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Logan Lynch  
*University of Iowa*

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# The Complexity and Variability of the Female mTBI Patient: A Case Report

Logan Lynch

DPT Class of 2019  
Department of Physical Therapy & Rehabilitation Science  
The University of Iowa

## Abstract

**Background:** Mild traumatic brain injuries (mTBIs) account for 70-90% of all brain traumas, with most of this population having full recovery of symptoms within 2 to 3 months. A small percentage experience their symptoms for months or years. The variety of symptoms that patients can have presents a challenge to clinicians. Females present an additional challenge, with reports of increased severity and longevity of symptoms when compared to males. The purpose of this case report is to describe some of the challenges associated with treating a female with persistent concussion symptoms due to the variability in symptom presentation and underlying pre-morbid factors. **Case Description:** The patient was a 26-year-old female who went through two episodes of care with the same clinic over a 4-year timeframe due to a concussion that was exacerbated by successive head impacts. Her symptom presentation was similar in both episodes, but the interventions varied between episodes of care and produced varying results. **Interventions:** The second episode introduced cervical kinesthetic exercises to prevent further head impacts, which seemed to have the most impact on her recovery. Other interventions were progression of activity tolerance, scapular strengthening, and manual therapy. **Outcomes:** The outcome measures used were the VAS pain scale, self-reported activity tolerance, Buffalo Concussion Test, and cervical joint position test. Others that could have been used are the Headache Impact Test and Major Depression Inventory. **Discussion:** This case study represents the complexity of a female with a concussion injury and the difficulty with determining the cause of long-term symptoms, making the treatment challenging as well. The patient demonstrated progress when her interventions were geared towards her most aggravating symptoms and measurable outcomes were used.

**Keywords:** mTBI, concussion, post-concussion syndrome, persistent concussion symptoms; physical therapy; rehabilitation; female concussion

## Introduction & Background

There is current evidence that shows there is a difference between men and women regarding the susceptibility to a concussion, as well as the severity and longevity of their symptoms. The evidence lacks, however, in explaining why these differences exist. The patient in this case study provides a good example of how complex the treatment can be for females with a concussion injury.

A concussion is defined as a “mild brain injury that involves a complex pathophysiological process induced by biomechanics forces”<sup>1</sup>. The impact to the brain can affect multiple systems of the body, and the patient can manifest their symptoms in multiple different ways. 80-90% of concussion symptoms resolve in a short timeframe, typically about 7-10 days. In the case that symptoms are prolonged, generally greater than 4 weeks, it becomes known as “persistent post-concussive symptoms”. It has also traditionally been called “post-concussion syndrome” as well. The reason that the term is being modified is because of the combination of nonspecific symptoms. These symptoms can consist of headache, fatigue, sleep disturbance, vertigo, anxiety, depression, apathy, difficulty concentrating, and exercise<sup>1</sup>. The symptoms can be linked to multiple processes which make it difficult to determine the cause and if they are truly due to the brain injury.

The discussion surrounding concussions seems to be growing within the media and the literature, but much of the focus has been on the male athlete. There is limited evidence that focuses on the female athlete, or just females in general, and the implications of a mild traumatic brain injury (mTBI) in this population. It is well-known within the literature that women have a higher incidence of mTBI than men playing sports with similar rules, such as soccer and basketball<sup>2</sup>. Women tend to have higher post-concussive symptom scores, greater cognitive decline, and poorer reaction time compared to baseline<sup>2</sup>. Females are also more likely to have reduced performance on visual memory tasks, experience more discomfort after injury, and are also more likely to seek treatment specifically for post-concussion headaches<sup>3</sup>. There are various suggested hypotheses regarding the differences between males and females, such as a difference in neck strength and dynamic stabilization, hormonal differences relating to the phase of her menstrual cycle at the time of impact, differences in microstructural alterations in the brain after impact, and pre-morbid psychiatric symptoms. The lack of evidence as to why there is such a difference between men and women in their severity and longevity of symptoms leads to an even further unknown of how to effectively treat these female patients. Thus, the purpose of this case report is to describe some of the challenges associated with the clinical decision-making process for the treatment of concussions in females due to the variability in symptom presentation and underlying pre-morbid factors, and present some of the current hypotheses regarding why females may present differently.

