REHABILITATION OF CHRONIC BRACHIAL PLEXUS NEUROPRAXIA AND LOSS OF CERVICAL EXTENSION IN A HIGH SCHOOL FOOTBALL PLAYER: A CASE REPORT

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ABSTRACT

Background and Purpose: Brachial plexus neuropraxia (BPN), or “burners” and “stingers”, affect 50-65% of football players, with a high rate of recurrence and the potential, in rare cases, for catastrophic injury. Existing literature on rehabilitation of these athletes is limited. The purpose of this case report is to describe the successful and comprehensive rehabilitation of a subject with recurrent brachial plexus neuropraxia using range of motion exercises, cervical and periscapular strengthening, stabilization exercises, and activity modification.

Case Description: The subject was a 17-year-old high school linebacker with repeated BPN episodes. He presented with limited cervical extension, rounded shoulder posture, and weakness of the cervical and periscapular stabilizers, and was known to tackle using the crown of his helmet. Physical therapy intervention consisted of regaining full passive & active range of motion and strength in the neck, shoulders and periscapular region, including several novel stretches and exercises to address the subject's unique presentation. Dynamic stabilization, postural control, safe tackling form, and long-term maintenance exercises were also addressed to decrease risk of injury recurrence.

Outcomes: The subject regained full pain-free PROM, AROM, strength & stability throughout the upper body after ten treatment sessions over five weeks, and was able to return to full participation the next season with normal safe tackling form and no further episodes.

Discussion: Despite the prevalence, chronic nature, and potentially devastating effects of BPN, little has been written regarding comprehensive rehabilitation of the condition. Regaining full upper body range of motion, strength, and dynamic stability, as well as normalizing tackling form, is essential to resolving BPN and preventing recurrence.

Level of Evidence: Level 4, single case report

Key Words: Brachial plexus neuropraxia, burners, cervical, stingers, football

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BACKGROUND AND PURPOSE

Brachial plexus neuropraxia (BPN), commonly called “burners” and “stingers”, affects 50-65% of football players,^{1,2,3} and has been reported in high school, collegiate (Div I-III) and professional athletes. BPN also been reported in Canadian football,² rugby,⁴ wrestling, hockey, basketball, boxing and weightlifting.⁵ The rate of recurrence can be as high as 50-87%.^{1,2} Generally thought to occur in younger athletes by a blow to the head or shoulder forcing cervical sidebending in one direction and shoulder girdle depression in the other, the subsequent traction on the upper extremity neurovasculature causes transient upper extremity tingling, numbness, weakness, and/or pain.^{2,6,7,8,9,10,11,12,13} Other described mechanisms include a direct blow to Erb's Point,¹⁴ and a compression-type injury to the nerve root, caused by ipsilateral cervical sidebending and/or hyperextension, thought to occur in older (collegiate or professional) athletes with degenerative cervical canal or neuroforaminal stenosis.^{10,12,14,15,16} Sixty-two to 83% of BPN injuries in football occur while tackling or blocking,^{2,3,17} and most commonly affect defensive linemen, linebackers, defensive backs, and offensive linemen, and to a lesser extent, running backs and wide receivers.^{1,2,3,17} The athlete may present on the sidelines slightly bent at the waist with the involved upper extremity lowered down, supported by the uninvolved side, and the neck flexed toward the side of the injury to reduce tension on the injured nerve. To relieve symptoms, athletes often shake their hands or bring their chin toward their chest.² Acute symptoms typically last seconds to minutes,² and the majority of injured athletes lose less than 24 hours of participation,¹⁷ or lose no time at all,² but regaining full symptom-free function may take days or weeks, especially after repeated episodes. Injured athletes often do not report their symptoms² and attempt to return to play once their symptoms partially subside, and sometimes suffer several neuropraxia episodes before notifying medical staff. Return to play after brachial plexus neuropraxia is generally allowed once symptoms resolve and the clinical examination is normal,^{9,13,18,19,20} including within the same game,^{12,20,21} although there is no consensus on this topic.²² Athletes with chronic symptoms and/or episodes are typically sent for plain film radiographs and/or MRI

to investigate for cervical pathology, and electromyography may also be considered for symptoms lasting several weeks.^{12,20,21,23}

