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Original Articles

Blount Disease in an Adolescent Male Athlete: A Case Report

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ABSTRACT

Objective: The purpose of this case report is to describe the clinical presentation, radiographic evaluation, physiological and pathological differentials, and surgical management of progressive symptomatic tibia vara (Blount disease).

Clinical Features: A 13-year-old male sought evaluation and care for knee pain at an outpatient chiropractic clinic. The chiropractor identified varus bowing of the involved leg and exaggerated lateral movement at the knee in the heel strike phase of the patient's gait. Radiographic evaluation revealed a medial proximal tibial slope, increased metaphyseal-diaphyseal angle, and metaphyseal beaking of the involved leg, consistent with Blount disease.

Intervention and Outcome: The patient was evaluated in two orthopedic clinics for management of Blount disease. An outpatient surgical intervention with tension-band plating was performed to arrest lateral tibial growth. The patient was weight-bearing at the time of release, with minimal pain management interventions, and with few activity restrictions.

Conclusion: Physiological tibia vara is common in young children and must be differentiated from pathological tibia vara by clinicians and radiologists through assessment of risk factors, clinical presentation, radiographic assessment, and monitoring of progression. Early detection and treatment of pathological tibia vara is essential to limit the

progression and subsequent complications of undetected or untreated Blount disease.

Key Words: Blount Disease, Tibia Vara, Bowed Legs, Lateral Thrust, Osteotomy, Epiphysiodesis, Metaphyseal Beak

INTRODUCTION

Bilateral and symmetrical outward bowing of the legs (tibia vara) is a common and expected physiological finding in toddlers under 2 years of age that tends to regress with increased age and skeletal development.[1] When the bowing deformities are persistent or progressive, continued monitoring through early adolescence is vital to distinguish between physiological tibial vara and the pathological tibia vara differentials of dietary vitamin D deficiency and vitamin D-resistant rickets, renal osteodystrophy, proximal tibial metaphyseal fibrocartilaginous defects, skeletal dysplasia, and physeal changes due to trauma, infection, or radiation therapy.[2] Early detection allows appropriate interventions before irreversible changes to the physis occur that could ultimately result in long-term patient complications.

Searches of Index to Chiropractic Literature (ICL), PubMed, PubMed Central, MEDLINE Complete, Academic Search Premier, Alt HealthWatch, Audiobook Collection (EBSCOhost), CINAHL Complete, eBook Collection (EBSCOhost), Library, and Information Science & Technology Abstracts yielded no case studies, reports, or research articles of Blount disease or tibia vara and chiropractic evaluation or intervention.

CASE PRESENTATION

A 13-year-old white male multi-sport athlete sought care in an outpatient chiropractic clinic for evaluation of persistent left knee pain. Starting at age 10, the patient experienced 2-3 knee pain episodes per year, located at the region of the lateral tibial condyle and fibular head, which was attributed by the parents to growing pains or possible Osgood-Schlatter disease (tibial tubercle apophysitis). Each episode of knee pain was managed successfully with 1-2 chiropractic treatments. Shortly after turning 13, the patient's knee pain became persistent. The chiropractor observed unilateral outward bowing and a lateral thrust in the patient's gait; bilateral AP and lateral knee radiographs were performed.

Findings of the bilateral knee radiographs included left proximal medial tibial physeal irregularity, with depression of the adjacent medial epiphyseal articular surface and the medial metaphysis, and a medial metaphyseal beak (**Figure 1** arrow); subtle widening and irregularity of the right proximal medial tibial physis; diaphyseal-metaphyseal angle of Drennan at 21° on the left and 9° on the right (normal <11°; **Figure 1** angle); left anterior tibial bowing was not identified. A diagnosis of Blount disease was made.

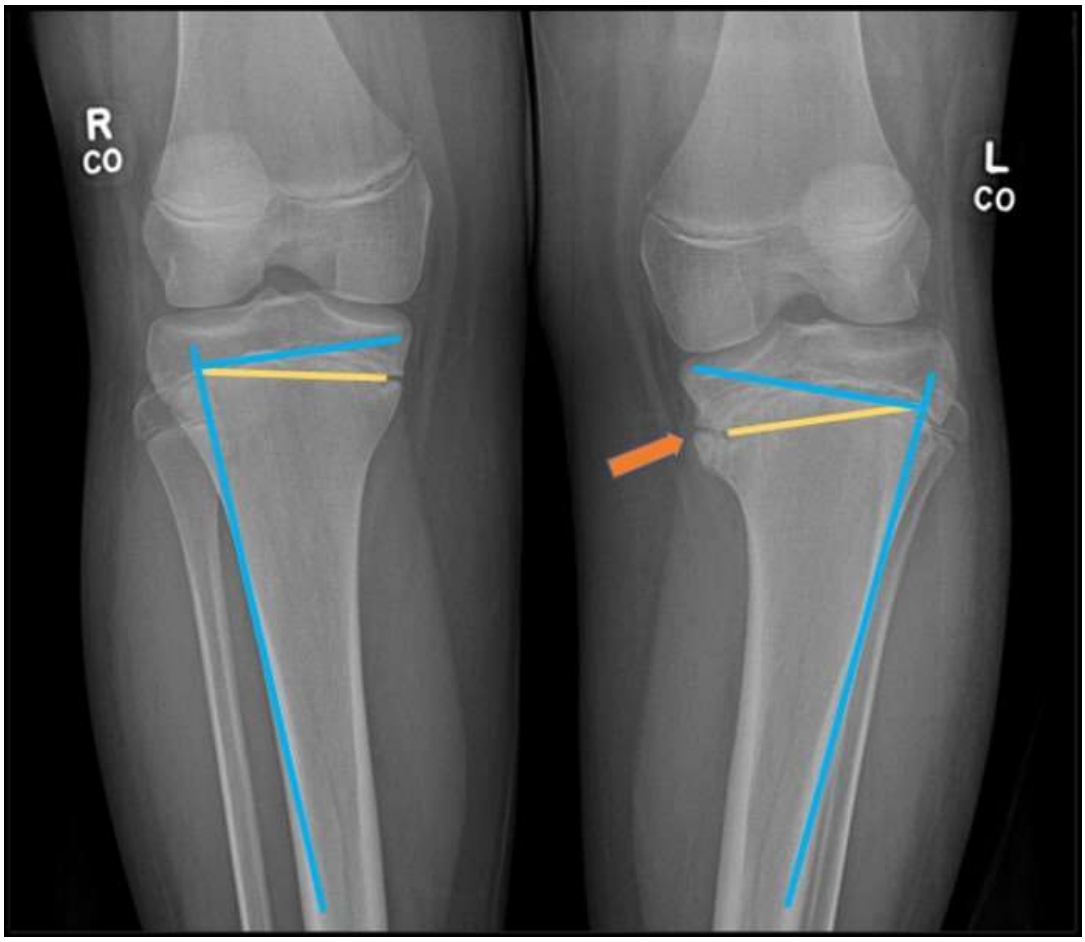

Figure 1: Anteroposterior radiograph of the bilateral knees of a 13-year-old male with left medial proximal tibial slope, increased metaphyseal-diaphyseal angle (MDA) and metaphyseal beaking (arrow).

The chiropractor referred the patient to an orthopedic clinic where surgical correction with an osteotomy was recommended. The patient and his parents were concerned about the extensive nature of this intervention and the projected 6 to 8-month recovery period. They sought consultation with a university-based orthopedic clinic, during which a lateral tension band hemi-epiphysiodesis with plate and screw fixation was recommended. The patient underwent this surgical correction approximately 8 weeks following the initial diagnosis of Blount disease and was discharged the same day (**Figure 2**). He was weight-bearing at the time of discharge, was off pain medication after 1 week, and was restricted from sports participation for 3 weeks. No rehabilitation program was prescribed.

Figure 2: Post-surgical (same day) anteroposterior radiographs of the bilateral knees of a 13-year-old male following tension-band plate placement at the left lateral tibia.

The patient underwent post-surgical evaluations at one month and 6 months and is scheduled for a 1-year evaluation. A second surgery to remove the plate will occur when the genu varum is effectively reduced. The patient is not restricted from any activity unless the activity results in pain.

DISCUSSION

Concerns of bowing deformities of the lower extremities in children may prompt their parents or caregivers to seek evaluations by chiropractic, pediatric, and orthopedic physicians. From the onset of walking to approximately age 2, physiological tibia vara or bowing is typical, owing to the expected growth and development of the tibia's coronal and transverse planes. Between ages 2 and 3, the knock-knee appearance of exaggerated tibial valgus is commonly seen, followed by lessening of the angulation around ages 6 to 7 to the typically slight valgus alignment seen in adults.[1]

Pathological causes of pathological lower leg bowing include Blount disease (most common), dietary vitamin D deficiency and vitamin D-resistant rickets, renal osteodystrophy, proximal tibial metaphyseal fibrocartilaginous defects, skeletal dysplasia,[1] and physeal changes due to trauma, infection, or radiation therapy.[2] In this patient's case, the unilateral presentation and the lack of cupping and fraying of the metaphyseal margins ("paintbrush metaphysis"), the absence of metaphyseal widening, and the lack of transverse lucent lines with adjacent sclerosis (Looser zones or pseudo fracture lines) did not support a radiographic diagnosis of vitamin D deficiency or vitamin-resistant rickets.

The progressive proximal tibial multiplanar varus deformity now known as Blount disease was first described as "tibia vara" in 1922 by Phillip Erlacher.[3] In 1937, Walter Putnam Blount reported on 28 cases, including 13 patients within his practice, in his article Tibia

Vara: Osteochondrosis Deformans Tibiae, published in The Journal of Bone and Joint Surgery.[4,5]

Blount disease is an acquired developmental growth disorder of unknown pathophysiology of the posteromedial proximal tibial physis and epiphysis,[6] leading to progressive genu varum deformity. The clinical presentation of the condition is commonly described in two forms: Infantile and Adolescent. Infantile Blount disease is identified as a varus deformity in children 2-5 years of age; adolescent or late-onset Blount disease develops in children 10 and older. In 1984, Thompson described a juvenile classification for patients 4 to 10 years of age, which is a less commonly utilized categorization today[6] and is considered a classification of untreated, poorly treated, or recurrent Blount disease.[7] The estimated prevalence of the infantile form of Blount disease in the United States is approximately 1%.[1]

Distinguishing between physiological and early-onset pathological forms of persistent tibia vara can be achieved through review of risk factors, clinical findings, and radiographic features. The risk factors for infantile or early-onset Blount disease include obesity; black African, African American, and Afro-Caribbean race; and ambulation prior to age 10 months.[1] Infantile Blount disease onset is typically prior to age three, is present bilaterally but asymmetrically in greater than 50% of cases, and is more prevalent in females.[3] Delayed growth at the posteromedial region of the proximal tibial physis causes flexion, internal rotation, varus deformity of the tibia,[1] and leg length discrepancy of approximately 1 cm.[7] The results of permanent epiphysiodesis (premature closure of the physis) mark a watershed stage of the disease in which the clinical features will include tibia varus and a gait disturbance of lateral (varus) thrust, amplifying the appearance of the bowed leg(s) during the initial phase of weight-bearing.

The risk factors of late-onset Blount disease are similar to those of early-onset Blount disease and comprise obesity, Afro-Caribbean race, and possible pre-existing tibia vara in children older than 10. Radiographic features include delayed physeal ossification at the posteromedial tibia, with widening of the medial tibial epiphyseal-diaphyseal growth center, and increased likelihood of medial femoral condyle hypertrophy and compensatory ankle valgus than in the early-onset form. The tibial deformities are less pronounced, with varus deformity occurring first, followed by medial tibial rotation and anterior tibial bowing; epiphysiodesis is rarely identified (**Table 1)**.[7]

	Infantile Blount Disease Characteristics	Adolescent Blount Disease Characteristics
Age of onset	1-3 years	10 or older
Obesity as a risk factor	30-60%	90%
Race as a risk factor	Black	Black
Sex as a risk factor	Female	Male
Distribution	Usually bilateral	Usually unilateral
Degree of varus deformity	Often >25 degrees	Rarely >30 degrees
Degree of epiphyseal angle	Often >25 degrees	Rarely >30 degrees
Recurrence after osteotomy	Common	Rare

Table 1: Distinguishing characteristics of infantile and adolescent Blount disease.[7]

Standing long-leg (full) anteroposterior radiographs are standard in the initial assessment of suspected pathological tibia vara.[8] The radiographic features of early-onset Blount disease are most evident after age 2.5, permitting differentiation from other causes of tibia vara.[7] The metaphyseal-diaphyseal angle (MDA), also known as the Angle of Drennan, is determined as the angle between a line perpendicular to the long axis of the lateral tibial cortex and a line in the transverse plane of the proximal tibial metaphysis (**Figure 1**).[8] A Drennan angle greater than 16° is considered highly indicative of pathological tibia vara, with an estimated 95% chance of progression. Metaphyseal-diaphyseal angles less than 10° have high likelihood (95%) of natural resolution of the bowing deformity. Drennan angles between 11-16° require close observation for the progression of tibia vara.[8]

Radiographic features and a classification system of infantile Blount disease were described in 1964 by Langenskiold and Riska.[1] Langenskiold's six stage radiographic classification system (**Table 2**), along with the Fort-de-France classification by Catonne,[7] is still used today by orthopedic surgeons to guide management decisions and predict outcomes,[9] and is based on progression of proximal tibial varus deformity, prominent osseous projection of the medial metaphysis, and varying epiphyseal findings ranging from absence to osseous fragmentation; in severe cases, physeal bony bars are seen.[10]

Langenskiold and Riska Infantile Blount Classification System		
Stage 1:	Ages 2-3	Irregular metaphyseal ossification line, slowed medial epiphyseal growth, and medial metaphyseal osseous projection (beak)
Stage 2:	Ages 2.5-4	Acute slope of the medial tibial ossification line, medial metaphyseal osseous beak, delayed growth of the medial epiphysis
Stage 3:	Ages 4-6	Increased depression of the metaphyseal beak, development of metaphyseal depression, increased wedging, and continued delayed growth of the medial epiphysis
Stage 4:	Ages 5-10	Growth center narrowing, epiphyseal enlargement, increased depth of metaphyseal depression, depression of the medial epiphysis into the medial metaphysis
Stage 5:	Ages 9-11	Separation of the bony epiphysis into two segments, partially doubled epiphyseal ossification line, medial articular slope
Stage 6:	Ages 0-13	Medial tibial growth arrest with ossification of the physis, normal lateral tibial growth

Table 2: Langenskiold and Riska six stage classification system of Blount disease[10]

Examination with magnetic resonance imaging (MRI) allows a more accurate evaluation of the cartilaginous tibial angle, the ligaments, the menisci, and the physeal blood supply. Evidence of homogeneous blood supply and absent signal changes in the physis support conservative management options.[7]

Few conservative non-operative treatments for early-onset Blount disease are available and their efficacy is disputed.[7] Orthotic treatment with a year or more of full leg bracing to limit knee movement and to apply valgus pressure to the knee may be appropriate and effective

for non-obese children younger than 3 years of age,[7] and is most efficacious in Langenskiold stage I or II disease. If orthotic treatment is not successful, surgical correction with osteotomy before the child reaches age 4 is indicated.[11]

Two primary surgical options are employed in the treatment of both early- and late-onset Blount disease: osteotomy and placement of tension band screw plates. There are several forms of osteotomy procedures, e.g., oblique, Z, V, inverted V, dome, closing and open wedge forms,[12] all of which remove bone from the tibia and/or elevate a portion of the tibia, changing its proximal articular surface angle, thereby reducing the varus load.[11]

In the 2006 review article *Guided growth: 1933 to the present*, Stevens advocated for tension-band plates (TBPs) as an alternative surgical intervention to osteotomies for leg length discrepancies and angular deformities.[13] The placement of a plate adjacent to the epiphysis and metaphysis through which one epiphyseal and one metaphyseal screw are threaded creates a focal hinge at the margin of the growth center, arresting the growth without violating the physis. Tension band plates are currently the most used implants for growth arrest. Complications of TBP interventions include early growth plate closure, screw breakage, and failure to complete normalization of the mechanical axis, with screw breakage in obese patients being the most common of all TBP complications.[14] Osteotomy surgery complications comprise peroneal nerve paresthesia, septic arthritis, osteomyelitis, misalignment, and union failure.[15]

Approximately 80% of patients receiving surgical re-alignment prior to age 4 achieve a full recovery.[16] Patients older than age 4 at the time of surgery, patients with late-onset Blount disease, patients with Langenskiold stages 5 and 6, and surgical overcorrection resulting in 15 degrees or less of valgus increase the likelihood of tibia vara recurrence.[17] While obesity has been established as the most-strongly associated risk factor for the degree of deformity in Blount disease, obesity has not been associated with treatment failure.[18]

CONCLUSION

This case report describes the clinical presentation, radiographic findings, risk factors, and complications of Blount disease, a pathological form of tibia vara. This case report also describes the necessity of thorough investigation and timely referral for surgical intervention to limit complications of delayed diagnosis and delayed treatment of Blount disease.