## Case Description

The patient was a 26-year-old female when she started her first episode of care, and 29 years old when she came to the clinic for her second episode of care. She was single, no history of drug use, alcohol use occasionally, and worked full-time as a fifth-grade math teacher. She had recently finished her doctorate degree, which she was in the process of getting during these events. She owned a home and had roommates, along with her dog. Her hobbies included exercise, reading, playing cards, and watching movies.

This patient was chosen because she has an interesting background of not only one, but multiple concussive events that prolonged her symptoms far beyond the average length of time for the majority of mTBI patients. As stated in the introduction, most people who sustain a concussion have symptoms that resolve within 7-10 days. Her medical diagnoses were as follows: mTBI, headaches, imbalance, and multiple visual diagnoses consisting of binocular vision disorder, visual disturbances/visual motion sensitivity, exophoria, photophobia, fusion with reduced stereopsis, and accommodative insufficiency.

**Episode 1**

The patient had quite an extensive history when it came to her concussion. She sustained her first concussion four years ago from a wake boarding accident. She had hit her head the same way multiple times before because she had lived her childhood on the lake, but this one in particular caused symptoms that she had never felt before. When she got back on the boat, she had an intense headache and when she tried to look at her phone, she could not read her texts. She was referred to a brain injury clinic six weeks later where she received a full comprehensive evaluation from speech, occupational, and physical therapy, in addition to a neuropsychological exam. Her main symptoms were that she could not focus well, she was having to close one eye to try and focus, difficulty reading and keeping her eyes focused on a page or screen, her eyes were “not working properly together”, motion sensitivity, light sensitivity, overstimulated in the car, headaches that were worse with physical or cognitive activity, dizziness, and balance problems intermittently, and personality and emotional changes. She also had a history of depression and anxiety, and she was experiencing more nervousness, loss of appetite, and nausea that she had not experienced before. She was no longer working at the time of her first evaluation due to her symptoms. Her physician prescribed her prism glasses to wear over her contact lenses for 4 weeks. She was also referred to physical therapy, occupational therapy, and vision treatment. She was not given any medications at the start of her care, and the physician predicted that she would have an excellent prognosis.

**Physical Therapy Examination and Evaluation**

The patient received her first physical therapy evaluation six weeks after her initial injury. She reported that she was having headaches, light and motion sensitivity, and trouble with visual tasks. She said that in the past she had hit her head a couple of times during the summer from wakeboarding, but the symptoms resolved within a couple of days normally and these symptoms were not going away. The patient received a full examination and evaluation from physical therapy that included subjective history taking, manual muscle testing, range of motion, joint mobility assessment, palpation of muscle tissue in the involved areas of pain, and a balance assessment. She demonstrated scapular weakness, hypomobility at C3-C4 and T1-T8, muscle tension and tightness in her left levator scapulae and upper trapezius, bilateral suboccipitals, scalenes, and sternocleidomastoids. The plan of care by the therapist at that time was to focus on increasing scapular strength, returning her to work/life roles, to decrease pain, and improve function.

One of the outcomes measures used at the initial evaluation was the Functional Gait Assessment (FGA). Approximately 30% of individuals with concussions have balance impairments, so having a balance assessment as a part of a physical therapy evaluation may be a priority<sup>4</sup>. The FGA is traditionally used for various patient populations including Parkinson’s Disease, spinal cord injury, stroke recovery, vestibular disorders, and neurologic rehabilitation<sup>5</sup>. Although she did not complain of any balance deficits, patients are often surprised by the impairments that can be brought out by some of these tests, so the use of the test was warranted. She scored 30/30, indicating that dynamic balance with gait activities was not a concern for this patient and did not need to be addressed in the plan of care.

