to reveal any neurological or rheumatologic conditions or congenital anomalies.[37]

There are several well validated pain scales used in children to rate pain and severity. The visual analog scale (VAS) is a method that quantifies pain severity. It is a continuous outcome measure and has a 100 mm scale from 0–100 with 0 being the low end of pain and 100 being the high end of pain. This is easy to administer and has been studied in older children and adults.[38] The Wong-Baker FACES Pain Scale is a tool that uses facial expression drawings to describe the severity of pain and been extensively studied in children. Additionally, it is a well validated scale for chronic pain. Its reliability and validity have been confirmed in children and adolescents aged 3–18. Strong correlations have been reported between the Wong-Baker scores and VAS.[39–40]

A focused musculoskeletal exam and neurological exam should be performed on all children and adolescents with a particular focus on deep tendon reflexes, muscle strength and sensation in the lower extremities. This will elucidate any underlying neurological or intraspinal pathologies that would require an urgent specialist evaluation and/or imaging. A neurological assessment should include lower extremity sensation, motor strength and reflexes of the patellar tendon (L4) and Achilles tendon (S1). Dermatome sensation of T12 and S1 as well as muscle function of the hip flexors (L2, L3) and quadriceps (L3, L4) and extensor hallucis longus (L5) should be examined. The musculoskeletal exam should focus on core strength and stability and will evaluate if there are not only weaknesses in the abdominal musculature, but also the paraspinal

musculature. The adolescent should be examined in all planes of motion while also sitting, standing or walking. Full range of motion exercises, such as lumbar lateral rotation, lateral bending, flexion and extension, should also be performed. Leg length discrepancy and scoliosis may present with spinal misalignment, scapular asymmetry or pelvic obliquity. Scheuermann kyphosis will present with a kyphotic deformity. The clinician should palpate the entire spine and back musculature to evaluate if there is any tenderness over any spinous processes, musculature or SI joint. There are also several major clinical examination tests that should be performed (Table 2) that may aid the clinician in diagnosis.

Assessing for warning signs or red flags of serious causes of LBP is a fundamental part of the clinical assessment. The purpose is to evaluate for any serious pathology that would cause LBP and warrant referral for urgent medical management. This would include pain that awakens from sleep, abnormal neurological findings, such as asymmetric reflexes, saddle paresthesia, muscle weakness, extensor plantar response, low rectal tone and bladder or bowel dysfunction, and are listed in Table 3. Suspicion for underlying infectious conditions, malignancy or fracture should be evaluated if the clinician notes any systemic signs, including fever, fatigue, weight loss, loss of appetite, or localized tenderness on the spine.[17,32,33,37] Neurological symptoms such as radiculopathy and loss of bowel or bladder function are concerning, and it is essential for the clinician to rule out intervertebral disk herniation or cauda equina syndrome. Morning stiffness may be due to inflammatory arthropathies. Physicians should also ask about family history of autoimmune diseases, malignancy and scoliosis. The consistent use of a diagnostic algorithm when evaluating an adolescent with LBP will ensure that concerning etiologies of pain are completely evaluated. Figure 1 describes an algorithm that can help the clinician work through process of evaluating an adolescent with LBP.[41,42]

There is also a strong link between psychosocial issues and LBP.[4,29] Factors like poor mental health, difficulties with peers, bullying, anger, attention and concentration deficits, having a parent with LBP, fatigue and other sources of pain can contribute to this complaint.[29,30] Involving the family and working with the whole family system to support the adolescent understand their pain is an important tool. Referral to a family counselor, pediatric psychologist or therapist or pediatric psychiatrist may be needed to address underlying mental health issues. Working through an algorithm can help reveal any positive psychosocial stressors, but also understand if there is a physiological source of their LBP as well.