LIMITATIONS

As this report describes a single patient's clinical presentation, diagnostic evaluations, and treatment, generalization of this report's content to other individuals with similar clinical presentations should be avoided.

CONSENT

Written informed consent was obtained from the patient and parent/legal guardian for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

COMPETING INTERESTS

The authors declare they have no competing interests.

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Spontaneous Regression of Two Extruded Lumbar Disc Herniations: A Case Report

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ABSTRACT

Objective: To report spontaneous regression of two extruded lumbar disc herniations in a 31-year-old male, as evidenced by the comparison between the initial and a 13-month follow-up MRI.

Clinical Features: A 31-year-old male complained of chronic low back pain that had recently exacerbated. The initial pain had started approximately 13 months ago with a diagnosis of two extruded lumbar disc herniations at L5-S1 based on initial MRI scan. Due to recent exacerbation of the pain, a follow-up MRI was performed and compared with the previous study.

Intervention/outcome: The initial MRI of the lumbar spine demonstrated two disc herniations, large left and small right paracentral disc extrusions at L5-S1. A follow-up MRI revealed no evidence of the disc herniations observed in the initial MRI.

Conclusion: The comparison between the initial and follow-up MRI studies demonstrates spontaneous regression of both extruded lumbar disc herniations. While not predictable, the

fact that a herniated disc can resolve spontaneously places more emphasis on the role of a trial of conservative treatment.

BACKGROUND

Low back pain (LBP) is one of the most common health problems, with the lifetime prevalence of non-specific low back pain estimated at 60% to 70% in industrialized countries.[1,2] In the Global Burden of Disease 2010 Study, LBP is the single leading cause of disability and is one of the most common reasons for missed work.[3] Approximately 5% of patients with low back pain is known to be due to disc herniation, yet lumbar disc herniation is one of the most common reasons for back surgery.[1,4]

While the treatment of lumbar disc herniation in relation to its efficacy is still a controversial issue, it is widely accepted that most of the patients' symptoms may improve with conservative treatment when there is no definitive surgical indication such as motor deficit, intolerable radiculopathy, or cauda equina syndrome.[5] Also, compared to conservative treatment, there is higher risk of potentially more serious complications related to spine surgery including wound infection, CSF fistula, would dehiscence, or failed back surgery syndrome.[6–8] Therefore, surgical intervention is not always considered the initial treatment of choice but rather an option typically chosen after weeks or months of conservative care.[9]

The clinical course of low back pain caused by disc herniation varies as well as the efficacy of conservative treatment. In some patients, the symptoms may last only a few weeks, while in others they may continue for many months or years.[7] Symptoms resulting from lumbar disc herniation may resolve or diminish without any surgical intervention and, in some of these patients, this is accompanied by a reduction of the size of or complete disappearance of disc herniation.[10] This phenomenon is often referred to as spontaneous regression of herniated disc, which may be partial or complete. Recent advances in magnetic resonance imaging (MRI) with improved easy accessibility and affordability have facilitated follow-up studies of intervertebral disc herniation and prospect of spontaneous regression.[11]

It has been shown that spontaneous regression is dependent on a few factors including the size, integrity, and radiological characteristics of the herniated discs.[12] According to Aha *et al.*, there is a positive correlation between the size of the herniated fragment and the likelihood of regression. Also, transligamentous extension of herniated disc fragment through the ruptured posterior longitudinal ligament appears to be an important factor to its reduction in size.[11,13] Spontaneous regression of the herniated disc is more likely to occur with extrusion rather than protrusion, which may be associated with a more pronounced inflammatory response with extrusion.[14,15]

The following two statements support the value of this case report; 1) the evidence that spontaneous regression of a herniated disc occurs places more emphasis on the role of a trial of conservative treatment in the absence of complications warranting surgical interventions for patients who do not prefer early surgical options; 2) Even though spontaneous regression of lumbar herniated disc has been well established and discussed in various studies, little has been reported in chiropractic literature. Especially, concurrent spontaneous regression of

two separate disc herniations at the same level has not been reported in either medical or chiropractic literature.

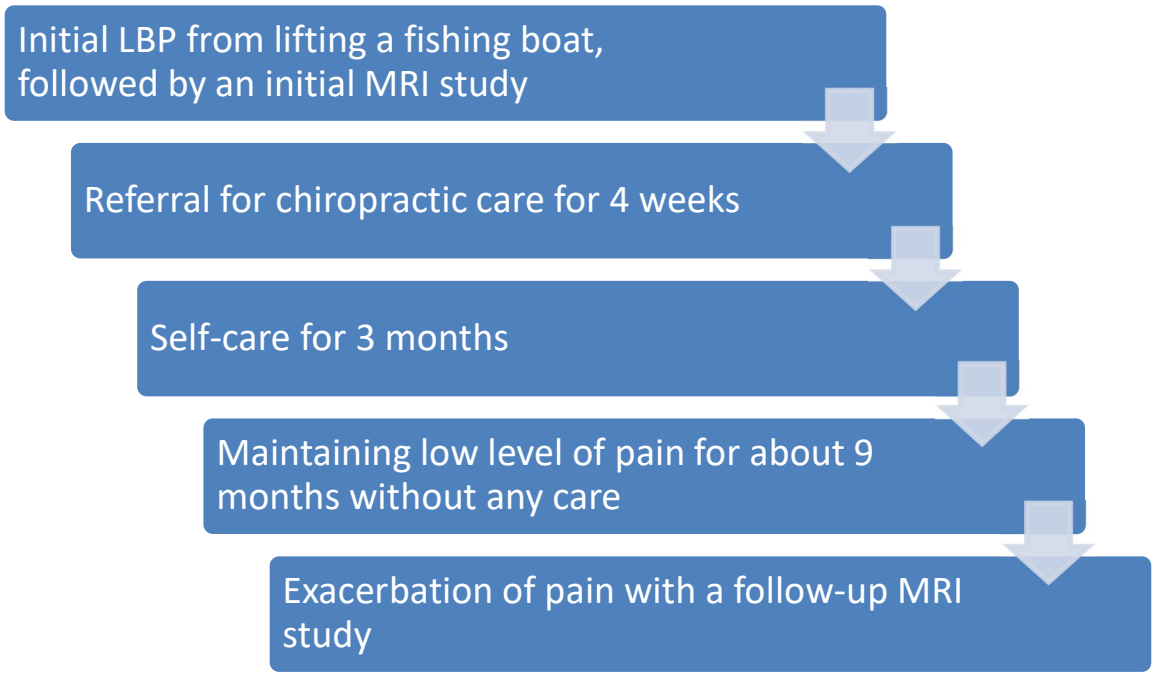
CASE PRESENTATION

A 31-year-old male presented with intermittent chronic low back pain associated with occasional radiculopathy along the posterolateral side of the left lower extremity and down to the lateral side of the foot, consistent with the S1 dermatomal pattern. Neurologic examination did not reveal sensory impairment or motor weakness even though the patient reported that occasionally he felt he could not use his left leg 'properly.'

His clinical history was significant only for a sudden initial onset of low back pain approximately a year ago when he was bending down to get into a car. However, he stated that the main precipitating factor for his pain was due to heavy lifting, which was attempting to lift a fishing boat that was struck in a muddy area the day before the onset of pain. The pain was followed by progressive spasms and burning and a tingling sensation radiating from his low back to the lateral side of his left heel. At the time, the patient was seen by a neurologist and diagnosed with two extruded disc herniations of different sizes at L5-S1 based on magnetic resonance imaging (MRI) performed two days after the onset of pain. The patient was referred for chiropractic care and was treated for four weeks. The debilitating low back pain, 10 out of 10 on a visual analog scale (VAS), decreased to 'somewhat manageable' level, which is 5 out of 10 on a VAS over the course of chiropractic care and rehabilitative exercises. Due to personal matters and lockdown from Covid-19 pandemic, the patient discontinued chiropractic care, yet continued the prescribed rehabilitative exercises complemented by Yoga, light stretching, kinesio-taping, and occasional application of topical analgesics on the area of pain for approximately 3 months.

For the following 9 months symptoms were reported as manageable with no significant acute exacerbation. However, due to persistent residual discomfort and intermittent and posture-dependent radicular symptoms along the lateral aspect of the left lower extremity in the S1 dermatomal pattern, the patient presented back for chiropractic care. MRI study of the lumbar spine was performed as per the patient's request and compared with the previous MRI study performed approximately 13 months prior. This timeline is summarized in **Chart 1**.

Chart 1. Summary of the timeline



Imaging Technique and Findings

The initial MRI included sagittal T2, sagittal T1, sagittal STIR, axial T2, and coronal T2 weighted images of the lumbar spine.

The osseous alignment of the lumbar spine on the sagittal plane demonstrated degenerative spondylolisthesis at L5-S1 along with mild disc space narrowing and disc desiccation.

The most significant finding was a large left paracentral disc extrusion at L5-S1, which measured approximately 11.4 mm x 7.02 mm in transverse and anteroposterior dimensions, extending caudally by approximately 14.9 mm, resulting in left lateral recess stenosis with associated compression on the traversing left S1 nerve root and spinal canal stenosis (**Figures 1 and 2**). At the same level, there was a smaller right paracentral disc extrusion indicated by an arrow in **Figure 3**, which measured approximately 5.1 mm x 4.4 mm in transverse and anteroposterior dimensions resulting in mild right lateral recess and central canal stenosis without significant caudal extension (**Figures 2 and 3**).

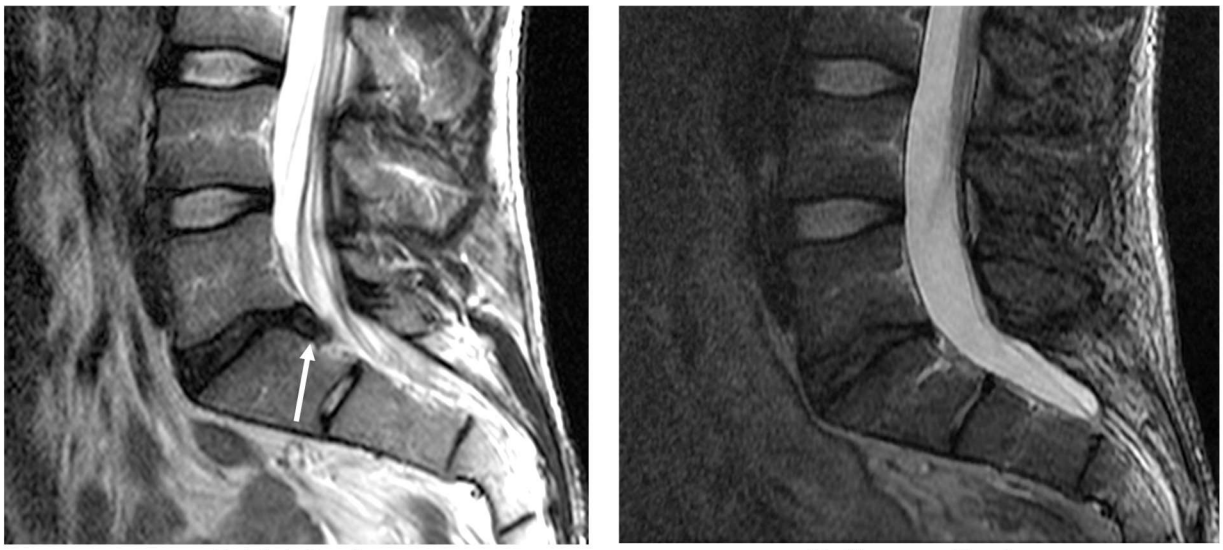
Figure 1. Sagittal T2 Weighted Image of Initial MRI

Figure 2. Axial T2 Weighted Image of Initial MRI

Figure 3. Sagittal T2 Weighted Image of Initial MRI

The approximately 13-month follow-up MR images demonstrated no evidence of the previously noted extruded disc herniations in the corresponding locations on sagittal (**Figure 4 and 5**) and axial (**Figure 6**) T2 weighted MR images. **Figure 4** is a comparison between the sagittal T2 weighted image from the initial MRI study demonstrating a large disc extrusion and corresponding sagittal plane from the follow-up MRI study revealing no evidence of the previously noted disc herniation. In a similar manner, the small left paracentral disc herniation is not visualized in the follow-up study on the selected sagittal (**Figure 5**) and axial (**Figure 6**) T2 weighted images.

Figure 4. Comparison of sagittal T2 weighted MR images between the initial and follow-up MRI studies

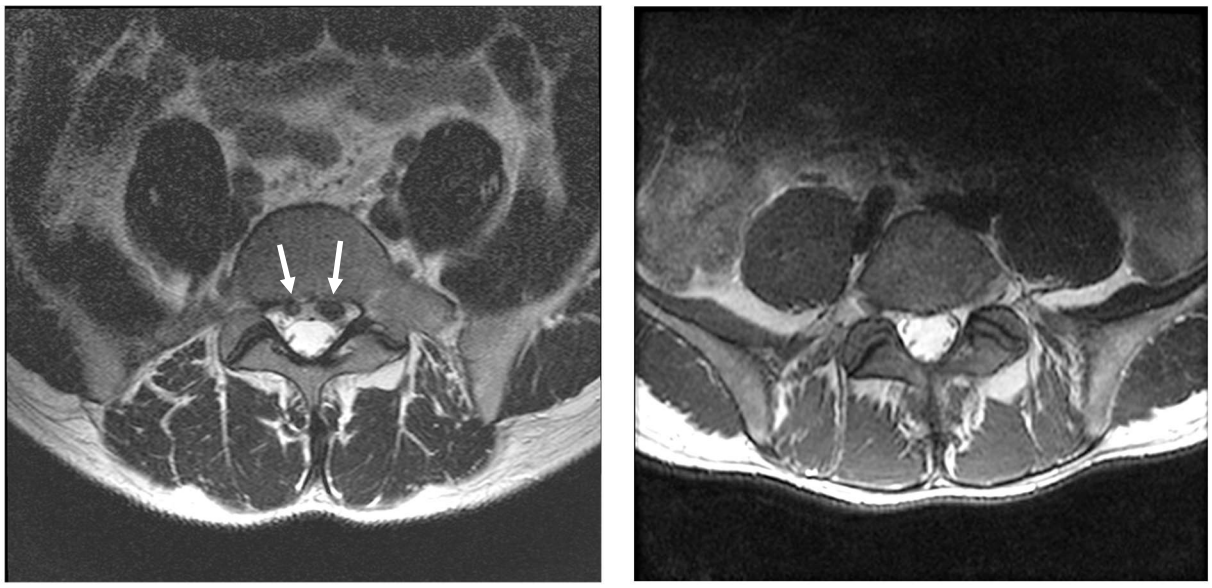


Initial Study Follow-up Study

Figure 5. Comparison of sagittal T2 weighted MR images between the initial and follow-up MRI studies

Initial Study Follow-up Study

Figure 6. Comparison of axial T2 weighted MR images between the initial and follow-up MRI studies



Initial Study Follow-up Study

DISCUSSION

This case report describes regression or disappearing of disc herniations without surgical intervention over a 13-month period of time based on the initial and follow-up MRI studies. While some studies report that the relationship between spontaneous regression of the herniated disc and clinical improvement has not been clearly accounted for, other studies have shown maximal clinical improvement within one year, and the decrease in size of the herniated disc continued thereafter.[6,15,17] Even though the exact timeline when regression of a herniated disc starts occurring is not clear, according to the study by K Oktay et al, the five selected cases showed follow-up MRI studies demonstrating regression of a herniated disc between as early as 3 months and as late as 12 months. In addition, in this study it was noted that the radiographic changes often followed clinical improvement (relief of pain).[9] It appears that the larger the herniated disc the longer it may take to spontaneously regress and achieve clinical recovery.[8]

Spontaneous regression of herniated disc tissue is well documented clinically. However, the underlying mechanisms remain unclear. One theory proposes that the herniated disc fragment decreases in size due to gradual dehydration and shrinkage, which may explain the decrease of signal intensity of the disc in follow-up MRI studies. A second theory suggests that the herniated nucleus pulposus may retract back into the intervertebral disc space which can be due to the tension applied by the posterior longitudinal ligament or decreased intradiscal pressure. However, this theory may fail to explain spontaneous regression of the herniated disc that has protruded through the annulus fibrosus and separated from it. Another theory, the most extensively studied with histological and clinical evidence to

support it, proposes inflammatory reaction as a cause of the gradual resorption of the herniated disc in association with production of proinflammatory cytokines with potent chemotactic activity resulting in macrophage infiltration and phagocytosis and enzymatic degradation.[10,18] The initial response is triggered by extruded nucleus pulposus into the epidural vascular space of the spine because the immune system recognizes the extruded nucleus pulposus as a foreign body. Depending on the clinical condition of each patient, it is suggested that one specific mechanism or different combinations of the three may operate in spontaneous regression of the herniated disc tissue.[19]

Generally, the management of herniated lumbar disc can be mainly divided into two options, conservative (non-operative) and operative treatments depending on the type of disc herniation and clinical symptoms and signs. Typically, extruded disc herniation poses more concern to both clinicians and patients, resulting in early surgical intervention at times due to pain even though there are no absolute indications for surgery.[6,20–22] Yet, spontaneous regression is more commonly associated with extruded disc herniation. Numerous studies have reported excellent recovery and prognosis of acute sciatica/radiculopathy due to disc herniation in the absence of indications for surgical interventions. Therefore, considering the risk of postoperative complications and the possibility of spontaneous regression of the herniated disc, conservative care should be considered as an initial approach in the management of those with herniated discs.

