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Physical Therapy Management for a Collegiate Football Athlete with Post-Concussion Syndrome – A Case Report

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PHYSICAL THERAPY MANAGEMENT FOR A COLLEGIATE FOOTBALL ATHLETE WITH POST-CONCUSSION SYNDROME- A CASE REPORT

by

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This Scholarly Project, submitted by Alyssa Theede in partial fulfillment of the requirements for the Degree of Doctor of Physical Therapy from the University of North Dakota, has been read by the Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

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ABSTRACT

Background and Purpose: A concussion is a traumatic brain injury caused by a violent bump, blow or jolt to the head that causes the head and brain to move or slide rapidly back and forth forcefully against the inner walls of the skull. This case study evaluates the effectiveness of physical therapy intervention for post-concussion syndrome and cervical spine hypomobility and pain, and discusses the outcomes experienced by the patient. **Case Description**. The patient was an 18-year-old male collegiate football athlete who acquired post-concussion syndrome, and cervical hypomobility and pain physical therapy treatment in an outpatient clinic for a total of six visits. The patient had a past medical history of multiple concussions in high school. **Intervention.** The therapy provided emphasized exertional rehabilitation for concussion, along with manual therapy manipulations to the cervical spine for hypomobility and pain. These interventions were used to increase functional ability and return to his prior level of function of football and academics. **Outcomes.** Over the course of treatment, the patient was able to decrease his post-concussion and neck symptoms, return to full contact football, and was able to concentrate when completing his academics. **Discussion**. The patient responded well to the treatment, and all of his short term and long-term goals were met. However, more research must be done to determine the best combination of interventions to effectively rehabilitate a patient with post-concussion symptoms and cervical hypomobility and pain.

CHAPTER I
BACKGROUND AND PURPOSE

Concussion is becoming a much more established topic in today's society, especially in the college population. Concussions are common and can occur in both sport and non-sport related activities. A study reported that from 2015-2018, the incidence among both general population and athletes was 132.4 concussions per 10,000 students. Specifically, in the 2017-2018 academic year, 15 out of 238 male athletes acquired a concussion while 22 out of 229 female athletes acquired a concussion[1]. Due to the high prevalence, concussions are common among the collegiate student and athletic population and significant in today's health care system when diagnosing, evaluating and treating the symptoms that persist.

Concussions have been an issue for many years, but to this day they are still not fully understood. According to the American Journal of Medicine, concussion has been recognized for over 1000 years[2]. It was first recognized in boxers around the year 1928, but did not get the much-needed attention, and studying it needed as this was the goal in boxing. Some of the first studied cases of concussion were completed in London in the 1930s-1950s in which they called the participating boxers as acting "punch drunk[3]." This is when a boxer gets hit so many times that he gets a sense of disorientation. Concussion has more recently been studied in retired professional football players in the last 15 years due to their high prevalence of developing chronic traumatic encephalopathy (CTE). The first published evidence of CTE was described in 2005 in a former Pittsburgh

Steeler football player. CTE can be defined as “brain trauma that is either repetitive, episodic, or a single precipitating event, leading to progressive brain neurodegeneration[4].” Due to this very serious disease, the study of concussions in recent years have skyrocketed due to the need to diagnose sooner, identify more accurate prognostic measures, and develop the equipment needed to prevent this from happening to more contact sport athletes across the world.

The American Academy of Neurology defines concussion as a “clinical syndrome of biomechanically induced alteration of brain function typically affecting memory and orientation, which may involve loss of consciousness[5].” The damage done is at the microscopic level which leads to abnormal movement of calcium, potassium, glutamate and other substances in and out of the injured cells that disrupts normal function of the cells in the brain. Following a concussion, the brain also restricts blood flow to the damaged areas which limits the attempt to repair itself which is why some symptoms may not occur until days after the injury[6].

There are different types of concussions based on symptoms that are scored on a 1-3 scale, 1 being mild and 3 being severe. The different levels depend on the amount of time the symptoms last and if the individual experienced loss of consciousness. In a mild concussion, symptoms last for less than 15 minutes with no loss of consciousness. A moderate concussion, symptoms last longer than 15 minutes with no loss of consciousness. A severe concussion, the person loses consciousness[7]. Symptoms can be monitored on

the field to diagnose a concussion, along with assign a grade to the concussion therefore it is important to understand the symptoms.