The next plan of care update was a little over two months later. The patient was independent with her scapular strengthening home exercise program at that point, but she was still having headaches every day since the day she tried returning to work, 2 weeks prior. She was having 3-4 headaches/week when she initially started physical therapy. She eventually had progressed to being able to go 4 days in a row at most without headaches a couple months back, but her headache frequency increased again when she returned to work. During her second week at work, she was having headaches 5-7 days/week, but they were staying at about 2/10 intensity. She also voiced

concern that she had noticed increased anxiety with returning to work and she was not sure how to manage it, such as seeking counseling versus medication. It was recommended that she follow-up with counseling services to address her anxiety, who would then recommend medications if they found it appropriate. The patient did not end up seeking counseling that we were aware of.

A couple months later, the patient was only able to tolerate 20 minutes of various intensities of activity. A new long-term goal was set to tolerate 45 minutes of continuous activity while maintaining stable vital signs, mostly focused on her heart rate. She was still reporting daily headaches at about 2/10 intensity, but exercise activities increased the intensity higher. The therapist assessed 1<sup>st</sup> rib mobility, which was found to be decreased and it was thought that it could be related to her headache.

A month later, she reported that she had not been able to increase her workout routine due to work and school. She was still having 2/10 headaches daily, but recently she was having more difficulty with her eyes not “working together” which could have been related to her increased headaches. She had been in contact with a physician to discuss her changes in vision and have them addressed.

The patient had her last visit 2 months later. At this time, she was able to tolerate 45 minutes of light to moderate intensity of activity but had not returned to her previous workout routine due to other obligations with school and work. She continued to have daily headaches at 1/10 intensity due to her eye strain and visual difficulties. She had been able to complete the rest of the semester of school, with an exception of 10 days towards the end of her school year. She had an event where she stood up her under a counter and hit her head, causing a re-aggravation of her symptoms. She said she felt fine immediately after hitting her head, but a few days later she noted that her symptoms increased. She was at work when she felt them come on, so she left her classroom as they were flaring up and was found by a friend on the ground somewhat disoriented. She was nauseated and it was difficult to open her eyes, but no loss of consciousness. She was taken to the emergency room and felt better after receiving intravenous fluids. After taking a week off work, she said her symptoms resolved well and was able to start back to half days at work.

She was also having decreased tolerance to loud environments. She was encouraged to try to use ear plugs in louder environments and to take breaks to help her manage her symptoms. The patient was supposed to return within a month if she had an aggravation of symptoms but would otherwise be discharged. The patient did not return to therapy, so she was discharged a month after her last visit. Her total number of PT visits during this episode of care was 38, and total OT visits was 20.

### ***Episode 2***

Three years later, the patient returned to the TBI clinic to address her continued concussion symptoms after multiple new head impacts over the past couple years. Since her last visit to the clinic, she went 1.5 years with no additional head impact. Over the last year, however, she had suffered 6-7 more head impacts/concussive events, making that 11-12 overall since her original injury in 2015. The patient called them her “head bumps”, and they were from hitting her head on counters, car doors when misjudging head clearance, passing out when giving blood and bumping her head on the ground, a hood of a car falling on her head, and sitting in a chair that was a lot lower than what she expected which caused a jarring of her head. The patient had become very frustrated and distraught that she was continuing to deal with these symptoms years later, which finally lead her to come back to the clinic. She had been seeing a chiropractor throughout the last year to address whiplash about once a week, but still was not getting the relief she wanted to live her life the way she did before.

### **Physical Therapy Examination and Evaluation**

The patient was examined and evaluated by a different physical therapist for her second episode of care. Her main complaints were recurring headaches from neck and shoulder muscle tension, eye