CONCLUSION

This case report presents spontaneous regression of two separate extruded lumbar disc herniations without surgical intervention based on comparison between the initial and 13-month follow-up MRI studies. This finding is significant in several perspectives. First, there is limited study regarding the natural history of the physical aspect of lumbar herniated disc in chiropractic literature. This may be the first case presentation in medical and chiropractic literature reporting spontaneous regression of two disc herniations at the same level. Secondly, the fact that a herniated disc can regress without surgical intervention may encourage clinicians to re-evaluate the value of conservative management of herniated discs in the absence of indications for surgical interventions, including but not limited to, significant neurologic deficit, progressive motor deficit, cauda equina syndrome, and severe unremitting leg pain despite conservative therapy.

LIMITATIONS

The primary limitation is the diagnostic imaging findings and outcomes represented in this case may not necessarily apply to other patients. Secondly, because of the retrospective nature of this study, it fails to give progressive information such as when regression of the disc herniations began and how long it may have taken to reach complete resorption. Further organized higher level studies with larger sample sizes are warranted.

CONSENT

Written consent for publication was obtained from the patient.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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A Commentary on the History of Chiropractic Prescriptive Rights in New Mexico

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INTRODUCTION

This article will discuss my initial involvement in the movement to expand the scope of practice for chiropractic physicians in New Mexico. I will comment on the need to prevent managed care companies from deleting chiropractic coverage and the change in Managed Care Regulations that not only prevented the deletion of chiropractic coverage but provided the opportunity for chiropractic physicians to become credentialed as primary care providers.

DISCUSSION

During 1991, I enjoyed the distinct honor of being the founding chiropractic physician of a chiropractic service within the Lovelace Health Care System.[1] It was a privilege to serve as a full-time chiropractic specialist within the orthopedic department, specifically occupational medicine. Although my full-time employment lasted only three years, my contractual relationship with Lovelace permitted me to serve for 25 years.

My tenure with Lovelace allowed me to learn the gatekeeper model, which required initially a referral from an orthopedic surgeon to a chiropractic specialist. Later all licensed physicians could refer patients for chiropractic services. Long term, the majority of referrals for chiropractic services were from primary care physicians. In fact, during my 25 years

with Lovelace 91% of my new patient referrals were from medical physicians. Hence, the gatekeeper model controlled the number of patients that could receive chiropractic services.

Although it became obvious that medical physicians would refer patients to chiropractic specialists if they trusted them, it was also obvious that the percentage of referrals was limited.[2] Less than 3% of Lovelace patients were referred for chiropractic services, while the national average of Americans receiving chiropractic care was close to 10%.[3]

During the latter part of 1999, the Corporation Commissioner contacted me and warned me that managed care companies had rewritten the Managed Care Regulations and proposed the elimination of coverage for chiropractic services. The changes were scheduled to take place by the end of the week. Of course, this was alarming, and I felt compelled to stop this inappropriate change in regulations. I immediately hired an attorney capable of assisting me and scheduled a meeting with the Superintendent of Insurance. Fortunately, the Superintendent was pleased to assist us with the process of not only preventing the deletion of coverage for chiropractic care but asked if any other changes were appropriate. We then added to the regulations that a chiropractic physician with appropriate training and credentialing could become a primary care provider.

Of course, to become a primary care provider, a chiropractic physician would need to be able to prescribe medications. Hence, several members of the New Mexico Chiropractic Association began pursuit of expansion of scope of practice to include prescriptive rights.[4]

CONCLUSION

Chiropractic physicians are trained to evaluate and manage patients suffering with neuromusculoskeletal conditions and other diseases. In order to serve as primary care providers, chiropractic physicians must enroll in postdoctoral training programs that lead to board certification and primary care medicine. Chiropractic schools should develop academic programs that prepare chiropractic physicians to serve as chiropractic specialists in both neuromusculoskeletal medicine and primary care medicine, which requires an expansion of scope of practice.

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Radial Shockwave Therapy Combined with Low Level Laser Therapy in a CrossFit Athlete with Chronic Shoulder Impingement Syndrome: A Case Report

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ABSTRACT

Objective: The purpose of this case study is to discuss a positive outcome following the use of radial shockwave therapy and cold laser in the treatment of a CrossFit athlete with chronic right shoulder impingement.

Clinical Features: A 31-year-old male presented to an outpatient chiropractic teaching clinic with chronic right shoulder pain. The pain was described as dull and radiating into the right arm. Radiographs revealed mild osteoarthritis of the right acromioclavicular joint. There was a decrease of active abduction and internal rotation range of motion due to pain, with point tenderness over the acromioclavicular joint. The Mumford procedure was the recommended medical treatment.

Intervention and Outcome: The patient received chiropractic adjustments and mechanical massage therapy to his right shoulder region with slight improvement. Shockwave therapy combined with cold laser was introduced at revaluation. The patient was advised to rest and/or limit his workout regime. The patient was compliant with the recommended treatment intervals, but did not limit his activity as directed. The patient was treated at a frequency of one or two days per week over the course of 16 weeks for a total of 28 visits, during which time there was a 50% reduction of pain, improved range of motion, and

improved ability to perform his activities of daily living. Outcome assessment tool scores showed 63% improvement.

Conclusion: This case report suggests that in this patient, Shockwave therapy in combination with cold laser therapy and manipulative/manual therapies may result in improvement of pain and functional limitations due to chronic shoulder impingement and may offer a conservative option for similar patients.

INTRODUCTION

Shoulder pain is frequently encountered in primary care and is a common presentation seen in a chiropractor's office.[1,2] Through a systemic review it was found that the estimated prevalence of shoulder complaints is about 7-34% in the general population, with shoulder impingement syndrome (SIS) accounting for 44-65% of all shoulder complaints.[1] SIS is typically seen in patients over age 40 and is a progressive painful syndrome resulting from entrapment of soft tissue most commonly in the subacromial space when the arm is elevated.[3,4] Shoulder impingement is classified into four types (**Table 1**) depending on where the soft tissue entrapment occurs within the shoulder joint with further classification as external or internal impringment.[1,3]

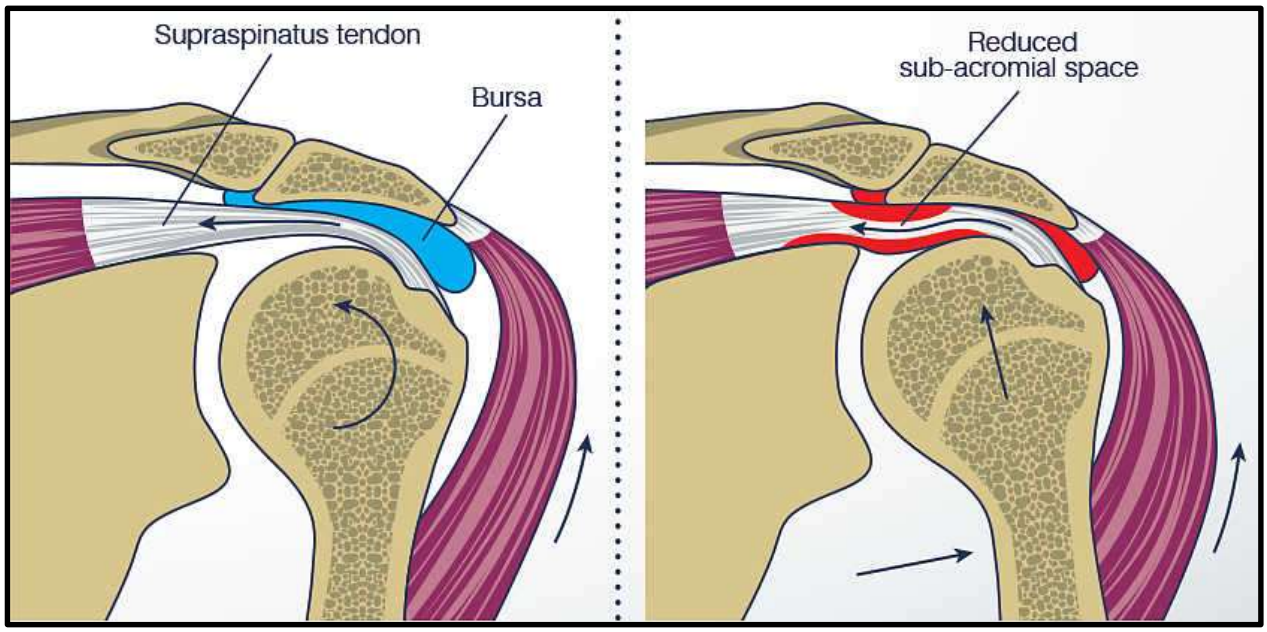
Table 1

Types of Shoulder Impingement
1. Subacromial impingement – External
2. Anterosuperior inner impingement – Internal
3. Posterosuperior inner impingement – Internal
4. Subcoracoid impingement

External impingement, also known as subacromial impingement/shoulder impingement, includes pathology or structures that encroach upon the subacromial space resulting in narrowing of the space which contains the subacromial bursa and the rotator cuff.[1,3] Internal impingement refers to any pathology that affects structures within the glenohumeral joint space.[1] The subacromial impingement is the most common form of impingement seen in practice, and is composed of primary and secondary forms. The primary form is due to

structural changes that mechanically narrow the subacromial space while the secondary form is from a functional disturbance of centering of the humeral head within the glenoid fossa.[3]

Common symptoms reported by the patient include pain on elevating the arm (between 70° and 120°, commonly known as the 'painful arc'), on forced movement above the head, and when lying on the affected side.[3] The pain is often described as being located over the lateral acromion and is frequently accompanied by radiation into the lateral upper arm area.[4] Other symptoms can include stiffness, loss of motion, weakness, and loss of arm function on the affected side.[1,4] This condition is generally diagnosed by history taking and examination with a diagnostic sensitivity of 90%.[3] Orthopedic tests commonly used to diagnose SIS are Hawkin's Test, Neer's Test, Empty Can Test, and a painful arc of motion. Plain radiographs may be useful initially for differential diagnosis and to exclude any arthritic changes or calcific tendonitis.[3]



(Searched free to share and use) espacio-subacromial-hombro-Efe-Salud.jpg (835×409) (almeriaisdifferent.com)

Treatment with good outcomes for SIS can be found through conservative and/or surgical methods with the goals of restoring joint function and eliminating pain.[3] Without known structural damage conservative therapies for SIS may include immobilization, NSAIDs, exercise, cortisone injections, ultrasound, manual therapy, therapeutic tape, heat, electrical muscle stimulation, acupuncture, low-level laser, and shockwave therapy.[3,4,5] If conservative care fails to provide significant improvement, surgical intervention may be considered as a treatment option. The most common shoulder surgery for shoulder impingement is arthroscopic subacromial decompression (ASD) with the goal of increasing the subacromial space.[1,6] However, in 2018 a clinical trial comparing the ASD surgery with diagnostic arthroscopy, a placebo surgery, found no clinically relevant benefit with the ASD surgery over the diagnostic arthroscopy even with the same post treatment protocols.[6] This

case report describes a patient with chronic shoulder impingement with disabling pain and the conservative treatment that allowed for a positive outcome.

CASE PRESENTATION

A 31-year-old male presented to an outpatient chiropractic teaching clinic with chronic right shoulder pain. The patient is a veteran of the United States Marine Corps with a previous right shoulder injury 10 years ago while in military. The patient's current episode began approximately one year ago with no direct mechanism of injury but mentions it may have occurred after a kettlebell swing workout during his CrossFit training. His pain was worsening due to overuse from his CrossFit workouts in preparation for a competition. Prior to his appointment at the clinic the patient had been treated for this current flare up through a Veterans Affairs (VA) facility at which time he was reportedly diagnosed with shoulder impingement. He was referred to physical therapy which he reports did not help. A right shoulder radiographic study including AP and lateral views was performed revealing mild acromioclavicular joint osteoarthritis. The patient was recommended to have the Mumford Procedure performed on his right shoulder, which he declined and opted to try conservative chiropractic care. The Mumford Procedure is a surgical procedure, either open or arthroscopic, that is performed to remove the distal portion of the clavicle to reduce pain.[7,8]

During his initial examination, the patient described the pain as dull with occasional sharp radiating pain into the right proximal aspect of the arm at 6/10 with rest and 9/10 with activity on the Visual Analogue Scale (VAS). Pain was present throughout the day and would flare up with provocative activities that would last 1-2 hours, which caused him to decrease the frequency of his CrossFit workouts from 5x/week to 2x/week. Aggravating factors included lifting, reaching, performing housework chores, driving, exercising, and sleeping. He reported that he was able to sleep only approximately three hours per night due to pain. Heat, ice, rest, and prescribed medical marijuana alleviated his symptoms. Initial differential diagnosis included supraspinatus tendinopathy, rotator cuff tear, and subacromial bursitis.

The patient reported a history of significant trauma during his time in the military, at which time he suffered a shoulder injury and a traumatic brain injury (TBI) with post-concussion syndrome as a result of direct trauma to the facial and upper torso region from a tire explosion. Patient was at high risk for chronic pain and disability with complicating factors such as depression with past suicide attempts, post-traumatic stress disorder (PTSD), and a current smoker.

Vitals, visual inspection, palpation, upper extremity motor, sensory, and reflex function, and right shoulder orthopedic tests were performed at his initial examination. Inspection revealed a bony protuberance and swelling over the right acromioclavicular joint region, and pinpoint pain over the right acromioclavicular joint. Upper extremity neurologic evaluation revealed hypesthesia to light touch at C5-T1 levels on the right side. Dugas Test, Lift Off Test, Impingement Sign, Speed's Test, Empty Can Test, and Painful Arc reproduced the patient's familiar right shoulder symptomatology. Palpation findings revealed thoracic spine segmental dysfunction. The patient's Upper Extremity Functional Index (UEFI) score was 33/80 with a fair prognosis.

His initial treatment plan consisted of mechanical massage therapy with range of motion exercises, thoracic spine adjustments as needed, and cold laser therapy at a recommended frequency of one to two treatments weekly for eight weeks, with initiation of shockwave therapy at week six. Self-care instructions consisted of lifting restrictions at work, no overhead reaching, and no excessive CrossFit workouts.

After eight weeks of care, a re-examination was performed. The patient described his shoulder pain as "about the same" with better range of motion. He reported the pain as dull with occasional sharp radiating pain into the right proximal arm at 5/10 with rest and 8/10 with activity on the Visual Analogue Scale (VAS). Pain was constant throughout the day and would flare up with provoking activities that would last one to two hours. Aggravating factors included lifting, reaching, performing housework chores, driving, exercising, and sleeping. Heat, ice, rest, and prescribed medical marijuana alleviated his symptoms.