Central canal and neuroforaminal stenosis has been strongly associated with chronic BPN in professional and collegiate football players,^{10,15,24} and has been identified in athletes ages as young as 15-18 years old.²⁵ Cervical intervertebral disc degeneration (CIDD) and decreased cervical extension ROM may also be related to BPN; in a recent study of 49 Japanese collegiate football players, of those with CIDD, 59% had sustained BPN injuries, compared to only 6% of those without CIDD.²⁶ In the same study, significantly lower cervical extension ROM was found in athletes who had sustained BPN during the previous season (50.9°) than in those that hadn't (60.2°).²⁶

Continuing to play despite repeated BPN can be devastating. Several authors have reported cases of traumatic cervical nerve root avulsion in football players, leading to near complete loss of upper extremity function.^{27,28,29,30} At least one of these subjects had a documented history of repeated BPN episodes.²⁸ The combination of congenital central canal stenosis, loss of cervical lordosis, and a tendency to lead with the crown of the head when tackling, called “Spear Tackler's Spine”, is considered extremely dangerous due to the risk for catastrophic spinal cord injury from axial loading and possibility of fracture/dislocation of the cervical vertebrae. Spear Tackler's Spine is generally considered to be an absolute contraindication to playing football,^{13,31,32} although there is debate on this topic.³³

Literature on rehabilitation of brachial plexus neuropraxia is quite limited, and generally consists of cervical range of motion and isotonic strength exercises, and strengthening of the upper trapezius, deltoids and rotator cuff musculature.^{34,35,36} Described strength exercises for the cervical spine typically include isometrics or isotonic using manual resistance, exercise bands, and weight machines. Despite their direct influence on stability and posture of the cervicothoracic spine and shoulder complex,^{37,38,39,40,41} and their inclusion in published rehabilitation programs for cervical radiculopathy,^{42,43,44,45} strengthening of the periscapular muscles has been mentioned only occasionally as part of BPN rehab, and not in

any detail. No literature could be found describing any kind of dynamic spinal stabilization, neuromuscular re-education, postural control, or tackling replication exercise as part of BPN intervention.

Equipment adaptations such as cervical collars or augmented shoulder pads are sometimes used, but their success in preventing brachial plexus neuropraxia has not been firmly established beyond anecdotal or biomechanical studies.^{14,46,47,48} These collars have been shown to somewhat limit hyperextension but have little effect on controlling the cervical sidebending typically found with brachial plexus neuropraxia.^{46,47,48} There is no known literature on rehabilitation of Spear Tackler's Spine syndrome and/or loss of normal cervical lordosis.

The purpose of this case report is to describe the successful and comprehensive rehabilitation of a subject with recurrent brachial plexus neuropraxia using range of motion exercises, cervical and periscapular strengthening, stabilization exercises, and activity modification. Some aspects of this group of interventions could be applied broadly to subjects with this condition, and others are unique to this particular subject.

CASE DESCRIPTION: SUBJECT HISTORY AND SYSTEMS REVIEW

The subject was a 17-year-old male high school football player (height 5'11"/1.80 m, weight 183 lbs/83 kg) seen 17 days following a football game in which he sustained two BPN episodes. Per his report, the first occurred while tackling another player, at which time his head was down and the other player ran directly into the superior aspect of the subject's shoulder. He felt immediate pain and weakness into the left arm and left the game, although he did not report his symptoms to the coaches or medical staff. He attempted to return to the game later but his acute symptoms returned when attempting to block another player, at which time he left the game and notified medical staff. The subject later admitted that similar episodes had occurred at least four times in the prior two seasons, all involving left arm pain, weakness and numbness following contact. He denied any previous neck, shoulder, or upper back injuries or symptoms, and all other past medical history was unremarkable. Post-injury cervical MRI &

plain film radiographs revealed a loss of cervical lordosis. The intervertebral discs were of normal height and alignment. Subject (and parents') goals were to return to football when safe to do so while avoiding further episodes of BPN.