strain, and continuing to have head impacts. Her biggest issue was visual coordination and spatial orientation, but she also was getting very fatigued from minimal screen time, reading, and exercise. She denied having any dizziness with her activities. Her primary goals were to prevent further head impact to be able to tolerate walking a half marathon, review her home exercise program for muscle tension and improve her headaches, and she wanted to be able to tolerate walking 1 mile with her dog. The patient was a very active woman prior to her first concussion so her primary goals were always focused around improving her exercise tolerance. The patient was having 7/10 headaches at worst, but consistently had 1/10 baseline headaches constantly. She demonstrated upper left cervical rotation limitation, upper trapezius that was tender and ropy, hypomobile thoracic spine, and C2 and C3 right to left glides were hypomobile. She had a normal vestibulo-ocular reflex in seated and standing on foam with a busy background, and she had a normal time of 30 seconds on the Clinical Test of Sensory Organization and Balance assessment (see outcomes measures). The patient's multiple head impacts lead the therapist to hypothesize that she had poor cervical kinesthetic awareness and decreased head control, which could have been contributing to the multiple impacts. A cervical kinesthetic assessment was performed in order to assess the patient at baseline for head position awareness. The testing done was similar to the standardized cervical joint position error test.

The cervical joint position error test is used to assess cervicocephalic proprioception and neck reposition sense<sup>6</sup>. It tests one's ability to relocate the head back to center after maximal or sub maximal rotation in the transverse and sagittal planes. The patient should be seated in a chair that has a backrest with vision occluded with a blindfold or eyes closed. The patient should be fitted with a laser pointer to a helmet or headband to measure the magnitude of head displacement during the test. For this case study, the protocol was modified and the patient was given restricted field view glasses where the lenses were covered with tape everywhere except a small hole on the right side that was small enough to where the patient could only see the printed target in front of her. The target is typically 40 cm in diameter with concentric circles in 1 cm increments, divided into 4 quadrants intersecting at the zero.

The patient was instructed to perform an active head rotation to one side, and then she would return to neutral starting position. The point where the laser lands indicates the global error related to the center of the target. For this patient, the active motions of the head tested were cervical rotation, cervical flexion and extension, and diagonal motions. In addition to the patient performing active range of motion, the therapist also performed passive range of motion first, and then patient performed active motion to return to neutral position. The patient was instructed to keep her eyes closed as her head moved into each head movement, and then she was to open them once she returned to neutral position to see where she landed on the target. The protocol was also modified to have the patient perform the test on varying surfaces. She did this test in sitting on a stable surface, sitting on a stability ball, standing on a stable surface, standing on foam, standing in tandem stance, and standing in tandem stance on foam. The rationale was to help the patient improve her cervical spatial awareness under various conditions that she may be exposed to in her life activities. This test was chosen based on the therapist's clinical decision making based on the patient's symptoms and the recurrent causes of her injury, but there are no current reliability or validity measures available for the use of this test with a concussion population<sup>6</sup>. Also, since the patient did not have a laser to use, she was to self-report how many lines away she was from the center of the target each time she came back to neutral. The therapist did not have any concerns about the patient being dishonest about her performance on the test.

During examination, she was consistently > 3 lines away from the center 100% of the time with restricted field glasses in all planes. She performed 5 head turns in each direction with the therapist moving the patient's head. A long-term goal was set in her plan of care to improve her spatial

orientation as measured by cervical joint position testing. The goal was to be able to maintain the center of the target > 90% of the time with cervical kinesthetic exercises on dynamic surfaces/complex environments to reduce the risk of repeat concussions.

### Plan of Care

The plan of care set during this episode of care was different than her previous plan and it seemed to more directly address the patient's deficits. This plan of care was set for 2x/week for 6 weeks. One of her long-term goals was that her headache intensity would return to baseline (1/10) with daily activities, so the patient was okay with having a mild headache at baseline. At this time her symptoms were getting up to 7/10 with screen time, exercise, and when she had muscle tension which was exacerbated with each additional head bump. Another long-term goal was to resume moderate physical activity in at least 45-minute bouts to resume her life role as a runner. During her first plan of care, her activity tolerance was assessed via self-report. In order to incorporate more standardized outcome measures the second time around, the Buffalo Concussion Treadmill Test (BCTT) was used to measure her baseline activity tolerance.