Re-examination consisted of vitals, visual inspection, palpation, upper extremity neurologic evaluation, right shoulder range of motion (ROM), and right shoulder orthopedic tests. Inspection revealed a bony protuberance over the right acromioclavicular joint region with observed swelling and pinpoint pain over the right acromioclavicular joint. There was hypesthesia at the C5-T1 levels on the right side. Passive range of motion revealed flexion, extension, external rotation, abduction, and adduction caused pain. Active range of motion revealed observed mildly decreased internal rotation with pain and moderately decreased abduction with pain. The following shoulder orthopedic tests were positive: Apley's Scratch Test, Codman's Drop Test, Dawbarn's Test, Lift Off Test, Neer's Test, O'Brien's Test, and Painful Arc. Palpation findings revealed thoracic spine segmental dysfunction at levels T1, T2, and T6, right acromioclavicular (AC) joint, and right scapula dysfunction. The patient's Upper Extremity Functional Index (UEFI) score was 32/80.

This case report focuses on the second course of treatment with a continued frequency of one to two times/week for eight weeks with a total of 17 treatments. Treatment included alternating cold laser therapy (MR4 LaserStim) and radial shockwave therapy (The Miracle Wave), along with spinal and right shoulder adjustments as needed. Due to the patient's CrossFit training alternating therapies were applied according to his training schedule. Shockwave therapy was not performed on days the patient trained because this therapy fatigued his shoulder. Patient self-care instructions were to ice the shoulder, perform appropriate warm up and cool down with physical activities, and he was advised to stop CrossFit training. The patient was non-compliant with the recommendation to discontinue his training.

At re-examination, vitals, visual inspection, palpation, upper extremity neurologic evaluation, right shoulder ROM, and right shoulder orthopedic tests were performed again. The bony protuberance over the right AC joint region was still observed with mild tenderness over the subacromial bursa. Motor, sensory, and reflex function was found to be within normal limits. Passive range of motion of flexion, extension, external rotation, abduction, and adduction were performed with no pain. Active range of motion with internal rotation remained the same but with no pain, and abduction range of motion moderately improved. The patient was able to abduct his shoulder from an initial observed range of motion of approximately 90° to 150° with little pain. Only the Dawbarn's Test was positive.

He had a 63% improvement with the UEFI and a 50% improvement on the VAS. The patient self-discharged and was lost to care.

DISCUSSION

Shoulder pain is a very common complaint seen in clinical practice with shoulder impingement being one of the most common causes of this pain.[5] Being a multiaxial joint capable of complex movements, it should not come as a surprise that shoulder complaints are the third most common musculoskeletal complaint in primary care.[2,9] Multimodal conservative treatment should be the first step and can yield very good results.[3] However, there is currently no standard treatment protocol for shoulder pain.

For this patient, conservative therapy provided significant relief and improved function to the extent that the patient could avoid surgery. When comparing the first and second treatment plans, the second demonstrated that combining the low-level laser and radial shockwave therapies improved and expedited patient results. Treatment showed improvement even with hindering factors such as continued CrossFit training, psychosocial concerns, and his daily smoking. A major strength of this case was that the patient was compliant with the recommended frequency of treatment and had a positive outlook.

Shockwave therapy research is expanding each year, but research seems to be limited with regard to the combination treatment of shockwave and low-level laser therapy, and even less so specifically addressing SIS.

A meta-analysis performed in 2017 that evaluated the effectiveness of conservative interventions for shoulder impingement that included shockwave therapy and cold laser reported that these therapies were superior to sham for pain, but showed non-significant results or consisted of low level evidence.[10] These therapies were not performed in combination but as stand-alone therapies.[10] A study in 2020 evaluating functional results after using shockwave therapy on patients with shoulder injuries had similar results to this current case report. That study showed improvement with pain, range of motion, and functional scores after the use of shockwave therapy.[11] A review of current knowledge on evidence-based shockwave treatments for shoulder pathology concluded there is evidence to support the use of shockwave therapy.[12]

On the contrary, a systematic literature review examining the effectiveness of conservative physical therapy treatments for subacromial shoulder pain indicated that the evidence does not support the effectiveness of shockwave therapy.[13] Much of the research reviewed states there is not enough evidence to form a consensus for the use of shockwave therapy for shoulder injuries, or research with significant results consisted of low level evidence.[10,13,14,15] Higher quality evidence is also needed for research evaluating the efficacy of cold laser and the development of optimal treatment protocols.[16,17]

In conclusion, no consensus has been formed with regard to efficacy or protocols for either shockwave or low-level laser therapies for the treatment of shoulder impingement. Further research with higher quality evidence is needed to provide this information.

CONCLUSION

This case shows that this particular individual experienced improved outcomes such as improved shoulder range of motion, decreased pain, and improved function with activities of daily living after receiving the recommended treatment. The positive outcome with this case establishes that shockwave therapy combined with cold laser therapy may be a viable option for treating chronic shoulder impingement.

LIMITATIONS

This case report does have a limitation due to the use of other treatments such as thoracic spine and right acromioclavicular joint and/or scapula adjustments. This case report was focused on the second course of care with a total of 17 treatments where thoracic spine adjustments, right shoulder adjustments cold laser, and shockwave were used at varying intervals. The combined treatments can make it difficult to definitively conclude that any one treatment or combination of treatment modalities were responsible for the positive outcome in this patient. Furthermore, due to the fact that this is a single-patient case report, the results of this report may not be generalizable to other individuals presenting with similar conditions.

CONSENT

Written informed consent was obtained from the patient for publication of this case report. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

COMPETING INTERESTS

The author declares no competing interests.

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A Commentary on the Value of Limited Prescription Rights for Qualified Chiropractic Physicians

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INTRODUCTION

The health care delivery system in the United States is changing. Evolving approaches to health professional regulation and administration have increasingly focused on improving efficiency and effectiveness and lowering costs through a more patient-centered culture. This trend emphasizes value to the patient.[1] No longer do medical doctors (MD) and doctors of osteopathy (DO) have absolute authority over patient care. Instead, the future of patient-centered care is integrated and best developed using evidence-based tools and practicality to achieve high-value care.

Expansion of scope of practice in health professions is part of a current trend to improve patient access to high-value care. Each state determines the scope of practice and rules of licensure for non-MD/DO providers. There are fundamentally two ways to broaden practice-scope laws. The first is by expanding the basic licensure of a profession to include additional modalities. The second is by adopting specialized training and certifications. This second method, used by the nursing profession and others, is commonly called tiering.

This article advocates for high-value, patient-centered care through expanding the scope of practice for qualified Doctors of Chiropractic (DC) to include limited pharmacological privileges through tiering.

DISCUSSION

In all but one state, DCs cannot prescribe pharmaceuticals. This limits the doctor's ability to manage common conditions based on evidence and standards of care without referring the patient to an MD, DO, or advanced practice nurse (APN) for medication.[2] The patient must engage two practitioners, one for manual therapy and another for prescriptive medications. This inefficient and ineffective model requires duplication of services and puts unnecessary demand on the health care system.[3]

In most jurisdictions, DCs cannot even advise or administer over the counter (OTC) drugs or inject natural medicines. And with increased regulation of nutritional supplements, new laws may eventually exclude a DC's existing right to dispense nutraceuticals.

DCs are well-suited to blend the best of conservative care with conventional medicine.[4] DCs are trained in differential diagnosis with special emphasis on neuromusculoskeletal conditions. But in most states, before DCs can integrate pharmaceuticals into practice, they must seek additional training and licensure outside of the profession.[5] Developing credible and legitimate pathways that enhance basic licensure through post-doctorate programs and certification in pharmacology within the profession is more efficient. Post-doctorate advanced training for interested DCs is a critical step to encourage scope expansion and ensure patient safety. The resulting integrative approach would add value to patient care and influence the future of health care.

Currently, the state of New Mexico is the only jurisdiction in the United States where a DC has prescriptive privileges; these include specific medications, hormones, and other injectable substances to treat health conditions.[6] As of December 2019, two other countries also allow the use of limited prescriptive medication privileges in the practice of chiropractic, Switzerland and Liechtenstein. Switzerland and Liechtenstein have prescriptive privileges that include analgesics, anti-inflammatories, and muscle relaxants.[7]

Chiropractic programs and professional organizations already provide credible training that supports scope of practice expansion.[8] In the United States, DCs are required to pass four national boards demonstrating competency in areas such as pathology, diagnosis, radiology, physiotherapeutics, and technique. Expanding standard curricula to include enhanced post-graduate education with standardized testing is not a new idea. Currently, a DC can elect to take post-doctorate training in several specialties, such as orthopedics, pediatrics, radiology, sports, neurology, and nutrition. These existing educational programs provide a credible and logical springboard for elective advanced practice pharmacology certification.

Through elective, advanced practice tiering certifications and laws, the chiropractic profession can provide more comprehensive and efficient patient care. Organizations such as the International Academy of Neuromusculoskeletal Medicine, in collaboration with our accredited chiropractic schools, stand ready to help administer those expansions.

CONCLUSION

States can deliver value to patients by granting limited prescriptive rights to qualified DCs. DCs already evaluate and manage patients as portal-of-entry physicians. But states should not require DCs to leave their professional base to further their education by adding prescriptive rights. DCs have long demonstrated a willingness to take elective training in many areas including pharmacology. And chiropractic-led, advanced-practice certification in pharmacology can better support this scope of practice expansion. This common-sense approach to enhancing value-based integrated care benefits the public and the profession.

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Game Schedules and Injury Occurrence in the National Football League – Are Injuries Affected by the Number of Days between Games?

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ABSTRACT

American professional football has one of the highest rates of sport injury. Despite this high rate of injuries, little is known on injury occurrence from unconventional game schedules or shortened rest periods. To determine whether time between games in the National Football League was associated with injury occurrence, time missed, body part injured, and player position, we examined injuries and game schedules from 32 NFL teams from 2012-2016. Data was collected from online resources and summarized by regular-season weeks and quarters. Time between games was classified as short: <7 days, regular: 7 days, or long: >9 days. Chi-square determined significance and true relationships between variables. Secondary analyses were performed to assess time between games and anatomical location, player position, and time missed. A total of 4,228 injuries were observed over 5 seasons. Longer rest periods between games resulted in a higher frequency of injuries in the second and third quarters of the season, but fewer injuries at the beginning and end. Shorter rest

periods and regular game schedules did not show a difference in injury occurrence. There was no difference in injury occurrence when analyzing rest between games and player position, anatomical body region, or amount of time missed by players.

Key Terms: epidemiology, game schedules, injury, national football league

Clinical Relevance: Game schedules, measured by time between games, affected injury occurrence. This may help teams plan game schedules to reduce the risk of athlete injury and cost to the player and organization.

What is known about the subject: American football has one of the highest rates of injury among sports. Unconventional game schedules have been proposed as a risk factor for injuries in these athletes.

What this study adds to existing knowledge: Game schedules, measured by time between games, affected injury occurrence. Longer rest periods between games resulted in fewer injuries in the 1st and 4th quarters of the season and more injuries in the 2nd and 3rd quarters of the season. Shorter rest periods and regular game schedules did not show higher injury occurrences. Rest periods between games did not affect player position, anatomical region injured, or amount of time missed by players. This may be helpful for teams when planning game schedules to reduce the risk of athlete injury and cost to the player and organization.

INTRODUCTION

Among sports, football has one of the highest injury rates.[1–3] Players in the National Football League (NFL) often sustain significant injuries during games. These impact the length of their career,[4] the outcome of their performance, and the overall success of the team.[5] For example, anterior cruciate ligament (ACL) injuries are common in the NFL and result in an inability to play the remainder of the season and entail a long rehabilitation.[6] Interestingly, players who have ACL injuries in the NFL earn ~$2M less in the 4 years following the injury, and 21-37% of NFL players who injured their ACL do not return to play (RTP) another game.[7] In addition, Achilles tendon ruptures are a growing trend in football with an average recovery time of 375 days.[2,8] American football has also been associated with one of the highest incidences of traumatic brain injury of all sports with concussions being one of the most frequent injuries occurring, leading to expensive league rule and policy changes.[9]

With high injury rates, research has examined risk factors for injuries in the NFL.[10,11] Proposed risk factors include time in season, altitude, temperature, time zone, distance traveled to game, playing surface, and fatigue.[10,11] Along with playing one game per week, NFL athletes practice up to 5 days a week.[5] Jet lag from travel along with increased amounts of exercise can lead to central nervous system fatigue, which may affect player performance, and increase risk of sustaining injuries during a game.[12] Dependent on the day of the week of a scheduled game, the player may be more fatigued from lack of adequate rest and recovery from a prior game.[2] Additionally, NFL players can be deconditioned, resulting in overtraining, leading to injuries in the season.[12]

In 2006, modified game schedules were introduced in the NFL, beginning with the addition

of Thursday night football games. Schedules were again altered in 2008 with elimination of many Saturday night games.[13] A concern was that unconventional game schedules, or shorter time between games, could lead to increased injury risk in athletes.[14,15] Most games are played on Sunday with a smaller number of games on weekdays. Little is known on the effect of shortened rest periods due to playing on a weekday rather than on Sunday. To our knowledge, few studies have attempted to look at this.[14,16] Perez et al. investigated the effect of time between games on in-game injury rates in the NFL and found short rest periods between games were not associated with increased injury rates. Quarterbacks were the only position with more injuries with shortened rest periods between games, however this finding was not significant and was underpowered.[14] They concluded future research correlating rest and quarterback injury and possible causal effects of rest time on injury are warranted. Their study only looked at in-game injury rates, which could have led to underreported injuries from not taking practices or less severe injuries (not resulting in stoppage of play) into account. Lawrence et al. also examined the effect of time between games on injury rates, utilizing publicly available injury reports and found no correlation between injury risk and time in season; however, this was only over two player seasons.[16] They utilized publicly available injury reports, not official NFL gamebooks. Unconventional schedules may create challenges for teams and players with shorter recovery times, decreased preparedness, and condensed travel schedules, possibly affecting their health, performance, and injury occurrence. Game schedules are a concern in other sports as well. The interval between games is associated with injury risk in other sports such as professional soccer, professional field hockey, and within the National Basketball Association (NBA).[15,17,18] Despite several studies documenting the prevalence of specific injury types in the NFL,[19] there is more evidence needed documenting the effect of rest between games and injury occurrence, as well as patterns of injury. This information could provide insight into the influence of future interventions for NFL injury prevention and game schedule planning.[20]

The primary aim of this study was to determine if unconventional game schedules, measured by time between games, were associated with injury occurrence, time missed, body part injured, and player position in the NFL. It was hypothesized that less rest time between games would increase injury occurrence.

METHODS

A thorough online review was conducted by two co-authors to document NFL injuries during the 2012-2013 to 2016-2017 seasons. The online information consisted of player news and team injury reports from a variety of sources that included Pro Football Reference (PFR), Rotoworld.com, NFL.com, ESPN.com, SBNation.com, and SI.com as well as each team's local sports blogs. Injury occurrence was defined as requiring physician referral, advanced imaging, missed practice or game, or if emergency care was provided. Injury information was supplemented by searches on Google.com with search terms incorporating player name, team, and year of injury. Weekly injury reports and team injury reserve lists were utilized to identify players who sustained injuries. Injuries were confirmed by monitoring official injury report sites that use the information from weekly injury reports from NFL teams, following previously published methods.[21] No institutional review board approval was needed, as the data is publicly available.

Each team's schedule information was gathered through PFR and the official team websites. Annual team schedules and location of each game were recorded to determine the home team and the day of the week a game was played. Through the online search and reports, additional player-specific details including team, position, and date of injury were gathered. Player position groups were defined as offensive linemen, defensive lineman, quarterbacks, offensive backs (running backs and full backs), wide receivers, tight ends, defensive backs, linebackers, and special teams (kickers, long-snappers, punters, and special teams).[22,23] The games recorded consisted of the NFL regular season (16 games and 1 bye week for each team, played during a 17-week stretch).