CLINICAL IMPRESSION #1

The subject's mechanism of injury and subsequent symptoms indicated a fairly classic presentation of brachial plexus neuropraxia. Examination should focus on strength, stability, range of motion, and posture throughout the cervical spine, scapulothoracic region, anterior chest and shoulders, as well as discussion of the subject's tackling technique. Weakness, tightness, and postural adaptations in these areas would indicate the subject would benefit from strengthening, stretching, manual techniques, stabilization exercises, postural interventions, and tackling technique corrections. The repetitive and worsening nature of the subject's multiple recent BPN injuries, including neurologic involvement, made the assessment of underlying compensations and adaptations, rather than symptom relief alone, especially important.

EXAMINATION

The subject complained of dull, burning pain in the left lateral aspect of the cervical spine and left shoulder at rest, and noted an area of altered sensation in the left anterior humerus, all of which were exacerbated by active or passive right cervical sidebending. He also noted sharp pain in the posterior cervical and left periscapular regions with active cervical extension.

Table 1 lists physical examination findings, including range of motion, measured using standard goniometry, and strength, using manual muscle testing.⁴⁹ It was noted that the subject's active cervical extension took place almost exclusively at the upper segments of the cervical spine, with virtually no motion palpated below the level of C3 during AROM. Bilateral passive scapular retraction performed by the therapist elicited a report of tightness in the pectoral region by the subject; while this test has not been formally studied or validated, this was thought to indicate decreased muscle length of the pectoralis muscles. Cervical segments from C3-4 to C7-T1 were hypomobile and

Table 1. Clinical Examination Findings.			
		<i>Initial Evaluation</i>	<i>Discharge (10 visits, 5 weeks)</i>
Active Range of Motion	Cervical Flexion	55	55
	Cervical Extension	40	55
	Cervical Rotation	65 R, 50 L	70 R, 70 L
	Cervical Sidebending	25 R, 40 L	40 R, 40 L
Passive Range of Motion	Shoulder Flexion	165 R, 180 L	180 R, 180 L
Joint Accessory Mobility	C3-T1 Left Sideglides	Hypomobile, Painful	Unrestricted, painfree
	C3-T1 PA Mobilizations	Hypomobile, Painful	Unrestricted, painfree
Strength Testing	Middle trapezius	4-/5 L, 4/5 R	5/5
	Lower trapezius	4-/5 L, 4/5 R	5/5
	Rhomboids	4-/5 L, 4/5 R	5/5
	Infraspinatus	4/5 L, 4+/5 R	5/5
	C6, C7 Myotome	Weak	Normal
	Anterior Cervical Stabilizers	Able to hold Chin-tuck head lift for <10 seconds	Able to hold Chin-tuck head lift for 45 seconds
Functional Testing	Active Contralateral Sidebending	Replicated chief complaint of left sided cervical pain	Symptom free
	Tackling Form (per patient/parents' report)	Head-down	Head-up

tender with posterior-anterior (PA) mobilizations as well as manual segmental side-glide examination on the involved left side, while the C1 and C2 vertebrae were pain-free and unrestricted with PA mobilizations and side-glides. Thoracic spinous processes were grossly well aligned with no pain or hypomobility with PA spring testing. Strength of the deep anterior cervical stabilizers was noted to be weak, as the subject was able to maintain a chin tuck/head lift maneuver for less than ten seconds.^{50,51,52} The subject's posture at rest was notable for bilaterally protracted and internally rotated scapulae.