Signs and symptoms play a very large role in the diagnosis of symptoms. It is important to diagnose concussions early in order to take a player out of the game or practice. Signs and symptoms of concussion vary greatly depending on the severity of the injury. Symptoms may be subtle or severe and may last for days or months. The most common acute symptoms include confusion, loss of consciousness, posttraumatic amnesia, retrograde amnesia, balance deficits, dizziness, visual problems, personality changes, fatigue, sensitivity to light/noise, numbness, and vomiting. Chronic, or post-concussion syndrome, signs and symptoms include fatigue, sleep disturbances, headache dizziness, irritability, affective disturbance, apathy or personality changes[8]. As an observer, coach or athletic trainer, one needs to be on high alert for both acute and chronic symptoms of concussion as many athletes may not report their symptoms.

An anonymous survey of a cohort of college athletes showed that 43% of athletes have suffered a concussion deliberately concealed their symptoms indicating underreporting[9]. Many athletes may not disclose their symptoms for fear of not being able to participate. This will cause a large issue in the case of CTE. If athletes are not reporting past concussions, or underestimating the amount of concussions they have had, the more likely they are to acquire CTE. Research has also linked CTE to age of beginning a contact sport. Starting football at the age of 5, instead of 14, may increase the risk of developing CTE by 10 times[10]. This means that the younger a player starts playing a contact sport

such as football, the more likely they are to acquire more concussions and experience symptoms of CTE later in life.

Post-concussion management and return to sport protocol play a large role in shortening the length of concussion symptoms. This can be completed by a physical therapist. A systemic review studied the evidence regarding rest and active treatment following a sport-related concussion. They found that 24-48 hours of complete rest following a concussion is appropriate. The patient should then gradually increase activity using a closely monitored submaximal aerobic exercise that was most beneficial. Interventions included cervical and vestibular rehabilitation for cervical spine pain and headaches[11]. In an article by Dematteo and colleagues, they studied return to activity following traumatic brain injury/concussions and how youth with post-concussion syndrome are affected by standardized exertion testing which consisted of a cycle ergometer. This study proved that exertional testing has an important role in the evaluation of symptoms and readiness to return to activity. Overall, controlled exertion seemed to lesson symptoms for most youth (8.5-18.3 yr) with previous confirmed concussion and has a big role in when the patient will be able to return to activity[12].

Research has also shown that typical post-concussion syndrome symptoms may not be the only source of signs and symptoms following a concussion. The cervical spine, or neck, can also show concurrent symptoms of hypomobility and pain following the mechanism of injury of a mild traumatic brain injury/concussion. The acceleration and deceleration of the head may cause

whiplash-like symptoms in the cervical spine causing hypomobility and pain. 90% of patients were considered by the clinician to have neck problems contributing to their current post-concussion syndrome symptoms utilizing the River mead Post Concussion Symptoms questionnaire, Neck Disability Index and Dizziness Inventory, patient -reported symptoms including headache, dizziness, and neck pain, and physical examination[13]. In order to treat the cervical spine symptoms, spinal manipulation of the cervical and thoracic spine in patients with mechanical neck pain shows a reduction in pain and increased cervical range of motion[14].

Research in the past has defined diagnose and symptoms of concussion and in great detail. There is some research completed on interventions that can be utilized to decrease post-concussion symptoms and return to sport protocols. Research is now focused on prevention of concussions. Through more research, we will better understand how concussions happen, diagnosis, prognosis, treatment, and how they can better prevent concussions from occurring. The purpose of this case study is to report the positive activity and participation outcomes of physical therapy intervention (exertional testing and cervical spine manipulations) of a collegiate football athlete that presented with post-concussion syndrome and cervical spine hypomobility and pain after sustaining a moderate concussion during practice.