The date was recorded for each injury. Because of the lack of regular interval rest before other games and because players would have had to suffer their injury from either the previous season, offseason, training camp (including practices and preseason games), or during the limited practices leading up to the opening game, exclusion criteria included injuries sustained during week 1. Injuries sustained outside of football activities were eliminated and removed from the data set. Descriptive statistics looking at the actual time between the game in which there was an injury, and the date of the previous game (days between games) was calculated. Further analysis characterizing the injuries by actual days between games, (classified as short: <7 days, regular: 7 days, or long: >9 days), time in the season, (broken up by both regular-season weeks and quarters of the season), and player position details were calculated. Anatomical location of injury was broken down categorically as head, core, upper or lower extremity, and undisclosed injuries. Amount of time missed by players was grouped as 0-2 weeks, 3-4 weeks, 1-2 months, >2 months.

Statistical analyses performed include chi-square to determine significance between all variables. Post hoc chi-square was used to determine true relationship between variables. Chi-square cut offs for statistical significance utilizing degrees of freedom were determined in accordance with Schield et al.[24] All calculations were performed in JMP 14 Pro (Statistical Analysis System, Cary, NC). Significance was set *a priori* at $\alpha < 0.05$.

RESULTS

There were a total of 4,228 injuries observed from the 32 NFL teams across the 5 player seasons. There were 1,131 injuries in the first, 972 in the second, 946 in the third, and 1,179 in the fourth quarter of the season, with a median of 255 injuries per week. Game schedules in the NFL, measured by time between games, did effect injury occurrence. To determine effects of time off between games on injury occurrence, a chi-square test was conducted with quarter of season by game day injury as categorized by short rest: <7 days, regular: 7 days, or long rest: >9 days. There was a statistically significant higher frequency of injuries in the second ($\chi^2=19.321$, $p<0.05$) and third quarters of the season ($\chi^2=57.475$; $p<0.05$) when there was a longer rest period (>9 days) between games (**Table 1**). Longer rest periods were associated with higher injuries mid-season; but statistically significantly fewer injuries at the beginning ($\chi^2=28.87$, $p<0.05$) and end ($\chi^2=37.731$, $p<0.05$) of the season ($p<0.001$; **Table 1**). Shorter rest periods and regular game schedules did not show a statistically significant difference in injury occurrence when analyzed by quarter of the season ($p<0.001$). When broken down by game week (1-16), there was no significant difference in injury occurrence regardless of short, regular, or long periods between games ($p<0.001$; **Table 2**).

TABLE 1. Number of Injuries by Days between Games in each Quarter of the Season during the 2012-2016 National Football League Regular Season

Quarter of the Season	Days between games		*<7 Days*	*7 Days*	*>9 Days*	*Total*
1		# Injuries	111	701	68	**880**
		Expected	126. 4	624.6	129.0	
		Cell χ^2	1.9	9.3	28.9 † ↓	
2		# Injuries	134	643	195	**972**
		Expected	139.6	689.9	142.5	
		Cell χ^2	0.2	3.2	19.3 *↑	
3		# Injuries	133	585	228	**946**
		Expected	135.9	671.4	138.7	
		Cell χ^2	0.1	11.1	57.5 *↑	
4		# Injuries	193	893	92	**1178**
		Expected	169.2	836.1	172.7	
		Cell χ^2	3.4	3.9	37.7 †↓	
	Total Injuries		**571**	**2822**	**583**	**3976**

Abbreviations: *Days between Games, (<7 Days = Short), (7 Days =Regular), (>9 Days =Long).*
*↑ indicates a statistically significant increase for cell χ^2
† ↓ indicates a statistically significant decrease for cell χ^2
Higher values of a Cell χ^2 equate to higher contribution of significance to the overall result.

TABLE 2. Number of Injuries by Days between Games during each Regular Season Week during the 2012-2016 National Football League Seasons

Days between Games		*<7 Days*	*7 Days*	*>9 Days*	*Total*
	# Injuries	0	0	1	
1	Expected	0.1	0.7	0.1	**1**
	Cell χ^2	0.1	0.7	5.0	
	# Injuries	48	233	23	
2	Expected	43.7	215.8	44.6	**304**
	Cell χ^2	0.4	1.4	10.4	
	# Injuries	36	262	18	
3	Expected	45.4	224.3	46.3	**316**
	Cell χ^2	1.9	6.	17.3	
	# Injuries	27	206	26	
4	Expected	37.2	183.8	38.0	**259**
	Cell χ^2	2.8	2.7	3.8	
	# Injuries	31	157	45	
5	Expected	33.5	165.4	34.2	**233**
	Cell χ^2	0.2	0.4	3.4	
	# Injuries	33	155	51	
6	Expected	34.3	169.6	35.0	**239**
	Cell χ^2	0.1	1.3	7.3	
	# Injuries	41	175	54	
7	Expected	38.8	191.6	39.59	**270**
	Cell χ^2	0.1	1.4	5.2	

Week of Season

	# Injuries	29	156	45	
8	Expected	33.0	163.2	33.7	**230**
	Cell χ^2	0.5	0.3	3.8	
	# Injuries	25	131	43	
9	Expected	28.6	141.2	29.2	**199**
	Cell χ^2	0.4	0.7	6.5	
	# Injuries	19	143	75	
10	Expected	34.0	168.2	34.8	**237**
	Cell χ^2	6.6	3.8	46.6	
	# Injuries	33	146	59	
11	Expected	34.2	168.9	34.9	**238**
	Cell χ^2	0.0	3.1	16.6	
	# Injuries	56	165	51	
12	Expected	39.0	193.0	39.9	**272**
	Cell χ^2	7.3	4.1	3.1	
	# Injuries	41	216	39	
13	Expected	42.5	210.1	43.4	**296**
	Cell χ^2	0.1	0.2	0.4	
	# Injuries	30	200	19	
14	Expected	35.8	176.7	36.5	**249**
	Cell χ^2	0.9	3.1	8.4	
	# Injuries	34	248	18	
15	Expected	43.1	212.9	44.0	**300**
	Cell χ^2	1.9	5.8	15.4	

	# Injuries	88	229	16	
16	Expected	47.8	236.4	48.8	**333**
	Cell χ^2	33.8	0.2	22.1	
Total Injuries		**571**	**2822**	**583**	**3976**

Abbreviations: *Days between Games, (<7 Days = Short), (7 Days =Regular), (>9 Days =Long).* Higher values of a Cell χ^2 equate to higher contribution of significance to the overall result.

Subgroup analysis revealed no significant difference in injury occurrence when comparing player position and rest between games (χ^2>25, p<0.05; **Table 3**). When analyzing anatomical location and rest between games, head, core, and upper and lower extremities had the same susceptibility to being injured regardless of time between games (χ^2>12, p=0.001; **Table 4**). Similarly, rest between games had no effect on amount of time missed by players (χ^2>12, p=0.040; **Table 5**).

TABLE 3. Number of Injuries by Player Position and Days between Games during the 2012-2016 National Football League Regular Seasons

Days between games		***<7 Days***	***7 Days***	***>9 Days***	***Total***
DB	# Injuries	145	603	124	**872**
	Expected	125.2	618.9	127.9	
	Cell χ^2	3.1	0.4	0.1	
DL	# Injuries	82	398	86	**566**
	Expected	81.3	401.7	83.0	
	Cell χ^2	0.0	0.0	0.1	
LB	# Injuries	82	432	93	**607**
	Expected	87.2	430.8	89.0	
	Cell χ^2	0.3	0.0	0.2	
OB	# Injuries	60	285	58	**403**
	Expected	57.9	286.0	59.1	
	Cell χ^2	0.1	0.0	0.0	
OL	# Injuries	78	439	82	**599**
	Expected	86.0	425.1	87.8	
	Cell χ^2	0.7	0.5	0.4	
QB	# Injuries	23	94	21	**138**
	Expected	19.8	97.9	20.2	
	Cell χ^2	0.5	0.2	0.0	

Player Position

	# Injuries	1	22	2	
ST	Expected	3.6	17.7	3.7	**25**
	Cell χ^2	1.9	1.0	0.8	
	# Injuries	34	229	38	
TE	Expected	43.2	213.6	44.1	**301**
	Cell χ^2	2.0	1.1	0.9	
	# Injuries	66	320	79	
WR	Expected	66.8	330.0	68.1	**465**
	Cell χ^2	0.0	0.3	1.7	
Total Injuries		**571**	**2822**	**583**	**3976**

Abbreviations: *Days between Games, (<7 Days = Short), (7 Days =Regular), (>9 Days =Long).*
Abbreviations: Player Position- DB, Defensive Back; DL, Defensive Lineman; LB, Linebacker; OB, Offensive Backs (Running Backs, Full Backs); OL, Offensive Lineman; QB, Quarter Back; ST, Special Teams (Kickers, Punters, Long Snappers, Special Teams); TE, Tight End; WR, Wide Receiver.
Higher values of a Cell χ^2 equate to higher contribution of significance to the overall result.

TABLE 4. Number of Injuries by Anatomical Location and Days between Games during the 2012-2016 National Football League Regular Seasons

Days between games		***<7 Days***	***7 Days***	***>9 Days***	***Total***
	# Injuries	422	1902	378	
LE	Expected	388.0	1,917.8	396.2	**2702**
	Cell χ^2	3.0	0.1	0.8	
	# Injuries	44	292	72	
Head	Expected	58.5	289.6	59.8	**408**
	Cell χ^2	3.6	0.0	2.5	
	# Injuries	58	410	76	
UE	Expected	78.1	386.1	79.8	**544**
	Cell χ^2	5.2	1.5	0.2	
	# Injuries	46	206	50	
Core	Expected	43.7	214.3	44.3	**302**
	Cell χ^2	0.2	0.3	0.7	
	# Injuries	1	12	7	
Undisclosed	Expected	2.9	14.2	2.9	**20**
	Cell χ^2	1.2	0.3	5.6	
Total Injuries		**571**	**2822**	**583**	**3976**

Anatomical Location

Abbreviations: *Days between Games, (<7 Days = Short), (7 Days =Regular), (>9 Days =Long).*
Abbreviations: Anatomical Location- LE, Lower Extremity (hip, knee, ankle, foot); Head, Head (concussion, head, neck); UE, Upper Extremity (shoulder, elbow, wrist, hand, finger); Core, Core (abdomen, pelvis, back, rib); Undisclosed, injury recorded but not specified.
Higher values of a Cell χ^2 equate to higher contribution of significance to the overall result.

TABLE 5. Number of Injuries and Amount of Time Missed by Days between Games during the 2012-2016 National Football League Seasons

Time Missed		Days between Games	<7 Days	7 Days	>9 Days	Total
0-2 weeks	# Injuries		351	1707	319	
	Expected		341.5	1,686.9	348.6	**2377**
	Cell χ^2		0.3	0.2	2.5	
3-4 weeks	# Injuries		91	517	116	
	Expected		104.0	513.8	106.2	**724**
	Cell χ^2		1.6	0.0	0.9	
1-2 months	# Injuries		68	291	84	
	Expected		63.6	314.4	65.0	**443**
	Cell χ^2		0.3	1.7	5.6	
>2 months	# Injuries		62	306	64	
	Expected		61.9	305.9	63.2	**432**
	Cell χ^2		0.0	0.0	0.0	
Total Injuries			**572**	**2821**	**583**	**3976**

Abbreviations: *Days between Games, (<7 Days = Short), (7 Days =Regular), (>9 Days =Long).* Higher values of a Cell χ^2 equate to higher contribution of significance to the overall result.

DISCUSSION

Since the NFL has one of the highest rates of injuries among sports and the effect of shortened or lengthened rest periods from playing on a weekday versus the weekend has not been thoroughly studied, this study is highly valuable. The primary purpose of this study was to determine if there was an association between injuries and rest periods between games, or unconventional game schedules. Some propose that shorter rest breaks between games could lead to higher injury rates in the NFL[12] from associations between fatigue, overuse, and muscle injuries,[25] however this has not been validated.

Players argue a shortened rest period remains a concern for player safety and suggest a shortened week reduces preparation time and increases injury risk.[26] Previous research that documents the association of myofascial injuries, muscle injuries, and muscle fatigue support their findings.[27] In our study, shorter rest periods and regular game schedules did not

show a statistically significant difference in injury occurrence. This agrees with existing literature which also failed to observe increased injury rates with shortened rest periods.[14,16,28,29] Perez et al. found significantly lower injury rates when playing with shorter rest breaks and longer rest breaks compared to regular schedules.[14] Lawrence et al. showed no correlation between injury risk and time in season.[16] Additionally, Teramoto et al. found no significant association between rate of concussion and unconventional game schedules in the NFL.[15] Similarly, the NFL released statistics finding the rate of game injuries on Thursdays similar or even lower than the rate on Sunday games.[30] Some medical reports also suggest that Thursday night football, requiring a shortened week, was not associated with increased injury rates.[31] Despite this, our data did reveal the time between games had significance on the occurrence of injuries. Longer rest periods between games were linked with increased injury occurrence in the 2nd and 3rd quarters of the season but significantly fewer injuries in the 1st and 4th quarters of the season. This data differs from Perez et al. who found significantly lower rates when playing with shorter rest breaks and longer rest breaks compared to regular schedules.[14] More data on injuries by game schedules is needed to increase statistical power and warrants future analysis.

In this study, longer rest periods between games were linked with increased injury occurrence in the 2nd and 3rd quarters of the season but significantly fewer injuries in the 1st and 4th quarters of the season. This could occur if players come into the season deconditioned, requiring more time for recovery in the beginning of the season, thus needing additional rest breaks between games to be prepared, benefiting from longer rest time between games. Additionally as the season nears the end, players may: 1) become physically or mentally fatigued,[32] or 2) experience additional exertion and need for high performance from high stake games,[32] requiring additional recovery days to keep injuries down. Higher injury occurrence midseason when there were longer rest breaks between games may be explained by 1) workload differences that may contribute to injury timing,[33] 2) decreases in training demand with less time for strength and movement training and more sports specific training during this time, or 3) possibly due to bye weeks beginning week four followed by a subsequent intense week or two at higher game speeds, acceleration, deceleration, or contact hits in these players.[33] Although researchers have attempted to investigate fatigue as a risk factor for injuries, the literature is varied in regards to their findings.[34,35] It remains unclear whether injuries are from muscle fatigue or other factors (i.e. mental, emotional, performance demand). Other considerations that could influence injury risk include minutes played, stress level, age, or experience. Future research is needed to elucidate why more injuries occurred with longer rest breaks during the 2nd and 3rd quarters of the season, but significantly fewer injuries were observed at the beginning and end of the season.

Subgroup analysis was used to determine if time between games was associated with body part injured, player position, and time missed in the NFL. Baseline information on injury occurrence and injury patterns in the NFL over a 5-year period from 2012-2017 was analyzed and a total of 4,228 injuries were evaluated. When analyzing anatomical location and rest between games, head, core, and upper and lower extremities had the same susceptibility to being injured regardless of time between games (**Table 4**). This is in agreement with Perez et. al, who found no significant difference in type of injury players sustained in relation to rest when analyzing official NFL game books.[14] By obtaining similar

results, this provides credibility to alternate methods utilized to gather information from analysis of varying databases. The current study showed 68% of injuries occurred in the lower extremity, 13.7% in the upper extremity, 10.3% in the head, 7.6% in the core, and 0.5% undisclosed (**Table 4**). Similar to other epidemiologic studies in football,[16,20,29] lower extremity injuries were most common. Lawrence et al. reported knee injuries were observed most, followed by ankle, hamstring, shoulder, and concussions,[20,36] similar to the current report. Other published studies confirmed similar anatomical injury results reported in the NFL,[3,37] soccer,[38] rugby,[39] and ice hockey leagues.[40]

Data revealed no significant difference in injury occurrence when comparing player position and rest between games (**Table 3**). Every position was susceptible to injury regardless of time between games, showing time off may be generalizable to all players regardless of position. Trends showed defensive backs (21.9%) were injured the most followed by linebackers (15.3%), offensive lineman (15.1%), defensive lineman (14.2%), and wide receivers (11.7%) (**Table 3**). Perez et al found tight ends, full backs, and linebackers had a lower rate of injuries with short rest between games; quarterbacks had a nonsignificant, higher rate with shortened rest, however the analysis was underpowered.[14] Differences in injuries by position could be due to workload differences at these positions including changes in game speeds, acceleration, deceleration, pivoting, cutting, and contact hits in these players.[33] A study by Dodson et al. found that wide receivers and tight ends, as well as line backers, half and full backs were at higher risk for ACL injuries.[41] Krill et al. found that defensive players sustained the majority of Achilles tendon ruptures in the NFL.[21] Despite having different physical and athletic requirements, player position did not appear to modify the effect of time between games on injury rates. Rest time between games equally affected all player position types in our study. Similarly, rest between games had no effect on amount of time missed by players (**Table 5**). When broken down (0-2 weeks, 3-4 weeks, 1-2 months, >2 months), time missed was not different based on time between games.