CLINICAL IMPRESSION #2

Findings confirmed weakness in scapular and cervical stabilizers, as well as tightness throughout the cervical spine and presumed tightness of pectoralis

minor. The authors expected to see improvement in manual muscle testing, ability to stabilize during perturbation exercises, and gross pain-free ROM of the cervical spine and shoulder within two to three weeks. Full, pain-free cervical and shoulder range of motion, strength, and stability during perturbation exercises were expected to take at least four to six weeks given the repeated nature of the injury and the long-term nature of his underlying impairments.

INTERVENTION

Initial treatment focused on subject education and reducing stress on the cervical nerve roots by re-establishing normal range of motion and posture. The nature of the subject's BPN syndrome, loss of cervical lordosis, and poor tackling habits was discussed at length, along with the resulting potential

for catastrophic spinal cord or nerve root injury. The subject was instructed in a home program of self-stretching for the cervical spine, shoulder, and anterior chest, along with active scapular and cervical repositioning to begin correcting his posture. The subject performed self-stretching at home with gentle overpressure into cervical flexion, and right and left rotation; these were also passively stretched by the therapist in the clinic. Contralateral side-bending was avoided due to re-creation of brachial plexus symptoms. Anterior chest muscle tightness was addressed with a doorway pectoral self stretch at home, keeping a neutral spine and retracting the scapulae as the subject moved forward through the doorway. The shoulders were stretched into flexion at home using a cane in supine, bilaterally. Proper scapular positioning was taught using seated scapular retraction and unilateral scapular circles, each done with an emphasis on moving the scapula while keeping a neutral spine posture to avoid compensation in the spine. Active cervical retractions were also prescribed, to be performed with the subject sitting with scapulae retracted. Each exercise was to be performed twice per day, 10-15 repetitions with five second holds.

Manual Grade II left side-glides and posterior-to-anterior (PA) joint mobilizations of the painful and hypomobile middle and lower cervical segments by the therapist were performed during the first two follow-up visits, but were abandoned due to persistent muscle guarding and discomfort during the mobilizations, as well as continued symptoms overall. Given the poor response to this aspect of treatment, a new method of regaining cervical ROM was needed. To regain normal extension in these segments, the subject was taught to actively extend the cervical spine with a towel wrapped around the middle and lower cervical segments, with instruction to feel his neck bending in the segments covered by the towel (Figure 1). While appearing similar to the commonly-used Mulligan SNAG technique,⁵³ the towel in this case was used for tactile cueing rather than joint mobilization. The subject was able to perform the stretch without the guarding and pain elicited by the manual joint mobilizations, and he finally felt motion in the targeted segments, which traditional stretches and mobilizations did not seem

Figure 1. Active cervical extension with towel to help isolate stiff segments.

Figure 2. Active cervical extension in prone-on-elbows position.

to achieve. This combination of tactile feedback and active participation by the subject helped not only with range of motion but also with proprioception and motor learning, which was the used later to incorporate proper active extension with tacking techniques. Active cervical extension was also performed in the prone-on-elbows position (Figure 2), letting the ribcage drop toward the table, which helped combine lower cervical and upper thoracic extension with scapular retraction. Each of these active cervical extension stretches were done twice per day at home, 10-15 repetitions for five seconds each.

Scapular strengthening exercises were also initiated in the early visits. At first these consisted of

unilateral and bilateral prone retraction with horizontal abduction, prone rows with a 1.36 kg (3 lb.) hand weight, and seated row with surgical tubing (three sets of 15 repetitions each, every other day only). Isolated scapular retraction was emphasized with each exercise, and care was taken to avoid excessive hyperextension or hyperabduction at the glenohumeral joint. The rowing exercises were specifically performed using a two-part motion of scapular retraction first, followed by glenohumeral motion, to further emphasize the scapular musculature. Strengthening of the deep anterior cervical stabilizers was initiated using a supine chin tuck/head lift (cervical retraction/flexion) exercise against gravity, five second holds, three sets of five to ten repetitions, done every other day.