If the clinician has a high suspicion for inflammatory, autoimmune, infectious or malignant process, laboratory work, such as a complete blood count and inflammatory markers (CRP, ESR) would be necessary. If concerned about an autoimmune process, consulting a rheumatologist prior to ordering labs would be important, because nearly 20% of the general population has a positive antinuclear antibody.[43] Imaging should be obtained in adolescents who have had LBP longer than 3 weeks and, ideally, anterior posterior and lateral X-rays should be considered. If initial radiography is inconclusive, advanced imaging may be pursued. Computed tomography (CT) can provide details on the bones and cartilage but does expose the growing adolescent to high doses of radiation and should be ordered with caution. Magnetic resonance imaging (MRI) can be used for suspicion of bone pathology, as well as soft tissue pathology.

TABLE 2:
Low-back pain examination maneuvers

CLINICAL TEST	DESCRIPTION	DIAGNOSIS
Adams forward bending test	Keeping feet together and knees straight, adolescent should bend forward. Positive test: asymmetry in rib cage or curvature of spinal column	Positive test suggests scoliosis
Straight leg raise	Supine position, adolescent's leg should be raised when knees are straight. Positive test: pain felt by patient when 30–70 degrees of hip flexion and radiates into the posterior thigh and knee	Sciatic pain suggests herniated nucleus pulposus If hamstrings are tight, pain is localized to the hamstring area.
Flexion, abduction, external rotation	Supine position, knee is flexed to 90 degrees, hip is abducted and externally rotated. The pelvis should be held and fixed by the opposite hand. Positive test: pain felt in buttock, groin or sacroiliac joint	Positive test suggests pathological condition of the SI joint or intraarticular hip pathology.
Trendelenburg	Standing on one leg check the position of the pelvis. Positive test: pelvis of the other side drops	Positive test indicates issues of the lower extremity and gluteal and hip abductor weakness, decreased core strength or a neurological deficit
One-legged hyperextension test	While standing on one leg and bending backward, pain is experienced in the ipsilateral back	Positive test suggests spondylolysis

TABLE 3:
Red flags for low-back pain

History	• History of acute or repetitive trauma • Pain that radiates down buttocks • Pain that is severe, nocturnal, at rest or progressive • History of malignancy • History of exposure to tuberculosis • Morning stiffness
Physical examination	• Abnormal neurological findings (eg, asymmetric reflexes, weakness, extensor plantar response, low rectal tone, bladder or bowel dysfunction, saddle paresthesia) • Fever with or without systemic findings • Weight loss

MANAGEMENT

The specific treatment for LBP varies widely depending on the etiology of the pain. Most adolescents present with non-specific LBP and will respond to conventional treatment including rest, avoiding any activities that exacerbate their pain and physical therapy.[44,45] There is a paucity of medical literature on randomized controlled trials that focus on conservative options for LBP in adolescents. From a recent meta-analysis and systemic review, it suggests that a supervised exercise program is more effective at reducing LBP compared to no program at all.[44] However, exercise alone will not alleviate all LBP. It appears that to focus on the multiple risk factors for LBP, including social, physical, psychological and lifestyle, that a multidisciplinary approach may be more effective.

In addition, there have been several rehabilitation programs with a focus on alleviating LBP, but little literature on supporting these programs. LBP rehabilitation programs must be individualized to address the various patient populations. The rehabilitation may include exercise and physical therapy to manipulation and bracing.[46] A recent systemic review evaluated the approaches to LBP rehabilitation and concluded that treatment should be multi-factorial.[47] No single exercise program is right for each patient, but should focus on muscular strength, flexibility and/or aerobic fitness. Improving core muscle strength can support the lumbar spine, increasing the flexibility of the muscles, tendons and ligaments of the lower back can increase the range of motion of that area and improve movement. Additionally, aerobic exercise enhances the flow of blood and nutrients to the lower back and will aid in the healing process. Cognitive functional therapy has been studied as part of a multidisciplinary and multidimensional approach to adolescent LBP.[43] The literature reflects an evolving emphasis on a biophysical approach to the diagnosis and treatment of LBP. Adolescents are motivated to learn about the non-physical factors that may contribute to their pain. Counseling may improve their general health.[29,30,45]