The purpose of the Buffalo Concussion Treadmill Test (BCTT) is to identify the heart rate threshold of exercise tolerance in concussed patients<sup>7</sup>. It helps to measure how much exercise is safe to perform based on the symptoms that they have at certain heart rates. There has been a study that found a threshold of < 135 bpm was associated with prolonged recovery (>30 days) from sport-related concussion. Before beginning the test, patients rate their current symptoms on a 10-point Likert symptom scale and their resting heart rate is measured. The patient then walks on the treadmill at a "brisk walking" pace, preferably above 3.0 mph at least. The incline begins at 0%, and then increases by 1 degree every minute for the first 15 minutes of the test. If the test continues beyond 15 minutes, then the speed is increased 0.4 mph every minute. Heart rate, 10-point Likert symptom scale, and Borg Rating Of Perceived Exertion (RPE) on the 6-20 scale are all recorded every minute until the patient has an exacerbation of symptoms that are beyond a 2-point increase from their baseline Likert score, or voluntary exhaustion measured by a report of 17 or more on the RPE scale. The examiner also watches for any new onset of symptoms or signs of distress and terminates the test if any new symptoms occur. The patient then has a 2-minute cooldown at 2 mph before a final heart rate is taken. The patient should be encouraged to report their symptoms throughout the test, not try to push through them<sup>7</sup>. In male and female adolescent athletes aged 13-18 years old, a difference between heart rate threshold and resting heart rate of less than or equal to 50 bpm on the BCTT was 73% sensitive and 78% specific for predicting delayed recovery in concussed adolescents<sup>7</sup>. Her initial heart rate was 100 bpm, she had 4/10 symptoms, and had no exertion at start of test. Her total test time was 11:50 minutes. She went up to 11% incline, and heart rate was up to 170 bpm. The test was terminated due to the patient reaching the target heart rate of 162 bpm. Her symptoms only increased to 5/10, and her RPE was 12. According to her results, the patient technically passed her BCTT, so there was no reason for the test to be repeated. The patient, however, self-reported that on a "good day" she was only able to walk 1 mile at most, which seemed to be inconsistent with the results of the test. Nevertheless, the patient expressed that she felt like she could work on the exercise progression part on her own and wanted to focus more on the manual therapy and cervical kinesthetic exercises during her sessions.

A month later at her next plan of care update, the patient reported that her symptoms had started to improve and her headaches were down to 4/10, but after she started back to school, they came back up to 7/10 at their worst. She had progressed to walking up to 2 miles and had been able to gradually increase her intensity and pace. She was consistently getting within 1 line from the center of the target 80% of the time wearing restricted field view glasses during cervical kinesthetic exercises on dynamic surfaces. She was becoming more independent with her home program, but just needed to manage

symptoms in more stressful environments like at school. Her plan of care at this point was changed to 1x/week for 6 weeks due to patient's increasing schedule and her improvement of symptoms.

The patient had her last physical therapy session about 6 weeks after her initial evaluation. She had another appointment scheduled but had to cancel due to her witnessing a car accident and she had to stay to give her statement to the police. She had yet another appointment a week later scheduled but had to cancel again as she was involved in a car accident. She had called reception to inform of the accident and reported that she was doing okay, but the airbags deployed so she was trying to rest. The therapist was very concerned about the amount of anxiety that these incidences would cause the patient, in addition to increasing her symptoms and hindering the progress that she had made. The patient planned to continue her care after she was feeling better. The total number of PT visits up to this point in care was 13, and OT visits was 14.

### **Outcome Measures**

#### *Cervical Joint Position Error Test:*

At initial evaluation, patient was > 3 lines away from the center of the target 100% of the time. Within a couple weeks, she had improved to scoring right on target to within 2 lines ~60% of the time. After another week, the patient was given more dynamic surfaces to stand on, such as foam, and the magnitude of the head turns was variable as well. She was scoring within 1 line from target 100% of the time on level ground but was less accurate on the foam surface and with larger head movements. After a month, patient was within 1" 90% of the time, and right on target 60% of the time. She did report neck tightness during exercises, but overall no increase in symptoms. After almost two months, she was on dynamic surfaces while spelling words backwards and therapist moved her head. She demonstrated improved balance and no increase in symptoms but was not as accurate due to neck tightness and an increase in the complexity of the task itself.