CHAPTER II
CASE DESCRIPTION

The patient was an 18-year-old male collegiate football player who played the position of tight end. A tight end is a combination of an offensive lineman and wide receiver. According to Baugh, Kiernan, Kroshus,, et al tight ends and defensive line have the highest rates of diagnosed concussions in college football[15]. He attended school with an undetermined major. He reported that he started having some confusion following a hit at morning practice but did not lose consciousness. He then had complaints of more severe confusion during the afternoon practice where he was unable to remember plays. This is when he talked to the training staff about it who sent him to the hospital where he had an XRAY completed of the cervical spine. The MD diagnosed him with a grade II concussion and cervical spine hypomobility and pain, told him to rest, and referred him to physical therapy for examination/evaluation, treatment post-concussion and cervical spine mechanical symptoms, and completion of return to sport protocol. The concussion occurred three days prior to the outpatient orthopedic physical therapy evaluation.

The patient lived in the freshmen dorm rooms with a roommate. The patient reported that he has weightlifting every morning with film and practice Monday-Friday. He was also starting class next week, therefore it made it somewhat difficult to schedule appointments. The patient's main activity limitation and participation restrictions included that he was unable to participate in football

or concentrate at school. He also reported that driving was difficult as it made him feel dizzy.

The patient was a multi-sport athlete in high school and had played tackle football since he was in the 5th grade, therefore he has been playing for eight years total. The patient had a past medical history of two previous concussions that occurred during high school football that went undiagnosed and untreated. He said that he believed these concussions were very similar to the recent concussion he had sustained as he did not lose consciousness but did experience symptoms in the days following. This is important to consider when making a medical decision for return to play, as the more concussions someone receives, the more likely they are to experience symptoms of CTE in future years such as headaches, memory loss, etc[10]. The patient has no other past medical history that would affect treatment and return to play protocol.

A systems review was completed and can be viewed in Table 1.

Table 1. Systems Review

Musculoskeletal system	Impaired. Cervical spine pain. Decreased cervical spine ROM.
Integumentary system	Not Impaired.
Cardiopulmonary system	Abnormal. HR: 84 bpm. Patient reported this was higher than normal. BP: 130/83. Patient reported this was higher than normal.
Neurological system	Impaired. Difficulty with memory. Decreased concentration. No radicular symptoms.

The patient's chief complaints/primary concerns were headaches, inability to remember things very well, vomiting, he has been sleeping more, light sensitivity, cervical pain, and he failed the ImPACT or "Immediate Post-Concussion Assessment and Cognitive Testing" test 3 times. The patient would like to return to football and his academics of general studies as soon as possible with no recurring symptoms.

Examination

Physical therapy initial evaluation included 1) Observation: The patient was observed in the waiting room as being distressed by the light and had an overall lack of energy. He had a normal standing posture along with normal respiratory rate that was not labored After bringing the patient to the examination room, he noted he had light sensitivity which would initiate headaches.

2) The patient was given the Neck Disability Index which is a self-reporting questionnaire, and was utilized to determine how the patient's neck pain affects his ADL's. Research has shown that this functional outcome measure has sufficient support and usefulness to retain its current status as the most commonly used self-report measure for neck pain[16]. The patient's total score was 19/50 along with a total percent of 38% disability. Table 2 lists the patient's response to each individual question.

Table 2. Initial Neck Disability Index

Pain Intensity	The pain is moderate at the moment
Personal Care	I can look after myself normally, but it causes extra pain
Lifting	I can life heavy weight, but it gives extra pain
Reading	I can read as much as I want to with slight pain in my neck
Headaches	I have severe headaches, which come frequently
Concentration	I have a lot of difficulty in concentrating when I want to
Work	I can do most of my usual work but no more
Driving	I can drive my car as long as I want with moderate pain in my neck
Sleeping	I have no trouble sleeping
Recreation	I am able to engage in a few of my usual recreation activities because of pain in my neck
Total	19

3) Cervical translations were completed and hypomobility was noted in the cervical thoracic joint along with tenderness to the left cervical spine during palpation. Cervical active range of motion was measured with a goniometer and was limited in rotation and side bending as follows in Table 3:

Table 3. Initial Cervical Range of Motion (in Degrees)

	Right	**Left**
Forward Bending	WNL	WNL
Backward Bending	WNL	WNL
Rotation	65	60
Side Bending	25	30