After six visits (16 days) the subject demonstrated normal myotomal strength, full shoulder ROM, and improved scapular strength (grossly 4/5), with full ROM and only mild discomfort at the end-range of active cervical extension. Several new exercises were begun to incorporate this new mobility and strength into the subject's ability to eventually tackle while maintaining cervical extension. Bilateral upper extremity overhead presses were done with exercise tubing in a bent-over position with the subject's torso as close to the horizontal plane as possible to closer replicate actual tackling posture (Figure 3). Scapular strengthening was progressed to standing horizontal abduction with tubing, which was performed unilaterally with emphasis on scapular retraction. Scapular retraction was also performed bilaterally in prone with the subject in full active cervical extension (Figure 4) in order to combine the action of the thoracic and scapular stabilizers with the cervical extensors, further reinforcing proper tackling posture and cervicothoracic stabilization. Several traditional shoulder strengthening exercises were performed similarly with the subject in cervical extension, including lat pull-downs, overhead dumbbell press, bent-over rows (Figure 5), overhead military press on a Smith machine, and dumbbell push-ups.

Before the subject could be safely discharged, his tackling form needed to be corrected. This was performed by simulating the tackling motion up to the point of contact with the subject maintaining cervical

Figure 3. *Bent-over overhead press while in cervical extension.*

Figure 4. *Prone bilateral scapular retraction while in cervical extension.*

Figure 5. *Weightlifting while in cervical extension.*

Figure 6. "Heads-up" tackling replication with perturbations.

extension (the "heads-up" position). At first this was performed with the subject simulating contact with the therapist as the therapist held a large exercise ball, with the subject facing a mirror for visual feedback. Once the subject understood correct positioning and muscular stabilization, rhythmic perturbations were applied at the head, shoulder, arms and physioball (Figure 6) to further reinforce proper stability and tackling form while maintaining cervical extension. The subject was instructed in anticipatory firing of the shoulder, scapular, and cervical stabilizers before contact so that the muscular support system would be engaged and prepared to maintain stability at the point of contact and through the end of the tackling motion, rather than attempting to fire them after the fact.

After 10 visits (five weeks) the subject had regained full pain-free active and passive cervical extension, symptom-free contralateral side-bending, normal (4+ to 5/5) scapular strength, and proper head and neck positioning which was maintained during tackling replication.

Return phase/Clearance

The subject was cleared by his physician to return to full contact sports including football upon demonstration of full symptom-free strength and ROM of the cervical spine and upper extremity, as well as normal cervical plain-film radiographs. The physician specifically recommended that the subject

discontinue football if any further episodes of BPN occurred.

Follow-Up

The subject's season had ended by the time he was cleared to return, but he was able to return to full participation the following season without further BPN episodes and with normal "heads-up" tackling form per his parent's report.

DISCUSSION

The authors believe that this subject's successful recovery depended heavily on restoring normal passive and active cervical extension, increasing periscapular and cervical strength, and, finally, performing neuromuscular re-education and tackling form modification.

Restoring cervical extension

While the authors do not advocate extension stretching for all subjects with cervical dysfunction, in this case, due to the subject's chronic BPN and habit of tackling with the crown of the helmet, it was essential to restore normal safe mechanics and function. Many players hit with their heads down in an effort to avoid looking at their target or (erroneously) to produce more force; however, this subject may have kept his head down simply because his loss of cervical extension prevented him from looking up to face his target.

In light of recent findings by Hakkaku, et al that athletes with BPN have decreased extension ROM,²⁶ the approach detailed in this case report may be applicable to many athletes with BPN. Screening specifically for extension ROM loss may help identify athletes at risk for BPN, and may also help identify some of the high number of athletes who have suffered chronic or repetitive BPN episodes, or have not reported their BPN injuries to medical staff at all.