#### *Clinical Test of Sensory Organization and Balance*

This assessment involves 6 scenarios that remove or conflict our sensory inputs. The procedures consist of alternating between standing on foam surfaces or the ground, with eyes open, closed, or looking at an object. The test typically is graded on a scale from 1 to 4, which lower value indicating least amount of postural sway. The test was modified for this patient; she was graded based on the length of time that she could maintain each position and what type of strategy she used to keep her balance. The CTSIB was shown by Guskiewicz et al to identify increased postural sway in individuals with concussion during the first 3 days after injury, but currently there are no reliability, sensitivity, or specificity measures that have been shown in the literature<sup>8</sup>. This test was only used during initial evaluation due to patient demonstrating normal results.

### **Referral and Care Coordination**

This clinic takes a multi-disciplinary approach for the care of their mTBI patients, so she had multiple other evaluations performed in order to fully assess her symptoms and decide which disciplines were necessary to help her recovery.

#### *Neuropsychological Evaluation:*

During the second episode of care, all her scores were within normal limits and there was a general trend of improvement since her last neuropsychology evaluation, which was performed 6 weeks after her initial concussion. She also completed neuropsychological testing. The results showed that she had frequent occurrences of various physical symptoms and had vague complaints of ill health and fatigue. It was noted that she was likely to be continuously concerned with her physical problems. Her social

conversations focused a lot on her health problems and her self-image had come to take on an identity of ill health and she had a belief that she was handicapped by her poor health. It was also noted that she had a lot of anxiety and concern each time she hit her head again and worried that it would be another concussion. Her perception of her health could have had a negative impact on her psychological function and impact her quality of life if she continued to over pathologize her symptoms. Overall, the neuropsychologist did not see any red flags that required further treatment or limitations.

Studies have shown that a previous history of depression and anxiety have been shown to predict poorer outcomes following a concussion, which is in alignment with the way that this patient is manifesting her beliefs about her condition based on the neuropsychological evaluation<sup>9</sup>. Almost half of patients with persistent post-concussion symptoms suffer from pre-morbid depression and anxiety, and the mental health status of patients prior to their injury has been shown to predict post-concussion symptoms in both adult and pediatric populations<sup>9</sup>. The challenging part is deciphering whether the depression and anxiety symptoms are a reaction to the injury, or if their pre-morbid symptoms increase the risk of reporting persistent symptoms.

One of the outcomes measures that could have been used to better track this patient's depressive symptoms is the Major Depression Inventory (MDI v.2.0). This is used as a self-reported way to measure the severity of depressive symptoms<sup>10</sup>. For this assessment, the respondent answers questions on a 6-point scale related to symptoms that reflect sadness, loss of interest, loss of energy, loss of self-confidence, guilt or shame, loss of pleasure, difficulties in concentrating, restlessness, sleep disturbances, and changed appetite<sup>11</sup>. The MDI has been shown to be a reliable tool for assessing depression in psychiatric outpatients<sup>12</sup>. Another study used the MDI in a sample of 43 subjects covering a variety of depressive symptoms. The sensitivity varied between 0.86 and 0.92, and specificity varied between 0.82 and 0.86, labeling it as an acceptable tool<sup>10</sup>.

### Occupational Therapy

The patient was seen 6 weeks after her initial injury for an occupational therapy evaluation. At that time, she could read for only 30 minutes and it increased her headache and caused nausea. She also was having nausea while driving. She ordered prism glasses per physician orders. Her occupational therapy plan of care focused mostly on visual hygiene. Her goals were to decrease eye strain and to be able to do computer-based activities for school. The recommendations for her were to read for only 10 minutes at a time and to use a line guide, along with her prisms. After about a month, the patient had started to dislike the glasses because they were causing her discomfort. Most of her visual care was followed by the physician at this time.