4) The patient's upper extremity, trunk, and lower extremity strength were tested with resisted isometrics and all motions tested 5/5 bilaterally with no pain reported. Neuro-Vascular testing was completed with no complaints of any radicular symptoms in either extremity. Upper myotomes were negative bilaterally and upper dermatomes were intact bilaterally. An oculomotor exam was done which consisted of 11 tests that were all normal, smooth, and intact bilaterally. Next, special tests were completed including the vertebral artery test (Sensitivity: 0%, Specificity: 67-90%) to rule out vertebral artery compromise,

Compression/distraction (Sensitivity: 30%, Specificity: 93%) to rule out nerve root compression/muscle spasm and Spurling's maneuver (Sensitivity: 50%, Specificity: 88%) to rule out nerve root compression.[17] All special tests were negative bilaterally.

5) Balance was assessed on the Kore Balance machine which can adjust the difficulty level using an inflatable and deflatable bladder. The surface was adjusted to a soft surface with eyes open, soft surface with eyes closed, hard surface with eyes open, and soft surface with eyes closed. Patient reported reoccurring concussion symptoms of dizziness, nausea and headache occurred which caused us to discontinue this examination procedure. Patient reported the symptoms subsided two minutes after.

Evaluation, Diagnosis, Prognosis, and Plan of Care

The initial examination caused some reoccurring concussion symptoms for the patient including a headache, dizziness, and nausea, confirming the MD diagnosis of a moderate (grade 2) concussion on the severity grading of concussions (1-3 scale). A main problem list that we made to address in physical therapy was created in Table 4. Following our examination and after analyzing the patient's chief complaints, our PT diagnosis was consistent with ICD10: S06.0X0A: a grade II concussion without loss of consciousness.

Table 4. Problem List

1. Concussion 2. Headache 3. Cervical spine hypomobility and pain 4. Unable to participate in football and academics

The plan of care was to complete therapy sessions three times per week for eight weeks. These treatment sessions were to include therapeutic exercise, therapeutic activity, gait training, neuromuscular rehabilitation, manual therapy to the cervical spine, and patient education. Throughout the treatment, the patient would slowly be able to return to football, with a good prognosis of being able to return to full contact play again in eight weeks. A short-term goal to be met in 4 weeks included that the patient will report decreased cervical spine pain below 2/10 with and without activity. Long term goals to be met in eight weeks included normalize spinal mobility to allow pain free spinal motion in all directions, demonstrate compliance with therapy attendance and HEP as outlined by the therapist, report decreased headache frequency, report return to prior level of function, and improve functional abilities via NDI. The patient was monitored very closely throughout the eight weeks for any need to reexamine/reevaluate to change the plan of care.

CHAPTER III
INTERVENTION

The patient was seen six times for exertional testing over a span of two months for 45-minute sessions. The interventions completed included patient education, manual therapy, neuromuscular rehabilitation, and exertional rehabilitation. Patient education was completed on plan of care, goals, concussion management of limiting activities that worsen symptoms such as being on your phone, watching TV, video games, reading, or physical activity, return to sport process, ImPACT testing, and a walking program. Contract relax stretching was completed when the patient had complaints of hamstring cramps throughout the return to sport protocol. High-velocity-low-amplitude (grade 5) manipulations with cavitation was done to the patient's bilateral upper cervical spine in supine due to pain and malalignment.[14] Neuromuscular rehabilitation was done to assess patients balance, and exertional testing was completed for return to play.[11]

Treatment 1: A heart rate monitor and recumbent stepper was used for exertional testing. The patient tolerated activity without symptom complaints when his heart rate was kept below 90 beats per minute (bpm). At seven minutes, his heart rate exceeded 90 bpm and reported that symptoms increased. He was instructed to slow to a target heart rate of 70-85 bpm which resolved symptoms. Then, at 12 minutes, he was instructed to increase his effort to 115 bpm for three minutes without symptom increase. A total of 15 minutes was completed on the recumbent stepper. Following exertional testing, a high-

velocity-low amplitude-manipulation (grade 5) with cavitation was completed to the patient's bilateral cervical spine in supine. A high-velocity-low-amplitude manipulation was also completed to cervical thoracic joint in prone with cavitation. Manual therapy was done to first rib grade four in supine.