The ineffectiveness of traditional passive self-stretching and manual joint mobilizations led the authors to find that the subject's loss of extension was not consistent throughout the region; he had essentially normal active and passive ROM in the upper cervical segments but the middle cervical, lower cervical, and upper thoracic segments remained in neutral or in flexion with marked muscle guarding. Restoring normal ROM therefore required stretching specific

Table 2. *Physical Therapy Interventions.*

Week 1 (3x/week)	<ul style="list-style-type: none"> • Self-stretching <ul style="list-style-type: none"> ○ Cervical flexion, R/L rotation, R sidebending; B shoulder flexion with cane in supine; B horizontal abduction in doorway 	10-15 reps, 5 sec holds, 2x/daily at home
	<ul style="list-style-type: none"> • Muscle activation <ul style="list-style-type: none"> ○ Seated scapular retraction, shoulder circles, & cervical retraction 	10-15 reps, 5 sec holds, 2x/daily at home
	<ul style="list-style-type: none"> • Manual PA glides & L sideglides* 	Grade II, 3 bouts of 30 seconds each
	<ul style="list-style-type: none"> • Periscapular strengthening <ul style="list-style-type: none"> ○ Prone retraction with horizontal abduction, prone rows with 1.36 kg (3 lb.) weight, seated row with surgical tubing 	3 x 15 reps each, every other day at home and in clinic
	<ul style="list-style-type: none"> • Deep anterior cervical strengthening (chin tuck/head lift) 	3 reps to fatigue, every other day at home and in clinic
	* <i>Discontinued due to pain & lack of response</i>	
	<ul style="list-style-type: none"> • Continue HEP stretching & periscapular/deep cervical strengthening 	
	<ul style="list-style-type: none"> • Cervical extension exercises <ul style="list-style-type: none"> ○ Active cervical extension with towel to cue movement to restricted segments ○ Active cervical extension in prone-on-elbows position 	10-15 reps, 5 sec holds, 2x/daily at home
Weeks 3-5 (1-2x/week)	<ul style="list-style-type: none"> • Continue HEP stretching & strengthening 	
	<ul style="list-style-type: none"> • Overhead and forward press strengthening with patient in cervical extension <ul style="list-style-type: none"> ○ Bent-over overhead press ○ Prone scapular retraction in cervical extension ○ Weightlifting in cervical extension (overhead dumbbell press, lat pulldowns, bent over rows, overhead Smith machine military press, dumbbell push-ups.) 	3 x 15 reps each, every other day at home and in clinic
	<ul style="list-style-type: none"> • Tackling replication in "heads-up" position <ul style="list-style-type: none"> ○ Holding physioball vs. perturbations by therapist 	2-3 bouts to fatigue in clinic

segments of the cervical spine individually rather than moving the neck as a whole. Active self-stretching with the towel serving as a tactile cue to guide his movement at the restricted segments allowed for improved proprioception, joint position sense, and motor learning, and also produced less muscle guarding and pain than the other passive methods attempted at first. Without regaining mobility in the restricted segments of his cervical spine and then re-learning the ability to actively extend from those segments, the subject likely would have had difficulty

incorporating optimal segmental cervical extension into a proper "heads-up" tackling form and may have returned to his previous habit of tackling with his head down and cervical spine in flexion.

Role of scapular & cervical strength

Scapular stability and positioning was emphasized from the first visit through the long-term maintenance program. Subjects with neck pain have been found to demonstrate altered scapular positioning and muscle activation.^{54,55,56,57} This area was

considered vital to normalize strength and stability of the shoulder complex, necessary for tackling, as well as to provide a stable and well-positioned thoracic spine from which to move and stabilize the cervical spine. Scapular strengthening exercises were performed unilaterally in prone on a treatment table, rather than bilaterally on an exercise ball as commonly described in rehabilitation literature. This position was chosen to avoid compensation from the glenohumeral joint, lumbar spine, or contralateral scapula, as well as to improve motor control and neuromuscular reeducation of the periscapular muscles.