Improving adolescent LBP relies on treating the acute injury, recognizing any problems in biomechanical function and changing the behavior or technique that may promote injury. Rehabilitation evolves through steps that focus on improving and encouraging range of motion and strength and reducing injury.[45] Emphasizing exercises that strengthen the hip flexors and hamstrings can increase hip flexibility. Core stabilization improves the strength, endurance, flexibility and neuromuscular control of the muscle groups that provide spine and trunk stability.[48] Therapy for specific diagnoses, such as spondylolysis, may involve a flexion-based therapy program, if there is pain with back extension, compared to conditions such as a herniated disc, which is treated with an extension-based therapy program because of pain with flexion.[49] The overall goal is a progression to activity specific exercises that allows an adolescent a gradual and pain-free return to their specific sport or activity.

Thoracic and lumbar bracing are also used in the management in the adolescent with LBP. Bracing includes soft lumbar corsets and rigid braces.[50] However, there is little evidence to support that bracing is more effective to conservative treatment alone. Some clinicians will use rigid bracing to further restrict activity that will exacerbate pain. Current medical evidence suggests against rigid bracing in spondylolysis and most have an excellent outcome with conservative treatment.[19,37]

To date, there are no randomized controlled trials comparing the use of analgesics such as non-steroidal anti-inflammatory drugs (NSAIDs) and acetaminophen in the treatment and management of LBP in adolescents. A Cochrane review looked at the efficacy of NSAIDs in those aged 16 and older with LBP, and NSAIDs seemed slightly more effective than placebo for short-term pain reduction and disability.[51] If a patient's LBP is unresponsive to conservative therapy or has persisted past four weeks a referral to a specialist may be warranted. A surgical approach may be needed for herniated nucleus pulposus, discogenic pain, apophyseal ring fracture and spondylolysis.[52]

OSTEOPATHIC APPROACH TO LOW-BACK PAIN

Osteopathic manipulative medicine (OMM) is a treatment modality used to diagnose and treat patients with somatic dysfunction. Somatic dysfunction is defined as altered and impaired function of the parts of the somatic system including the skeletal, joints and muscular structures as well as their neural, lymphatic and vascular properties. There are four major principles or tenets of osteopathic medicine:

- The body functions as a unit of body, mind and spirit
- The body is able and capable of self-healing, self-regulation and health maintenance
- Structure and function are interrelated
- Rational treatment is based upon an understanding of the basic principles of body unity, self-regulation and the interrelationship of structure and function.

Osteopathic manipulative treatment (OMT) is an effective and safe approach used by osteopathic physicians to complement conventional management of LBP. OMT can be used to diagnose and treat LBP and has been shown to decrease pain and improve musculoskeletal function and movement. LBP is one of the most

frequently treated conditions with OMT.[53,54] There are several systematic reviews and meta-analysis that demonstrate that OMT is more effective than control measures in pain reduction and functional status for adult patients with acute and chronic LBP.[53, 55–57] These results suggest that the positive benefits of OMT may have the potential to last beyond one year.

The American Academy of Pediatrics recommends that clinicians understand that there are many pediatric conditions that would benefit from a complementary health approach.[58] OMT is one of the most frequently used complementary health treatments for pediatric patients with neck and back pain.[59] In a review of outpatient pediatric clinical encounters at a neuromuscular medicine/OMM clinic, the most common age group were early adolescents. The primary presenting complaint, in the early and late adolescence age group, was back pain. In the same age group, the most common clinical assessment was LBP or lumbar strain/sprain.[58] OMT in children appears to be a safe treatment modality when done by physicians with training and expertise in OMM.[54,58,60,61]

Techniques used in pediatric OMT include counterstrain (CS), myofascial release (MFR), muscle energy, high velocity/low amplitude (HVLA), and lymphatic pump and are described in Table 4.[54,60–62] A comprehensive history and physical and using a standard algorithm will help the clinician discern the patient's diagnosis. The overall goal of OMT is to remove the obstruction and restore normal motion and function. OMT is classified by indirect or direct techniques. HVLA and muscle energy requires the clinician to move the region of restriction through a barrier and indirect techniques, such as CS, are directed opposite the restricted barrier. MFR can be either direct, indirect or both. In determining which technique to use, the clinician should take the patient's age, level of cooperation and ability to follow directions into consideration.