Treatment 2: The heart rate monitor and recumbent stepper were used for exertional testing for a total of 20 minutes. The patient tolerated sub 115 bpm activity without any symptom complaints. The patient maintained a heart rate of over 100 bpm for the majority of the exertion work. He did have symptom increase at 10 and 17 minutes which was then decreased intensity to under 110 bpm. Neuromuscular re-education was completed during this therapy session on the Kore Balance machine. Interactive games were then completed on the computer screen to work on balance, but patient quickly reported return of his symptoms (dizziness, nausea, headache), therefore, we stopped this activity. The patient reported that the symptoms subsided 2 minutes following stopping this activity.

Treatment 3: The heart rate monitor and recumbent stepper were set on rolling hills for exertional testing to increase workload. These machines were utilized for the first 10 minutes of testing. He had mild complaints starting at 130 bpm, we then reduced intensity which resolved the head throbbing complaint. It was documented that he tolerated it well. Then, the heart rate monitor and elliptical were used to increase the intensity. These machines were utilized for the next 15 minutes. Heart rate was taken between 125 and 166 bpm. He reported that his symptoms increased at 150 bpm. These symptoms resolved in

approximately three minutes when the intensity was reduced to 130 bpm. Finally, he was able to increase his heart rate from 150 bpm to 160 bpm before his symptoms started again. Manual therapy was completed in the middle of this treatment to the hamstring muscles as patient reported “having a cramp.” Contract relax manual therapy method was used on the right hamstring in supine and the patient reported that the cramping resolved. High-velocity-low-amplitude manipulation (grade 5) with cavitation was completed to the patient’s bilateral upper cervical spine in supine.

Treatment 4: The heart rate monitor was used with the elliptical for exertional testing to start for a total of 11 minutes. The patient was able to achieve a HR of 140 bpm at the end of testing with no complaints of reoccurring symptoms. It was documented that the patient tolerated this well. Then, the patient switched to the treadmill to increase physical effort. Manual heart rate was taken twice over a total of 11 minutes. Incremental increased were used with 100 meters of walking at a speed of 2.8 mph at the end of each lap. The first two laps were jogged. The next lap had increased effort by increments of jogging 300 meters at speeds of 5.5 to 6 to 7. Following the completion of this section, the patient reported having a headache behind his eye. The patient’s HR was then measured and found to be 140 bpm. The patient then walked 100 meters. The patient reported that walking reduced the headache symptoms, and physical exertion testing continued symptom free. The following 300 meters was increased from speeds of 5.5 to 6 to 8.5 followed by a manual HR taken at 172

bpm with no symptoms. He then completed a cool-down which consisted of walking for 100 meters.

Treatment 5: The patient completed exertional testing on the treadmill for a total of 17 minutes. His heart rate was taken twice manually in this time. The speed was taken up in increments to 7.5. His heart rate was then taken to be 164 bpm. The speed was then increased to 9.0. His HR was then manually taken again up to 188 bpm. He tolerated exertional testing well with no symptoms. Manual therapy was completed in the middle of this treatment to the patient's anterior lower leg (dorsiflexor) muscles as the patient reported having bilateral shin splints. Dorsal stretching in standing was completed and the patient reported that the shin splints went away.

The final session consisted of the discharge of the patient. No exertional testing was completed during this therapy session. The patient was educated on a plan for return to practice and taking the ImPACT test. The PT informed the patient that he would give permission for return to full contact play following a passing ImPACT score. Outcome measures were also taken during this therapy session.

CHAPTER IV
OUTCOMES

Upon discharge, the patients' outcomes were positive which correlated to the positive prognosis. Studies have shown that symptom recovery, neurocognitive testing, provocative exercise test, normalization of balance, and IMPACT testing are the most common outcome and return to sport tools utilized.[18] Subjective and objective information were evaluated. By the end of physical therapy intervention, the patient reported that things were going well, as he was feeling he had returned to his prior level of function. He no longer had any sensitivity to light. He had started some return to practice. The patient wore full pads and did complete some contact at football practice the day before. He had been able to sleep and was waking up without symptoms. The patient was now able to focus when in class and completing homework. He had been symptom free for a week.