Strength and endurance of the deep anterior flexors is critical for dynamic cervical stability, and has been shown to be decreased in subjects with chronic neck pain^{58,59,60,61,62,63,64}. Several authors have demonstrated improved strength and decreased pain using a variety of therapeutic exercises directed at these deep muscle groups.^{64,65,66,67,68} While not as specific as performing an isolated supine craniocervical flexion maneuver,⁵¹ lifting the head against gravity while maintaining craniocervical flexion has been shown to be effective.⁶⁸ This specific exercise allowed the subject to progress his cervical strength and endurance at home without equipment. This was also thought to be more applicable to football, where the subject would be using all cervical stabilizers, including the deep and superficial layers, to withstand contact at the head. Finally, isolated deep flexor exercise alone has not been shown to carry over to functional tasks.⁶³ For this reason, these muscles were specifically used during tackling replication exercise later in the process, using rhythmic stabilization and functional positioning, in order to reinforce proper stabilization of the cervical spine while in the act of tackling.

Combining cervical extension with arm motion

Ordinarily, subjects with cervical dysfunction are encouraged to maintain a neutral spine position with all corrective and functional exercise. In this circumstance, normalizing this subject's tackling form (and thus reducing risk of catastrophic injury) required combining his newly-improved cervical extension and upper back/scapular strength with

the arm and torso positioning used in football tackling to help him avoid cervical flexion when making contact. This may be even more important in light of recent findings of decreased extension ROM in athletes with BPN, indicating a possible relationship between loss of cervical extension and BPN.²⁶

Anticipation: engaging stabilizers before contact

The subject was instructed in anticipatory firing of the cervical, scapular, and glenohumeral stabilizers before contact so that these muscles would be engaged and prepared in order to maintain dynamic stability of all involved segments and joints leading up to the point of contact, rather than attempting to fire them after contact was initiated. Research by Hodges, Falla and others^{58,59,69,70,71,72,73,74,75} has indicated a loss of this anticipatory firing of the stabilizing musculature in individuals with chronic cervical and lumbar spine pain, and specific re-training exercise has shown to normalize the anticipatory firing pattern of transversus abdominis in subjects with chronic low back pain.^{74,75} Anticipatory stabilization firing may be even more important in cases of brachial plexus neuropraxia because of the apparent inability to stabilize at contact, allowing the head, neck and shoulder girdle to deviate from their neutral positions, thereby placing tension or compression on the nerve roots.

Monitoring/Improving tackling form

All of these changes would be for naught if the subject returned to his prior tackling habits on the football field. Observing him in live contact situations with his team was essential to monitor and give feedback on his tackling form. His coaches, trainers, and parents were included in this oversight to be sure he maintained good form throughout the season, and they were encouraged to give reminders and corrections if needed.

Limitations

As with all case reports, this case report is limited in its generalizability and its ability to prove cause and effect. It is also limited by its lack of objective data (hand-held dynamometry would have been preferable to manual muscle testing) and also lacked patient-reported outcome measures, pre- and

post-intervention radiographs, formal measurement of anterior chest wall (or pectoralis minor/major) tightness, and long-term follow-up.

CONCLUSIONS

The results of this case report indicate that the 17-year-old subject who had sustained several episodes of BPN was able to return to contact sport performance (football) after comprehensive rehabilitation that focused on range of motion, strength, dynamic stability, and activity modification. This case report details a more comprehensive and detailed approach to resolving recurring brachial plexus neuropraxia than is currently found in the literature. In addition to regaining strength and mobility of the cervical spine, the elements of scapular strengthening, anticipatory firing of stabilizing musculature, and tackling form modification are, in the opinion of the authors, equally crucial elements to resolving BPN in athletes and preventing recurrence. Future research might include case series with long-term follow-up, and might also further examine the relationship between BPN and loss of cervical extension, for both predictive and therapeutic applications.

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