Student athletes involved in throwing or kicking sports are at a higher risk of SI injury.[62] Common techniques for SI dysfunction include HVLA and muscle energy.[54] Patients may complain of pain up to 48 hours post-treatment, but the pain usually self-resolves.[54,62] OMT may decrease unnecessary imaging, medications, referrals and invasive interventions. In addition, a more holistic approach to diagnosis and management may help the provider understand any risk factors that may exacerbate LBP. Contraindications to OMT include acute sprain or strains, fractures or dislocations, joint instability, malignancy or infection. Larger and more robust randomized controlled trials are needed in children and adolescents to determine and validate the effects of OMT on acute and chronic LBP. OMT and exercise have been shown to be effective in the adult populations, high quality research is needed to understand their effectiveness in the adolescent population with LBP. An ideal study would be a double-blind randomized controlled trial to address the intervention of OMT in adolescent LBP.

TABLE 4:
Osteopathic manipulative techniques

OSTEOPATHIC MANIPULATIVE TECHNIQUE	DESCRIPTION
Counter-strain	Gentle indirect treatment. Place patient in a position of mild strain in the direction opposite the barrier. Involves a tender point and patient is positioned to maximum comfort until pain is reduced by 70%.
Myofascial release/ soft tissue technique	Areas of dysfunction are revealed with soft tissue palpation and technique involves soft tissues versus skeletal or arthrodial structures. Treatment involves lateral and linear stretching, deep massage, traction and muscle stretch or compression. The goal is to restore motion and functionality with tissue relaxation.
Muscle energy	Direct patient muscular contraction away from a restrictive barrier against resistance from the clinician. Used in treating motion restriction.
High velocity/low amplitude	Using a thrust or impulse there is direct engagement of a motion barrier. Goal is to improve joint motion.
Lymphatic pump	Gentle and rhythmic technique that improves function through improved fluid drainage. Goal is to improve lymphatic movement.

PREVENTION

The skeletally immature adolescent goes through periods of rapid growth. They are more vulnerable to muscle contractions and trauma so focusing on education and prevention of injuries is important.[63] Evolving evidence suggests that programs that focus on a pre-season conditioning program that starts several weeks before the start of a sport season allows for a gradual increase in activity level. The program should aim to increase flexibility, endurance and neuromuscular training which has been shown to reduce injury rates.[61,62] Also, the adolescent should be allowed to rest and recover after a low-back injury especially with activities that require repetitive movements. In general, if the clinician follows an evidence-based advice strategy, young athletes should not participate in more hours of sports per week older than their age in years, which will help reduce overuse injuries and most back injuries.[63,64]

CONCLUSION

LBP in adolescents is a diagnosis that is most often self-limited, musculoskeletal or non-specific in nature and responds to simple conservative treatments. The clinician should perform a comprehensive history and physical and by using an algorithm should be able to distinguish between benign and serious causes of LBP. In addition, the clinician should be vigilant and understand the warning signs of serious causes of low-back pain and respond

promptly and provide the appropriate referrals, imaging and lab work. The role of psychosocial factors as an etiology of LBP in adolescents should also not be undervalued and involving the appropriate mental health specialists may be necessary. Physical therapy can be helpful with core-strengthening exercises and increasing lower extremity flexibility. In addition, patient education on preventative measures such as postural awareness, improving and increasing core strength, increasing core flexibility, relaxation and stress management and age-appropriate sports participation should help reduce future LBP injury. Finally, there is more mainstream acceptance of the efficacy of OMT in treating LBP. Several studies have demonstrated safety and efficacy of OMT in the adult and pediatric population. OMT should be considered a treatment modality in adolescents with LBP as it is safe, low-cost, non-invasive, effective and practical.

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