CONCLUSION

This study suggests a significant relationship between amount of rest between games and observed injuries in the NFL. Long rest periods between games in the 2nd and 3rd quarters of the season were associated with higher injury occurrence but lower injury occurrence in the 1st and 4th quarters of the season. Shorter rest periods and regular game schedules did not show an association with increased injury occurrence in the NFL. There was no difference in injury occurrence when analyzing rest between games and player position, anatomical body region, or amount of time missed by players. These findings could be useful for team staff and medical professionals in the NFL to plan game schedules and attempt to limit the negative effects injuries have on teams and players. In addition, this data demonstrates that season fatigue does not lead to increased rates of injury.

LIMITATIONS

In this study, we relied on public website data for injury information, since we did not have access to the NFL injury surveillance system, therefore there is possible injury information not available to us for analysis in this study. This could have led to overreporting total injuries by including injuries sustained in practice as well as possible reporting bias because of reporting variability from team-to-team. Although our study considers heterogeneity in

team practice schedules and player exposures, it paints a strong picture of actual injuries that occur over time, not just what is reported in a game. There can be discrepancies in reporting injury data from one team to another. While teams can be fined for providing false information, these fines are rare. Despite not having paid access to official NFL game books, our results produced similar findings to a recently published study that had this access[14] providing credibility to alternate methods and resources for obtaining similar data. Publicly reported injuries on multiple sites likely produced consistent results regarding association of game schedules and injuries with data similar to the NFL injury surveillance system. Counting the number of injuries in a given season is important in understanding how effective new NFL rules have been on player safety but there is no standard measure of seriousness of injury. Medical records are not released to the public for justifiable reasons but even if released, there is no medical consensus on injury severity.[42] Injury data was limited to anatomic location, however specific diagnosis, severity, injury history, and skill level information was not available. We were unable to consider contact versus non-contact injuries as this data was extremely challenging to accurately determine with a lack of video analysis of all injuries and that many of the injuries were chronic in nature. The NFL has evolved significantly with faster and stronger players. This results in players with more momentum when they make contact with another athlete or the ground, increasing the likelihood of more serious injuries. Additionally, when observing trends, the NFL has become a more offensive-dominant game, leading to more plays per game and more players involved per play.[43,44] Future research with focused analyses on these specific criteria is needed. The number of games played on weekdays is small in comparison to Sunday games. Up to 15 different games occur on Sunday, while only 1-5 games are played on weekdays, showing the need for additional data on the effects of playing on a weekday. In this study, only NFL injuries were observed. Consequently, the results could be different for other sports requiring different game time or total time in season or frequency of competitions. Furthermore, investigation of time played in game or time in season and its effects on injury occurrence in different sports is recommended,[35] as research is emerging in other sports indicating a relationship between stage of the season and injury risk, specifically in soccer and field hockey.[17,45] This study is observational; therefore, we cannot draw causal inferences of injury and game schedules from our data. For future investigations, researchers should observe different types of injury occurrences and identify whether age and sex apply to these trends.[46] More data on injuries by game schedules is needed and warrants future analysis. The findings of this study could be useful for team medical professionals in the NFL in terms of monitoring injuries and determining game schedules. By determining appropriate time off between games, this could decrease the cost to teams and players and could keep athletes at a lower risk of developing a season or career-ending injury.

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COMPETING INTERESTS

The authors have no conflicts of interest to disclose.

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Os Acromiale Identified While Utilizing the Swimmer's Lateral Cervical Projection: A Case Report

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ABSTRACT

The swimmer's view is used to evaluate the lower cervical spine as a supplement to the standard cervical spine series. Findings outside of the axial skeleton, such as os acromiale, can also be visualized on the swimmer's view. While os acromiale may be considered an incidental or benign normal variant, it can be symptomatic and associated with disease processes. These include, but are not limited to, shoulder impingement, acromioclavicular osteoarthritis, and rotator cuff pathology.

Key Words: acromion, radiology, anatomic variation, shoulder impingement syndrome, shoulder pain, diagnostic imaging

INTRODUCTION

The standard radiographic cervical spine evaluation consists of an anterior to posterior lower cervical projection, a lateral projection, and an anterior to posterior open mouth projection of the upper cervical spine. To fully evaluate the lowest cervical disc space, visualization of the superior endplate of T1 is required on the lateral projection. If this is not accomplished, a swimmer's lateral view is recommended, herein referred to as a swimmer's view. Cervicothoracic evaluation may be limited due to under penetration in patients who have larger body habitus or who have broad shoulders.[1,2] Twenty-two percent of all cervical spine evaluations at one clinic system utilized the swimmer's view (averages calculated utilizing

Palmer College Clinic data July 2021 through June 2022).

The swimmer's view is designed to evaluate the cervicothoracic spine, yet it can yield additional information about the shoulder girdle such as os acromiale. An os acromiale is a failure of fusion of the ossification center at the distal aspect of the anterior acromion process which typically fuses by 25 years of age. An analysis performed by Yammine showed prevalence of os acromiale to be between 4.2% to 9.6%.[3] The acromion develops from four ossification centers which include the pre-acromion, meso-acromion, meta-acromion, and basi-acromion. The type of os acromiale depends on where the nonunion of the ossification centers occur.[3,4] While this anomaly is well demonstrated on axillary views of the shoulder, complicated patient and receptor positioning may preclude this view from being performed at all facilities. Due to the orientation of an os acromiale it can be difficult to identify on standard anterior to posterior or internal and external rotation views of the shoulder.[5] An axillary view requires the patient to be supine with an abducted arm. The image receptor is placed vertically and contacting the upper aspect of the shoulder with the central ray directed towards the axilla.[2] Radiographic findings of an os acromiale include the double density sign, the ossicle projected over the remainder of the acromion, when observed from an anterior to posterior projection.[6] Os acromiale is typically an incidental finding but can be symptomatic and painful, especially with instability.

This report will explain how radiographic findings included in a swimmer's view can aid in visualization of an os acromiale.

CASE PRESENTATION

A 23-year-old male presented for evaluation and treatment with a chief complaint of neck pain and stiffness following an exercise-related lifting injury. He described pain into his left upper trapezius region which was reproduced with cervical spine left rotation and extension. The diagnosis with the highest clinical suspicion based off the history and physical exam was muscle strain which led the clinician to order cervical spine radiographs. It should be noted that these examination findings do not meet the Canadian Cervical Spine Rule (CCSR) for Radiography in Alert and Stable Trauma Patients. Therefore, the clinician did not follow the recommendation to avoid imaging as outlined by the CCSR reasoning for whiplash type injuries. The likelihood that imaging would provide clinically significant findings for a whiplash type injury is low.[7]

The patient was referred for standard cervical spine images including an anterior to posterior lower cervical spine, lateral cervical, and anterior to posterior open mouth projection. Additionally, due to the superimposition of soft tissues, broad shoulders, and the inability to visualize the superior endplate of T1, a swimmer's view was ordered.

Radiographic findings on the standard cervical three view series included cervical hypolordosis and minor lateral curvature. An os acromiale was identified on the swimmer's view leading the patient to be reassessed for clinical significance (**Figure 1**). The radiographic finding of os acromiale correlated with the patient's symptoms of pain on the superior aspect of the shoulder. Unfortunately, the patient was lost in follow-up. As a result,

management thorough rehabilitation and further imaging to assess stability of the os acromiale was not completed.

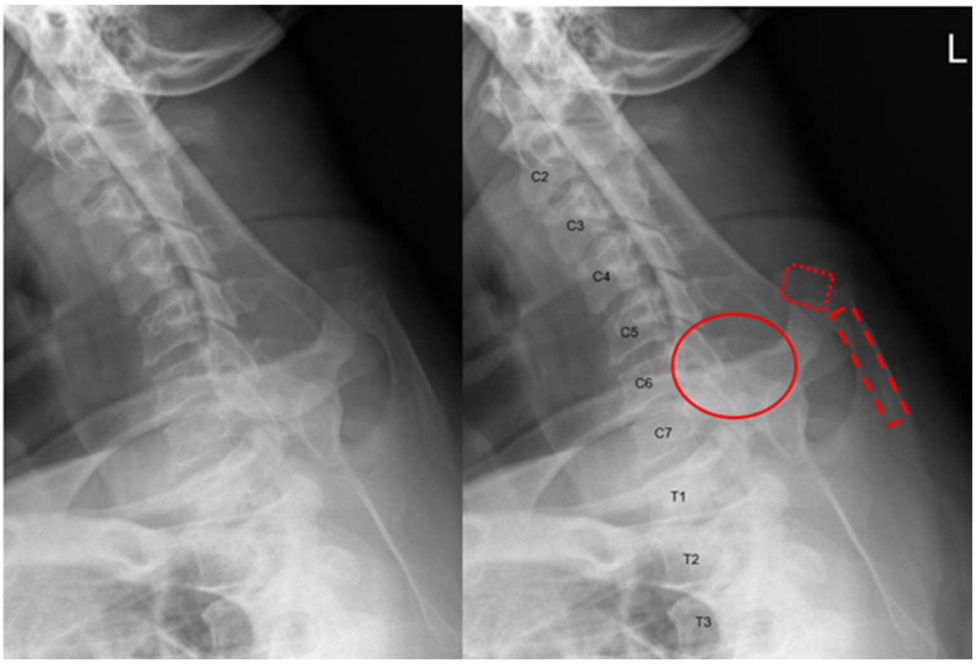

Figure 1: Non-annotated and annotated left lateral swimmer's view. The vertebral bodies are numbered, the left sided humeral head (circle), os acromiale (dotted outline), and remainder of the left acromion process (dashed rectangle) are outlined.

Positioning and Technique

For a swimmer's view lateral projection, the patient may be in a seated or standing position. The seated position is preferred to decrease motion artifact and combat issues related to the patient's ability to maintain the required position, also known as positioning fatigue. The arm closest to the image receptor is raised in full shoulder forward flexion with the elbow extended so that the arm is oriented vertically, next to the patient's ear (**Figure 2**). The image receptor should be placed vertically.[1,2] If the cervicothoracic junction remains under penetrated, the application of alternative techniques such as a caudal tube tilt of 3 to 5 degrees, or a combination of patient rotation and shoulder depression of the arm away from the image receptor can be completed. These techniques are useful for decreasing superimposition of anatomy.[1,2]

Figure 2: The patient is positioned with the arm oriented vertically, running next to the ear.

The source to image receptor distance is set at 40 inches, equivalent to 100 cm. The central ray is centered at the T1-T2 level at the mid axillary plane, with collimation to least 8x10 inches (**Figure 3**).[1] A high mAs and kVp of approximately 85 is necessary for adequate exposure and penetration. Bontrager et al. states that technical factors should be similar to what is required for a lateral thoracic, but in practice this can lead to underpenetrated images.

Figure 3: The central ray is centered at the cervicothoracic junction.

The cervicothoracic junction is denser than the air-filled thoracic cavity, therefore, to provide proper radiographic penetration and tissue detail, the mAs will likely be higher.[2]

The swimmer's view is primarily used to visualize the cervicothoracic junction, but portions of the shoulder girdle are also included within the field of view. On the swimmer's view, the humeral head that projects larger and inferior to the T3-T5 vertebral levels is the side that is positioned farthest away from the image receptor.[1] The swimmer's view is traditionally used for spinal findings, but it may occasionally show appendicular anatomic variations and lesions. Identification and awareness of these findings may contribute to patient presentation and symptomatology, therefore clinical correlation is warranted.

DISCUSSION

Typically, patients with a symptomatic os acromiale present with superior shoulder pain.[8] These patients may also have decreased shoulder motion, especially shoulder abduction, forward flexion, and/or decreased muscle strength. These patients may have difficulty with functional movements such as overhead activities.[8,9] With an unstable os acromiale, muscular pull at the attachment of the deltoid muscle on the terminal aspect of the acromion can cause downward movement of the ossicle during humeral flexion and abduction.[4]

When indicated, further dedicated clinical evaluation and imaging of an os acromiale utilizing MRI can be performed. Additionally, MRI can be used to evaluate lesions occurring in conjunction with os acromiale, such as shoulder impingement, rotator cuff pathology, and degeneration of the acromioclavicular joint. Symptomatic os acromial will present on MRI as high signal intensity at the margins of the pseudoarthrosis with possible sclerotic and cystic changes.[6] Rovesta et al. reported that upon evaluation of 726 shoulder MRI examinations of patients with symptomatic shoulder complaints, 25 (3.44%) of the patients studied had an os acromiale. Of the patients with os acromiale, 72% also had subacromial bursitis and 56% had rotator cuff pathology.[4]

Treatment for os acromiale is typically nonsurgical and includes nonsteroidal anti-inflammatory drugs, corticosteroid injections (especially subacromial), and rehabilitation to address impingement symptoms.[9-11] Targeted exercises used to treat symptomatic os acromiale may include strengthening the internal and external rotator muscles, resulting in depression of the humeral head, scapular stabilization, and serratus anterior strengthening.[12] A systematic review performed by Harris et al. investigated 115 patients with os acromiale who elected for surgical management following failure to respond to conservative care. The patient cohort with os acromiale who failed conservative management were middle aged (49±11 years), had symptoms for about a year (12±8.6 months), and had a meso-acromion type of ossicle. The most common type of surgery was internal fixation, followed by excision and acromioplasty. Patients frequently had concurrent surgical repair of the rotator cuff.[13] The meso-acromion type os acromiale had the most common incidence of adjacent degeneration at the acromioclavicular joint which was present in approximately 66.6% of patients.[3]

CONCLUSION

The swimmer's view is designed to add important radiographic information regarding the cervicothoracic junction. This view can also contribute to the evaluation of the included appendicular skeleton which may clarify the clinical picture. Os acromiale is typically considered an incidental finding but in some cases may be symptomatic. If identified on a radiographic examination, correlation with the patient's clinical history and physical examination findings could indicate the need for further evaluation and can guide clinical treatment and additional imaging.

LIMITATIONS

Limitations of this case presentation include the patient being lost in follow up, therefore follow up management and imaging was not reported upon. The swimmer's view should not be used as a screening tool for os acromiale. Referencing guidelines such as those outlined by CCSR can ensure that best practices in imaging are followed. A clinical need for imaging should be established prior to examination.

CONSENT

Written informed consent was obtained from the patient for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

COMPETING INTERESTS

The author declares no competing interests.

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Manual Therapy and Cerebral Palsy: A Narrative Literature Review

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ABSTRACT

Objective: The purpose of this paper was to collect and review articles to determine the effectiveness of manual therapy for the treatment of cerebral palsy. This exploration of such a diverse topic would help to synthesize the body of evidence available to practitioners of manual therapy-based disciplines.

Methods: A systematic search was performed to identify literature related to manual therapy and cerebral palsy symptoms. For potential inclusion, articles must have been published in a peer-reviewed journal. Database access was provided by Palmer College of Chiropractic and included: Index to Chiropractic Literature, Alt Health watch**,** MEDLINE Complete, CINAHL Complete, Academic search primer, Information Science and Technology Abstracts, EBSCO host, Dynamed, and PubMed.

Results: The current level of evidence in the literature, while overall positive, is limited and inconclusive due to complications of small study sample size, mixed results across techniques, and multiple trials consisting of mainly pilot studies. The findings of this review are consistent with reviews that had evaluated portions of the investigated topic.

Conclusion: While the studies in this review outline the prospective benefits of manual therapy on visceral function and management of spasticity, the results were complicated by study limitations. Further inquiry into the effectiveness of manual therapy techniques including joint manipulation, tissue mobilization, and diaphragmatic stretching techniques should be conducted in larger studies to determine the replicability of the observed optimistic therapy effects.

Key Words: cerebral palsy, spasticity, manual therapy, manipulation, visceral function.

INTRODUCTION

The purpose of this project was to collect and review articles to determine the effectiveness of manual therapy for the treatment of cerebral palsy. The exploration of such a diverse topic would allow for practitioners of manual therapy-based disciplines to have a synthesized review to inform clinical decision making. An examination of the current published literature around the effectiveness of manual therapy as a treatment for individuals with cerebral palsy was conducted.