The neck disability index was completed for discharge scoring (see Table 5). The patient scored a total of 2 compared to a 19 at examination. This means that the patient had no disability at this time.

Table 5. Discharge Neck Disability Index

Pain Intensity	I have no neck pain at the moment.
Personal Care	I can look after myself normally without causing extra neck pain.
Lifting	I can lift heavy weights without causing extra neck pain.
Reading	I can read as much as I want with no neck pain.
Headaches	I have slight headaches that come infrequently.
Concentration	I can concentrate fully with slight difficulty.
Work	I can do as much work as I want.
Driving	I can drive my car without neck pain.
Sleeping	I have no trouble sleeping.
Recreation	I am able to engage in all my recreational activities with no neck pain at all.
Total	2

The patient also completed the Rivermead Post-Concussion Questionnaire which is a self-reporting scale to measure severity of post-concussive symptoms.[19] The patient reported that he was not experiencing any of the symptoms listed which included headaches, dizziness, sleep disturbances, concentration, double vision, etc.

No special tests or oculomotor tests were completed at discharge due to all being negative at examination. Cervical active range of motion was reassessed (see Table 6) with no left sided tenderness and normal mobility to the cervical thoracic joint.

Table 6. Discharge Cervical Range of Motion (in Degrees)

	Right	**Left**
Forward Bending	WNL	WNL
Backward Bending	WNL	WNL
Rotation	88	87
Side Bending	40	42

All items on the problem list previously defined were addressed. The patient was no longer demonstrating signs or symptoms of concussion, he had very few headaches, he was back to his normal activity level and tolerance to activity, and we had developed a selective progressive home exercise program for the patient to continue to complete.

All patient goals determined during the evaluation were met. The patient reported a pain level below 2/10 (0= no pain, 10= maximum pain) with and without activity, he demonstrated normal spinal mobility that allowed pain free spinal motion in all direction, he demonstrated compliance with therapy attendance and HEP as outlined by the therapist, the patient reported decreased

headache frequency, he reported return to prior level of function and improved functional abilities via NDI.

He had started the return to play practice protocol with the athletic training staff and passed the ImPACT test, therefore physical therapy had cleared him for full return to practice and games. The patient reported that he was very satisfied with his physical therapy experience and was discharged following this appointment.

CHAPTER V
DISCUSSION

This patient came into physical therapy with grade II post-concussion symptoms that was limiting him in his school, football scholarship, and activities of daily. After a review of the literature demonstrates that it has previously been shown that post-concussion management or return to sport protocol plays a large role in shortening the length of concussion symptoms. Research has shown the evidence regarding rest and active treatment following a sport-related concussion.[11] This article found that 24-48 hours of complete rest following a concussion is appropriate. The patient should then gradually increase activity using a closely monitored submaximal aerobic exercise that was most beneficial. Other interventions included cervical and vestibular rehabilitation for cervical spine pain and headaches. After examining this research, the patient had already had 48 hours of rest before presenting to physical therapy for evaluation and starting the exertional intervention. Throughout the weeks of intervention, cervical spine manipulations a long with vestibular rehabilitation was completed. This combination of intervention did help the patient to decrease cervical spine pain, headaches, and other symptoms related to his concussion.

Another article studied return to activity following traumatic brain injury/concussions and how youth with post-concussion syndrome are affected by standardized exertion testing which consisted of a cycle ergometer.[12] This study proved that exertional testing has an important role in the evaluation of symptoms and readiness to return to activity. Overall, controlled exertion seemed

to lesson symptoms for most youth (8.5-18.3 yr) with previous confirmed concussion and has a big role in when the patient will be able to return to activity.

Research has also shown that the typical concussion symptoms are not the only source of post-concussion signs. The neck is also a source of symptoms in mild traumatic brain injury/concussion patients due to the mechanism of injury and causing whiplash-like symptoms in the cervical spine. Patients have shown to have cervical spine hypomobility and pain following concussion a long with post-concussion syndrome[13]. These symptoms can be treated with manipulations to the cervical spine. [14]

In eight weeks, using manual therapy to the cervical spine, neuromuscular re-education, and exertional testing, this patient regained many of the abilities he felt he had lost. The most important abilities to this patient were his return to football practice and the ability to concentrate in his classes. His headaches had decreased, he was able to remember things better, he was no longer vomiting, he did not have light sensitivity, and he had increased pain free cervical range of motion to bring all motions to within functional limits.