When her second episode of care started, she was evaluated again by occupational therapy. She was diagnosed with visual disturbance and headaches. The most aggravating factors of her headache pain were increased reading time, exercise, and noise. She had complaints of blurry vision, vision deficits that were impacting her activities of daily living, headaches, and sensitivity to light. Her plan of care consisted of long-term goals in order to help improve her visual deficits: demonstrate improved convergence and divergence during advanced level binocular vision tasks with minimal increase in headaches for improved reading skills, improved visual processing in multi-stimulating environments for improved skills in her classroom setting, and complete a visual home exercise program to resume participation in previous life roles. Her plan of care was set for 2 times a week for 8 weeks.

### Speech Evaluation

For the second episode of care only, speech therapy was also involved during the initial evaluation. She scored within functional limits on all tests given including auditory comprehension, reading comprehension, verbal expression, cognitive communication, attention, memory, and executive

function. She reported that she consistently uses a planner for schedule management for personal life and work and uses her notes app and alarms on her phone for reminders. No speech therapy treatment was recommended due to the patient testing within functional limits.

## Discussion

This case study represents how complex the management of concussions can be, especially in a female population and how variable outcomes can be based on pre-morbid factors, intervention strategies, and the symptom presentation of the patient. Studies continue to come up with hypotheses to explain why there are differences between males and females when it comes to concussion recovery, but the evidence is still ongoing, and nothing has been proven.

There is evidence to support that one of the reasons that women are at a higher risk for concussions is due to differences in head-segment mass and dynamic stabilization. Dynamic stabilization is defined as “the ability of a myotendon unit to absorb external loads and minimize excessive joint movement”<sup>13</sup>. Females were shown to have up to 43% less head-neck segment mass compared to males, 25% more angular acceleration upon impact, 50% less isometric strength within their neck musculature, and 117% more muscle activity during impact<sup>13</sup>. The increased muscle activity may cause fatigue, leaving the head-neck segment more vulnerable upon impact. A possible solution for this susceptibility could be the use of headgear in sports like soccer, but some of the research looking at headgear have shown the opposite effect. There was a 32% increase in linear acceleration when women were wearing headgear and only a 10% increase without it. There has been shown to be a protective effect in men with headgear, but women have shown the opposite effect<sup>14</sup>.

There has also been recent research suggesting that hormonal differences during the menstrual cycle could also have an impact on a female’s recovery from a concussion. A study by Wunderle suggests a theory known as the “withdrawal hypothesis”. This theory suggests that despite progesterone previously being identified as neuroprotective, when a TBI occurs during a high progesterone phase of the menstrual cycle there is a sudden decrease in progesterone that could be a cause for worse outcomes<sup>2</sup>. This is in comparison to people who experience TBI during a low progesterone phase, which also includes men because they are always at a lower concentration. This study found that women who were in the luteal phase of their menstrual cycle, when progesterone is high, they have worse symptoms for a longer duration compared to women who were in the follicular phase when progesterone is lower. This study also suggests some implications for treatment, for example keeping track of menstrual cycles or doing serum screening tests to aide in determination of prognosis based on what the suspected levels of progesterone were at the time of injury<sup>2</sup>.

This patient presented with symptoms for much longer than most patients who sustain a concussion, which made her treatment and plan of care much more complicated because it was a constant battle to try and help her progress, but also not overdo it to where she exacerbated her symptoms and regressed. Generally, only about 15% of all mTBI patients have symptoms that do not resolve within a couple weeks<sup>15</sup>. Post-concussion syndrome refers to a presentation of multiple symptoms such as headaches, poor sleep, lack of concentration, dizziness, irritability, mood changes, and exercise intolerance. One of the biggest problems with continuing to try and treat these symptoms is that these may be present in the general healthy population as well, so the challenge is deciphering whether the patient’s symptoms are truly still a factor of the concussion or from another underlying condition.

Headaches are the most common persisting physical symptom reported after mTBI; over 90% of concussed athletes have persistent headaches following concussion<sup>15</sup>. The patient in this case study had consistent headaches throughout her episodes of care. Management of her headache symptoms was always one of the goals set in her plan of care. Chronic post-traumatic headache, one that persists

beyond three months, can lead to decreased quality of life, impaired activities of daily living, impaired societal functioning, and loss of work<sup>15</sup>. This is an interesting finding in relation to this patient because her condition became a part of who she was, and it was a common topic of discussion. She was always focused on it and considered herself to be disabled. It is important to note that females have been shown to have a higher prevalence of headaches and migraines in comparison to men in the general population<sup>16</sup>. She is an individual who has been having chronic headaches, but it makes it difficult to decipher whether the cause truly is from her concussions, or if she was a female who already had chronic headaches and the continued head impacts has been perpetuating the problem. This is a reason for obtaining a good extensive subjective history at the beginning of care, so the baseline level is well identified.