Cerebral palsy is a neurodevelopmental disorder involving abnormalities in muscle tone and motor function due to damaged cerebral tissue in development and is not a single disease but rather a heterogeneous clinical syndrome.[1] Cerebral palsy is the most common physical disability of childhood, occurring in 1 out of 323 children in the United States.[2] Despite nonprogressive neurological deficits, the prognosis varies depending on severity of impairment, birth weight, and socioeconomic status.[1] Due to the incurable nature of this condition the overall goal of clinical management of cerebral palsy is to improve function, participation, and mobility while reducing complaints of limitations and pain. The significance of this project is to evaluate the current literature on management of cerebral palsy through utilization of manual therapy.

The current healthcare model calls for an optimum team which includes “a primary care physician experienced in neurological rehabilitation, a psychologist, a physical therapist, an occupational therapist, a speech therapist, a social worker, and a schoolteacher” to provide high quality patient care.[3] Encompassing a wide-range of techniques, manual therapy has been defined as “physical treatments used by physiotherapists, chiropractors, osteopaths, and other practitioners” for the treatment of musculoskeletal disabilities and pain. Commonly included under this umbrella term are techniques such as “massage therapy, joint mobilization, and manipulation”.[4] If a manual therapy specific treatment is shown to have a positive impact on patient outcomes, it could provide the opportunity for manual therapy to play a valuable role in the management of cerebral palsy. It would be beneficial to have a collection of current literature to examine the potential that manual therapy has in a treatment plan for cerebral palsy.

METHODS

A systematic search was performed to identify literature related to manual therapy and cerebral palsy symptoms. For potential inclusion, articles must have been published in a peer-reviewed journal. Database access was provided by Palmer College of Chiropractic and utilized the databases listed in **Table 1**. The search terms utilized, along with the associated MESH IDs are listed in **Table 2**. The compiled research used for this review consisted of randomized clinical trials and controlled clinical trials. An additional requirement for inclusion was the reviewed literature must include an aspect of manual therapy. The treatment effect of manual therapy techniques was evaluated using outcome measures quantifying quality of life changes such as the Gross Motor Function Measures (66 item or 88 item),[5-8] Timed up and Go (TUG),[9] Peabody Gross Motor scale,[10] and the Visual Analogue Scale.[6,11-13] Clinical evaluations such as Center of Pressure (COP) displacement,[9] Spirometry,[14,15] musculoskeletal ultrasound, [14] and the "Neuroflexor"[16] spasticity measuring device were used as objective measures in clinical evaluation. These measures have been shown to be valid and reliable for evaluation of functional performance in individuals with cerebral palsy. Articles used were selected based on the use of manual therapy specifically for cerebral palsy with the intention to decrease symptoms or improve functional ability. All additional treatment interventions to manual therapy were noted to ensure that outcomes were reflective of the effects of manual therapy. Additionally, supplemental treatment interventions or medications the patient was taking were recorded. This review did not require human subject considerations as it consisted only of a search of the current body of literature. The inclusion and exclusion criteria below were used to determine what studies were included in this review.

Table 1

(Databases searched 1980-February 2021)

- Index to Chiropractic Literature
- Alt Health watch
- MEDLINE Complete
- CINAHL Complete
- Academic search primer
- Information Science and Technology Abstracts
- EBSCO host
- Dynamed
- PubMed
- Hand Searching for articles

Table 2

- Cerebral Palsy: MeSH Unique ID: D002547
- Spinal Manipulation: MeSH Unique ID: D020393
- Manual Therapy: MeSH Unique ID: D026201
- Manipulation, chiropractic: MeSH Unique ID: D026882
- Muscle spasticity: MeSH Unique ID: D009128
- Quality of life: MeSH Unique ID: D011788

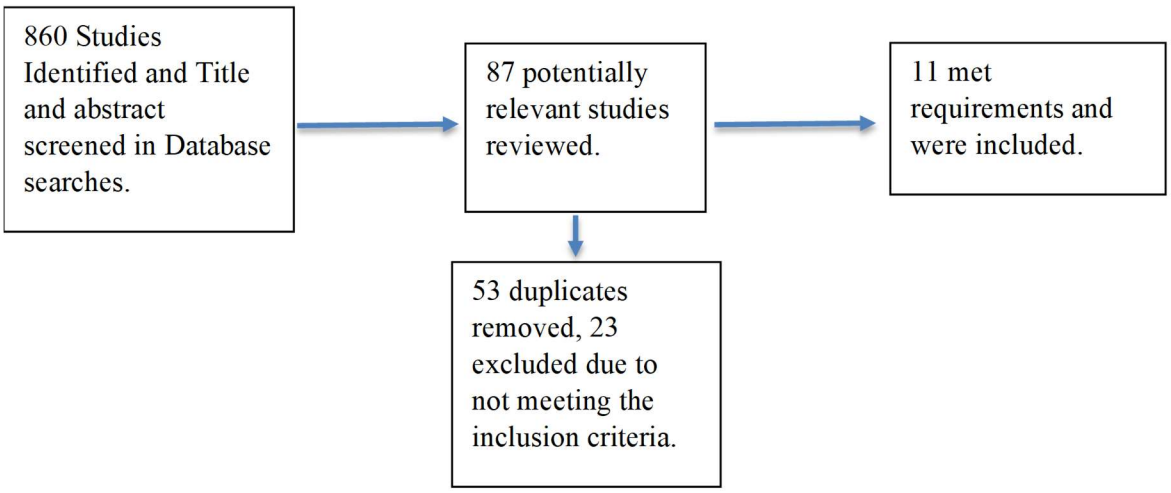
Inclusion Criteria:

- The study must be peer reviewed
- Treatment must include manual therapy as a primary treatment
- Treatment effect must be examined with an applicable outcome assessment tool
- Study must be a randomized controlled trial or clinical trial

Exclusion Criteria:

- Unrelated to cerebral palsy
- No manual therapy component
- Incomplete study

Figure 1: Inclusion/Exclusion Flow Chart



RESULTS

The literature search identified 860 articles and 87 potentially relevant studies were reviewed. After evaluation, 11 articles met the requirements for inclusion and were included in the final analysis. The included studies are summarized in **Table 4** below.

Table 4: Evidence Table

Reference	Sample	Test	Study Design	Design/Treatment intervention	Results
Bennet et al. 2021	Fifty-three children with spastic CP were randomly assigned to experimental (n = 27) and control (n = 26) groups.	The outcome variables were diaphragmatic mobility assesed via ultrasound, pulmonary function via spirometry and chest wall expansion.	Randomized Control Trial	The experimental group received Manual diaphragmatic stretching technique (MDST) on non-consecutive days, three days per week for six weeks alongside standard physiotherapy (SDPT), while the control group received only SDPT.	MDST significantly improved diaphragmatic mobility on both sides of the body, with a between-group difference of 0.97 cm (95% CI 0.55-1.39 cm, p < 0.001) for the right side and 0.82 cm (95% CI 0.35-1.29 cm, p = 0.001) for the left side. MDST significantly improved chest wall expansion at the xiphoid process and umbilical levels, with between-group differences of 0.57 cm (95% CI 0.12-1.20 cm, p = 0.013) and 0.87 cm (95% CI 0.31-1.43 cm, p = 0.003), respectively. There was no significant difference in pulmonary function testing between the groups. However, there was a statistically significant increase in FVC% predicted after treatment in the experimental group (M = 86.37%, SD = 26.22%), when compared to pre-treatment (M =81.81%, SD = 24.56%, t(26) = 2.112, p = 0.045). There was also a significant decrease in FEV1/FVC ratio among the control group after treatment (M = 103.77%, SD = 11.50%), when compared to pre treatment (M = 106.81%, SD = 11.00%, t(25) = 2.262, p = 0.033).
Hansen et al. 2012	8 children with spastic cerebral palsy of mild to moderate severity (Gross Motor Function Classification Measure levels II, III, and IV), aged 2 to 7 years old	The primary outcome measure was the Gross Motor Function Measure-66	Randomized crossover design	Each child was scheduled for 10 weekly 60- to 90-minute sessions of the intervention (myofascial structural integration) and 10 weekly sessions of a control intervention (play). Half of the children underwent play followed by myofascial structural integration and the other half in the reverse order.	Results showed that 6 of 8 children had improvement in their Gross Motor Function Measure score during myofascial structural integration treatment. The mean change on the Gross Motor Function Measure score after treatment for the 7 (of 8) that completed the test was a positive 4.49; mean change after play was positive 1.52. For 2 children younger than age 5 years (Gross Motor Function Classification Measure level II), the average change on the Gross Motor Function Measure score after approximately 3 months of treatment was a positive 7.4. This degree of change exceeds the expected average change on the Gross Motor Function Measure over 12 months for this age (anticipated mean change of +7.00, +3.19, and +3.35 for Gross Motor Function Classification Measure levels II, III, and IV, respectively). For the 5 children older than age 5 years, the mean change on the Gross Motor Function Measure score after treatment was a positive 3.2 over 3 months; this change also exceeds the expected average change on the Gross Motor Function Measure over 12 months for that age (near 0 for all Gross Motor Function Classification Measure levels). It was found that 3 of the children showed improvement only during treatment, and 3 children showed improvement in scores after treatment and after the control condition. Consistent improvements in ankle range of motion (ROM) across the group were not found. However, 3 children showed considerable improvements in ankle dorsiflexion after myofascial structural integration treatment. All the children (including 2 children who did not show improvement in Gross Motor Function Measure score) experienced improvements to their health and well-being after myofascial structural integration treatment that were not reflected in the measured outcomes but were reported by parents at the exit interview. Parents reported positive changes in their children's appetite (n =5), bowel function (n= 1), speech (n= 2), drooling (n= 3), and mood and maturity (n= 4). Out of 8 parents, 7 also reported an increase in height and/or weight during the treatment in children previously below the normal growth curve.
Kachmar et al. 2018	8 participants with spastic CP (7-18 years) without contractures or hyperkinetic syndrome	Wrist muscle spasticity was measured quantitatively with NeuroFlexor (Aggero MedTech AB, Solna, Sweden), a device assessing resistance to passive movements of different velocities. Between-group difference was calculated using the Mann-Whitney U test. Manual dexterity was evaluated by the Box and Block test.	Randomized Control Trial	The experimental group underwent SM to the cervical, thoracic, and lumbar spine, and the control group received sham SM. A second evaluation was performed 5 minutes postintervention.	In the experimental group, a statistically significant decrease in the neural componet of muscle spasticity was measured. Spasticity was reduced by 2.18 N from a median 5.53 N with interquartile range of 8.66 to a median 3.35 newton with interquartile range of 7.19; the difference was statistically significant (P = .002). In the control group, reduction in spasticity was negligible. The between-group difference in change of muscle spasticity was statistically significant (P = .034). Improvement of manual dexterity was not statistically significant (P = .28).
Youn et al. 2020	We recruited 32 children (spastic diplegia) diagnosed with CP and categorized them in two groups: the ankle joint mobilization (n = 16) group and sham joint mobilization (n = 16) group	passive ROM in ankle dorsiflexion in the sitting and supine position, center of pressure (COP) displacements (sway length, area) with eyes open (EO) and closed (EC), and a gait function test (timed up and go test (TUG) and 10-m walk test)	single blind, randomized controlled trial with two groups	Following a six-week ankle joint mobilization, the authors examined measures such as passive ROM in ankle dorsiflexion in the sitting and supine position, center of pressure (COP) displacements (sway length, area) with eyes open (EO) and closed (EC), and a gait function test (timed up and go test (TUG) and 10-m walk test).	The dorsiflexion ROM, TUG, and 10-m walk test significantly increased in the mobilization group compared to the control group. Ankle joint mobilization can be regarded as a promising method to increase dorsiflexion and improve gait in Cerebral Palsy-suffering children.