Limitations of this case study report included that the patient was not blinded, but he was open to all exercises and treatment. A second limitation was that the patient did miss one therapy session due to a conflict with football film that he forgot about when scheduling the appointment with the receptionist. Further randomized controlled trials are needed to study the cause and effect of the intervention completed and the outcomes that were given.

REFLECTIVE PRACTICE

Following the completion of this case study, and reflecting on the examination, evaluation, diagnosis, prognosis, POC, interventions and discharge, there are some changes I would have made to better the care for this patient. It is also important to reflect on your practice, and how you can better treat future patients that you encounter that have the diagnosis of a concussion and cervical hypomobility and pain. I feel the questions we asked during the examination were thorough and included all information that we needed to receive a full case description and background of the patient.

The first thing that I would change was during the examination. We did not complete cognitive function testing, perceptual function testing, motor function, or clinical rating scales. We did not give the patient the Rivermead Post-Concussion Questionnaire to complete. At this time, I was unaware that this functional outcome existed. This would have been appropriate for the patient to complete as this was his main problem. We did give the Rivermead Post-Concussion Questionnaire to him at discharge to assess all functional abilities and impairments were back to normal. But, giving it to him at examination would have been helpful to compare to his outcomes score that he received.

Some of the goals within the plan of care should have followed the SMART (Specific, measurable, attainable, relevant, and time based) model, and ABC (Audience, behavior, condition, degree, emphasize function, and time frame) formats better. For example, “within two weeks, the patient will report

decreased neck pain below 2/10 with and without activity." This goal is missing the condition portion of the ABC format and should have been written as "Following PT intervention, the patient will report decreased neck pain below 2/10 in order to be able to concentrate at school. (to be met in two weeks.)" The second goal that was missing portions of the ABC format was "within four weeks, the patient will report improved functional abilities via NDI." To make this goal conform more to the ABC format, I would reword it as "Following PT intervention, the patient will reduce his NDI score from a 19 to a 2 in order to be able to perform functional abilities independently. (To be met in four weeks)" This goal now includes the "condition" (following PT intervention) and "degree" (19 to 2) that it did not include in the goal written at evaluation. I would rewrite these goals to be more functional based, and more individualized to this patient.

There is good evidence behind the interventions we used (exertional testing and cervical spine manual therapy) as stated in the introduction and discussion. I would seek further evidence on the prognosis of concussion patients. The article I found for the prognosis described the tools that can be used when assessing if the patient has recovery of their signs and symptoms, but I will be completing further research on the amount of time predicted for the return to sport for different grades of concussion in order to better educate my patients in the future.

No referrals were made throughout the plan of care. The MD referred this patient to physical therapy for post-concussion management, return to sport protocol, and cervical spine hypomobility and pain. The patient was also working

with the athletic trainer at the school. There could have been better communication between the PT and the athletic trainer in order to have a better interdisciplinary approach to treating this patient. I would make no further referrals throughout the plan of care as there were no red flags.

The patient completed a total number of 6 visits. After using the Medicare Outpatient Therapy Claim Pricer from the APTA website, it was calculated that the average cost per visit was $87.25 (1 Ther Ex, 1 Manual Ther, 1 Neuro ReEd).[20] The total cost per care was $532.67. $133.17 was the final cost to the client while $399.50 was the final cost for the third-party payer. I believe that this cost was reasonable for the patient as following physical therapy intervention, the patient was able to return to his prior level of function and was able to return to football which was his main goal from therapy. I do not believe we were able to reduce costs to the patient and retain these same outcomes. Because of this, the cost benefit analysis was positive due to his influence on future role in society and the patient reporting that he was satisfied and pleased with his physical therapy service.

Overall, I believe my clinical instructor did a very good job at guiding me through, giving me resources and recommending different interventions throughout this patient's plan of care as he had gone to many continuing education courses on concussion. But, following reflecting on my practice, there are still a few things that I would do differently in the future, and am very interested in taking continuing education courses on how to better treat patients with a concussion.

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