When it comes to management of post-traumatic headaches, one of the first steps is to provide good education and lifestyle modifications for the patient. Improving sleep hygiene, having regular healthy meals, staying hydrated, identifying stressors and avoiding them as possible, gradual progression back to exercise, and reducing stress are all ways to help reduce the effects of their headache<sup>15</sup>. Pharmacological management may also be used, but we need to be aware of medication overuse headaches and how they can make the problem bigger. Medication overuse headaches can be caused from the use of analgesics, opioids, triptans, or ergot alkaloids<sup>16</sup>. It is important to try and address the underlying issue causing the headaches, rather than masking it.

Considering the impact that this patient's headaches had on her daily function, it may have been beneficial to consider using more objective outcome measures to assess the progress she was having with her headache symptoms and relating it to her function and the impact they were having on her life, rather than just rating it with a number which is common in practice. One of the outcomes measures that can be used for headaches is the Headache Impact Test (HIT-6). The HIT-6 can be used to assess the impact that a headache can have on a patient's ability to function at work, school, home, or in social situations. There are 6 questions regarding the frequency that someone has symptoms ranging from 'never' to 'always'. The higher the score, the bigger impact their headache is having on their function<sup>11</sup>. According to a study published in *Cephalalgia* journal, the HIT-6 is reliable, with internal consistency reliability between 0.82 and 0.90, and a valid tool for measuring headache impact for chronic migraine pain<sup>17</sup>.

A preventative approach may be beneficial to implement with females in order to minimize the risk of a detrimental concussive impact during activity. In this specific case, the therapist implemented an intervention strategy in order to help the patient improve her head-neck stabilization and kinesthetic awareness. The first episode of care focused on headache symptoms without a functional outcome measure to assess it, as well as scapular strengthening. Gearing the physical therapy plan of care towards the patient's symptoms, obtaining an extensive history of the patient during subjective questioning, and identifying when referrals need to be made to the appropriate healthcare provider are all important to remember when evaluating a patient with a concussion.

An interesting area of future research is the idea of the interdisciplinary approach to concussion management. The clinic took a multi-disciplinary approach to treatment in this case because of the variability of her symptoms and various disciplines that were trained to identify and treat her symptoms. There is research to suggest that the most effective approach to mTBI patients is by working with an inter-disciplinary team. In a study by Rytter et al., an interdisciplinary rehabilitation program was more efficient at reducing persistent post-traumatic symptoms. The symptoms were in the physical, cognitive, and emotional domains. This group also had increased activity levels and decreased mental fatigue<sup>11</sup>. One of the limitations of this study, however, was that it was very costly. Continued research on how to make concussion management the most efficient and cost effective for this patient population will be

necessary in order to help more patients experience the benefits of working with an interdisciplinary team.

The patient in this case represents a good example of how complicated it can be to treat a female with a concussion whose symptoms do not resolve in the typical length of time. The challenge with this patient was that it was difficult to decipher what the root cause of her continued symptoms were. She is a female, so the menstrual cycle hypothesis could have been a factor from the beginning. She also was seeing multiple providers for her various symptoms, so it is hard to determine what treatment interventions were the most effective. One of the most important aspects to an effective plan of care for a female with a concussion is to obtain a very extensive history in order to determine what the patient's baseline level of function is so the interventions can accurately be assessed as effective or not. This case also demonstrates how extensive a plan of care can be for a concussion, so helping these patients understand the severity of a concussion so they are adherent with recommendations for their own continued safety. Continued research focusing on understanding the cause for these sex differences in the mTBI patients will aide in further improving the care given to this population.

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