Rutka et al. 2021	Influence of Chest and Diaphragm Manual Therapy on the Spirometry Parameters in Patients with Cerebral Palsy: A Pilot Study	Spirometry test	Randomized Control Trial	The spirometry test was performed six times in the following order: (1) at baseline, (2) after the first and after the third simulated sham therapy, (3) two-week break (no spirometry measurements), (4) before the actual therapy, and (4) after the first and third actual STM therapy sessions.	No difference was found with FVC between the first and third sham manual therapies. After the first actual therapy, FVC increased by 16% compared to the baseline measurement ($p < 0.001$). After the third actual therapy, FVC increased by 19% from baseline ($p < 0.001$). FEV1 after the first actual therapy increased on average by 0.18 L (95% CI 0.17–0.21, $p = 0.04$) and after the third actual therapy by 0.24 L (95% CI 0.18–0.31, $p = 0:005$) as compared to the baseline results. An increase in FEV1 by 0.18 L is statistically but not clinically significant. After the third therapy, both clinical and statistical increases in FEV1 were observed. No difference was found with regard to FEV1 between the first and third sham therapies. After the first actual therapy, FEV1 increased by 16% compared to baseline ($p = 0.05$). After the third actual therapy, FVC increased by 20% compared to baseline measurement ($p = 0.003$). No statistical differences were found for PEF or FEV1/FVC measurements.
Tarsuslu et al. 2009	13 children with cerebral palsy diagnosed as having chronic constipation by a gastroenterologist.	Gross Motor Functional Classification System, Functional Independence Measure for Children, and Modified Ashworth Scale were used to determine the level of disability, functional independence, and muscle tonus, respectively. In addition, Constipation Assessment Scale was administered to the subjects to determine the severity of constipation. The satisfaction from the treatment was measured using a Visual Analogue Scale at 3 and 6 months.	Randomized Control Trial	The subjects were separated into 2 groups. Group 1 was treated with osteopathic methods and group 2 underwent both intervention with medication and exactly the same osteopathic treatments of group 1. Osteopathic treatments included fascial release, iliopsoas muscle release, sphincter release, and bowel mobilizations.	Most of the children included in this study were determined as level IV or V according to Gross Motor Functional Classification System. The satisfaction of the subjects or the families with the treatments was not different when the groups were compared ($P > .05$). Constipation Assessment Scale scores decreased significantly in both groups ($P < .05$). Pretreatment (initial evaluation) and posttreatment (follow-ups at 3 and 6 months) results revealed no difference between the groups in either aspects ($P > .05$). However, both groups showed significant improvements compared with baseline evaluations ($P < .05$). Osteopathic methods alone were as effective as osteopathic methods combined with medication intervention. The results of this study suggest that osteopathic methods may be helpful as an alternative treatment in constipation.
Wyatt et al. 2011	142 children from Greater London and the South West of England, aged 5-12 years with cerebral palsy.	Blind assessment of motor function by physiotherapists using the Gross Motor Function Measure-66 (GMFM-66) and quality of life using the Child Health Questionnaire (CHQ) PF50 at 6 months.	Randomized Control Trial	Children randomised to the intervention arm were invited to have six cranial osteopathy sessions: three in the fi rst 10 weeks and the remaining sessions within the 6-month study period. All practitioners were experienced, qualified osteopaths, registered to practice with the General Osteopathic Council. No attempt was made to constrain the form of osteopathic therapy given. Each child was assigned an osteopath who planned the course of therapy based on their assessment of the child's individual needs. A total of 37 osteopaths provided treatment. In order to provide a partial attention control, parents of children allocated to the 6-month waiting list were invited to take part in two semistructured interviews to ascertain their views of services for their children and their decision mak ing about CAM therapies. After children in the control group had completed the final assessment at 6 months, they were given a voucher entitling them to six prepaid sessions of cranial osteopathy. Parents were asked that their child not begin any new CAM therapies while in the trial and to continue with their usual management as recommended by the health and education professionals working with the family. To detect a clinically significant difference between groups of 0.6 SDs in the primary outcome measures, the GMFM-66 and the CHQ PF50, with 90% power and at the 5% signifi - cance level, 60 children were needed in each group (120 children in total). The authors planned to recruit a total of 150 children to allow for a possible 20% loss to follow-up. Parents and osteopaths completed forms after each treatment session to monitor compliance.	Compared with children in the control group, children in the osteopathy group demonstrated no statistically significant differences in GMFM-66 (mean difference 4.9, 95% CI -4.4 to 14.1), CHQ Physical Summary Score (mean difference 2.2, 95% CI -3.5 to 8.0) or CHQ Psychological Summary Score (mean difference 3.4, 95% CI -0.8 to 7.7). There were no significant differences between groups with respect to pain; sleep (either 'time asleep' or 'time to sleep'); or main carer's quality of life. Compared with children in the control group, carers of children receiving cranial osteopathy were nearly twice as likely to report that their child's global health had 'improved' at 6 months rather than 'decreased' or 'remained the same' (38% vs 18%; odds ratio 2.8, 95% CI 1.1 to 6.9). This trial found no statistically significant evidence that cranial osteopathy leads to sustained improvement in motor function, pain, sleep or quality of life in children aged 5-12 years with cerebral palsy nor in quality of life of their carers.
Duncan et al., 2008	55 children, 38 (69%) were boys. All children were between the ages of 20 months and 12 years. Only 3 children (5%) were younger than 24 months. Forty-three children (78%) were aged 4 years or older.	Outcome measures included standard instruments used in the evaluation of children with cerebral palsy. Less traditional measures were also used, including spinal evaluations by an independent blind osteopathic physician and visual analog scale assessments by an independent osteopathic physician and the parents or guardians. A total of 11 outcome variables were analyzed.	Randomized Control trial	Fifty-five patients were included in the study. Individual analyses of the 11 outcome variables revealed statistically significant improvement in two mobility measures for patients who received OMT--the total score of Gross Motor Function Measurement and the mobility domain of Functional Independence Measure for Children (P<.05).	No statistically significant improvements were seen among patients in the acupuncture treatment arm. A series of treatments using osteopathy in the cranial field, myofascial release, or both improved motor function in children with moderate to severe spastic cerebral palsy. These results can be used to guide future research into the effectiveness of OMT or acupuncture in treating children with spastic cerebral palsy.
Silva et al.,2012	28 children under age 4 with developmental delay and motor tone abnormalities. Fourteen children had high motor tone as a result of cerebral palsy (CP), and 14 children had low motor tone as a result of Down syndrome.	Peabody Gross Motor Scale (PGMS) Object Manipulation scores	Randomized controlled trial	Both groups received a qigong massage intervention delivered by trained staff and parents for 5 mo. The trainer version is given weekly and designed to advance the progress of the child from week to week. The parent version is given daily and designed to maintain and support progress and strengthen the child on a daily basis. Group A (n = 14) received 5 mo of treatment. Pretesting and posttesting of sensory abnormalities and gross motor skills was carried out for both Group A and Group B. A single experienced evaluator who was not blind to group conducted the motor evaluations. At the end of 5 mo, Group B (n = 11) began receiving treat ment, and another set of posttreatment data was col lected. A final data set to evaluate the maintenance effect for both groups was collected 10 mo after the start of treatment (n = 21)	Multivariate analysis and post hoc analysis of variance showed large effect-size improvements in Peabody Gross Motor Scale (PGMS) Object Manipulation scores ($p < .01$) and large effect-size improvements in overall PGMS scores ($p < .04$) in treatment versus control groups after 5 mo intervention. Follow-up evaluation 10 mo from the start indicated continued improvement. Sensory responses showed no treatment effect.
Mahmood et al., 2020	37 subjects in the control with a mean age of 6.81+/- 2.31. 38 in the intervention group with a mean age of 7.05+/- 2.47.	Modified Ashworth scale	Randomized controlled trial	Both groups received routine physical therapy in 30-minutesboth groups received routine physical therapy in 30-minute sessions once daily, five times a week for three months. However, the intervention group also received traditional massage in 30-minute sessions additionally before the start of exercises. Routine physical therapy provided to both the groups comprised stretching exercises, strengthening exercises and positioning. Each spastic muscle was stretched up to the level of mild discomfort where it was held for 20 seconds and the procedure was repeated five times.	Reduction in MAS grades were statistically significant in the right upper limb at the 6th week ($p<0.05$) , and in the right lower limb after the 12th week ($p<0.05$) in the intervention group. There was statistically significant difference from the baseline to the 6th and 12th week readings in both groups.
Rasool et al., 2017	60 children, 30(50%) in each group. The control group consisted of 14(46.7%) males and 16(53.3%) females compared to 16(53.3%) males and 14(46.7%) females in the experimental group ($p=0.72$). The overall mean age was 6.03±1.73 years.	Modified Ashworth scale	Double-blind randomized controlled trial	Both groups were given routine physiotherapy treatment which consisted of applying hot pack for 15 minutes and Bobath treatment (reflex inhibitory postures) followed by stretching the Achilles tendon (10 repetitions with at least 8 seconds hold); however, the intervention group was additionally provided with cross-friction massage on both the legs at soleus and gastrocnemius along Achilles tendon. Treatment session for both groups lasted for 30 minutes with each treatment session for 5 times a week for 6 weeks. At the end of each session, patients were assessed for improvement by an assessor blinded to the treatment.	In terms of mean MAS of controls and cases, there was no significant difference between the groups (3.87±1.19 vs 3.80±0.86) at the beginning of the study ($p=0.86$) and also after 6 weeks (3.73±1.22 vs 2.87±0.74) ($p=0.26$). However, comparative analysis within the groups showed significant improvement in the intervention group after 6 wceks ($p<0.001$). There was no significant difference observed between the groups with respect to functional level at the beginning (7.20±1.70 vs 6.80±2.04) and after 6 weeks (7.27±1.67 vs 6.87±1.92) of the study ($p=0.56$ and $p=0.55$, respectively)

DISCUSSION

Improved Visceral Function

Research found regarding the effect of manual therapy on patient outcomes in individuals with cerebral palsy, was included in this review regardless of positive or negative outcomes. While most of the research evaluated the effect of manual therapy techniques on spasticity and motor function, three studies evaluated the use of manual therapy as treatment of visceral limitations such as constipation and depressed pulmonary function. Bennet et al utilized manual diaphragmatic stretching technique (MDST) in children with cerebral palsy. This technique was hypothesized to stretch diaphragmatic muscles and improve chest wall expansion while also potentially activating the muscle spindle and Golgi tendon organ of the diaphragm, thus improving its contraction ability. In this study, the intervention group received 18 treatments of MDST and standard physiotherapy while the control group received only standard physiotherapy. Physiotherapy consisted of mat activities, stretching

exercises, balance training, range of motion exercises, and neuro-developmental training for 40 minutes per day, three days per week, for six weeks. Results showed a clinically significant increase in diaphragmatic mobility on both sides, as well as lower chest and abdominal expansions in the MDST group, when compared with the control group. Despite the changes to mobility, no clinically significant difference in pulmonary function test variables between groups were found. However, weakness of the diaphragm can lead to recurrent pneumonia and respiratory distress, two of the most common causes of mortality in children with cerebral palsy. Therefore, the authors concluded any improvement in the motion of the diaphragm may consequently lead to a reduction in respiratory complications and improvements to these other organ systems.[14] The limitations of this study were outlined by the authors. For example, most study participants were found to have spastic diplegia, with no GMFCS level V. This specificity in tested subjects makes it difficult to extrapolate the same treatment benefits recorded in the study to different individuals.

A second study evaluated the effect of manual diaphragmatic release technique. Rutka et al evaluated the effect manual therapy plays on chest and diaphragm function as measured by spirometry in patients with cerebral palsy. In the therapeutic intervention group, a clinically significant improvement in forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) was noted after the first session of therapy. The improvements of both parameters were on average 15% to 16% after the first therapeutic session. Further treatment brought a further increase in the average values of these parameters, but they were insignificant in relation to the results obtained after the first therapeutic session in the experimental group. The control group who received sham therapy had no differences in the stated parameters. Because the sham group had no treatment effect, the author concluded that the measurable effect after manual therapy was not related to learning or the placebo effect.[15]

A third study which evaluated changes in visceral function was a pilot study that evaluated the effect of osteopathic treatment on children with cerebral palsy who were suffering from constipation. Tarsuslu et al found constipation is one of the most frequent problems in children with cerebral palsy because of several reasons such as insufficient nutrition, malnutrition, increased muscle tone, decreased defecation, and immobilization. The osteopathic treatment in the study included fascial release, iliopsoas muscle release, sphincter release, and bowel mobilization which were conducted in the given order during a 30-minute session. The intervention group was treated with osteopathic methods and included seven participants. The second group included six participants and underwent both medication and the same osteopathic treatments as group one. Although there were important improvements of symptoms in both groups, there was no difference between groups. The authors concluded this may indicate that the drug regimen had no additional beneficial effects on constipation whereas osteopathic methods alone might cause these improvements.[17]

Spasticity/mobility Improvements

The most measured impact of manual therapy on cerebral palsy was regarding changes in spasticity. Eight studies evaluated the impact of various forms of manual therapy from

utilization of joint or osteopathic manipulation to various massage techniques.

First, Youn et al found a clinically significant increase in all ankle range of motion in the experimental group after joint mobilization compared to the control group which received sham therapy. Spasticity exacerbates joint contracture and muscle weakness as well as contributes to changes in muscle contractile properties. Ankle joint mobilization can be applied to reduce the spasticity of the soleus muscles, restore ankle joint flexibility, and causes articular reflexogenic effects consequently increasing dorsiflexion muscle strength. Furthermore, ankle joint mobilization may also improve balance as the authors found that it can reduce center of position displacement by improving sensory motor function and arthrokinematic restrictions. The study concluded ankle joint mobilization improved ankle range of motion and gate in cerebral palsy. However, the beneficial effect on standing balance was not confirmed.[9] The largest limitation of this study was that it failed to compare the treatment intervention to current treatment methods of patients with cerebral palsy. The authors also failed to identify adverse effects, if any occurred, of the evaluated therapy. For these reasons, the benefit of implementation in the clinical setting cannot be fully determined.

Next, three studies evaluated the treatment effect of osteopathic manipulation for management of spasticity. First, Duncan et al evaluated gross motor function changes in children following osteopathic manipulation. The authors concluded that there was statistically significant improvement from baseline Gross Motor Function Classification System scores in the osteopathic manipulation treatment group. No clinically significant changes were found in the acupuncture groups nor in the waiting list groups.[11] One limitation to this study was the failure to provide confidence intervals or P-values to support evaluation of treatment effectiveness. Additionally, it should be noted that this study was a pilot study and may serve as foundation for further research trails to be conducted.

A second study evaluated the impact of manipulation on spasticity. Kachmar et al assessed spasticity quantitatively with a Neuroflexor device by measuring the resistance to passive movement of the wrist, performed with different velocities by a computer-controlled step motor. Wrist muscle spasticity was measured quantitatively as a neural component of the muscle tone. Spinal manipulation was carried out in the thoracic, lumbar, and cervical regions. Statistically significant reduction of neural component after spinal manipulation was noted in the experimental group values dropped from the median 5.53 N to 3.35 N. In the control group, there was only a slight reduction of values from the median 6.83 N to 5.7N. Comparison between the groups revealed statistically significant difference in spasticity reduction (P=.034). The second outcome measure in the study was the study of hand dexterity measured by means of the box and block test. There was a statistically significant difference between baseline and post intervention assessment measured in both groups. In the experimental group, the pre-and post-difference was a positive 4.1 blocks per second (95% confidence interval = 5.52-2.68). In the control group, the pre-and post-difference was a positive 3.01 blocks (95% confidence interval = 4.41-1.69). While the experimental group showed a more substantial improvement, the difference between groups was not statistically significant (P= .28). The contribution of this study is that it corroborates the hypothesis that spinal manipulation may decrease muscle spasticity temporarily in

participants with disordered muscle tone regulation, specifically children with cerebral palsy. Despite these positive findings, the limitations of this study were outlined extensively by the authors. The short-term design, the potential that participants in the control group may have suspected sham therapy, and the preliminary nature of findings of decreased spasticity associated with spinal manipulation were listed as considerations by the authors.[16]

A study on the potential effectiveness of Cranial Osteopathic Therapy was conducted by Wyatt et al. This study attempted to evaluate the potential improvement that this therapeutic approach may provide in the health or quality of life of children with cerebral palsy. The authors found little evidence that cranial osteopathic therapy had a sustained improvement in the health or quality of life of children aged 5 to 12 years with cerebral palsy. At six months, neither the independent assessment of motor function (GMFM-66), nor caregiver quality of life, sleep, or pain, suggested any statistically significant difference between children who had a course of cranial osteopathic treatment and those assigned to a waiting list.[18]

Myofascial Structural Integration was examined regarding the impact that it may have on gross motor function of pediatric cerebral palsy patients. In this crossover study, each child underwent 10 weekly 60-to-90-minute sessions of myofascial structural integration, in addition to 10 weekly sessions of play, which was the control intervention of the study. The advantages of this approach, as suggested by the authors, are the fact that it targets changes in the muscle and fascial tissue directly, is a noninvasive therapy, and does not interfere with the developing movement patterns of the individual. The authors found improvement in gross motor function measure scores in six children after myofascial structural integration treatment. While it was not observed that there were consistent improvements in ankle range of motion across the group, three children showed considerable improvements in ankle dorsiflexion after myofascial structural integration treatment. While the largest limitation to these findings is the small sample size of study participants, the authors concluded this preliminary study indicates that using myofascial structural integration as a specific, complementary technique to loosen and realign muscles and joints could facilitate improved motor function in young children with spastic cerebral palsy.[8]

In their study, Mahmood et al, studied the effects of traditional massage on spasticity of children with cerebral palsy. Their determination was that traditional massage, when coupled with routine physical therapy was found to have a statistically significant effect on the reduction of spasticity when compared to routine physical therapy alone. While the right-side changes were both clinically and statistically significant the left-side did not meet either of these benchmarks.[12]

Deep friction massage was investigated by Rasool et al. In their investigation, they evaluated the effect of this therapeutic approach on both spasticity and functional ability. The study described a statistically significant reduction in spasticity after six weeks, five sessions a week, of deep friction massage within the experimental group. However, between the two groups, spasticity reduction was not significant ($P = .26$). Moreover, there was no significant improvement observed in the functional level of study subjects on both within and between the group analysis.[13]

A third study evaluated the effect of massage techniques on children with cerebral palsy and down syndrome. Silva et al evaluated qigong massage techniques in the treatment group of the study. The children with cerebral palsy who received the treatment intervention experienced positive, statistically significant improvements in all three motor domains including stationary body control, locomotion/movement, and object manipulation. Children in the control group experienced minimal, non-statistically significant changes. While there were large and significant overall treatment effects in motor development (p=.039), the overall results for the sensory impairment indicated no treatment effect (p=.265). Despite the positive findings of massage intervention in this study, the authors outlined limitations that should be considered. Limitations are consistent with those of a small pilot study, including a small sample size, short period of intervention, and the need for a wider battery of outcome measures to be administered by blinded examiners.[10]

The current level of evidence in the literature, while overall positive, is limited and inconclusive due to complications of small study sample size, mixed results across techniques, and multiple trials consisting of mainly pilot studies. The findings of this review are consistent with reviews that had evaluated portions of the investigated topic. For example, Pin et al conducted a systematic review evaluating the effectiveness of passive stretching on children with cerebral palsy. The authors found that the evidence to support the effectiveness of passive stretching in children with spastic cerebral palsy remains weak. It was concluded there is some evidence favoring passive stretching to increase range of motion in children with cerebral palsy, although the effect size remains small. Additionally, there is evidence indicating that passive stretching may reduce spasticity in children with cerebral palsy, but the effect size and clinical merit remains limited. Lastly, there is some evidence to indicate that sustained stretching is preferable to manual stretching in improving range of motion and reducing spasticity in targeted joints and muscles.[19]

CONCLUSION

The prevalence of cerebral palsy has remained steady at 2.11 per 1000 live births despite increased survival of at-risk preterm infants.[20] The consistency of the prevalence of cerebral palsy warrants additional investigation into proper management and treatment options. While the studies in this review outline the prospective benefits of manual therapy on visceral function and management of spasticity, the results were complicated by study limitations. Further inquiry into the effectiveness of manual therapy techniques including joint manipulation, tissue mobilization, and diaphragmatic stretching techniques should be conducted in larger studies to determine the replicability of the observed optimistic therapy effects. Once manual therapy has been found to be effective, further studies on frequency would also be beneficial. In a similar vein, a recent study by Ryu and Suh examined the optimal frequency of physical therapy in young children with cerebral palsy.[21] The “current treatment for people with cerebral palsy involves substantial expense. The size, nature and distribution of the economic burden emphasizes the importance of finding effective strategies to reduce the risk and severity of cerebral palsy”.[22] After treatment effectiveness and optimal frequency has been determined, clinical application of manual therapy can be compared in both effectiveness and cost-benefit ratio to current management techniques.

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