The Effects of Post-Concussion Symptoms on a Patient's Overall Quality of Life

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Introduction

Growing up the best remedy for a simple bump on the head or a slight trip was a kiss on the forehead or a little ice on the "boo-boo" to make it all better right? Nothing ever seemed that serious unless it resulted in being knocked unconscious. As knowledge in areas of head injuries continue to grow symptoms and patterns of behavior have developed into more than just a kiss or ice to make the pain and trauma go away. Through the continuous studies and research done on those suffering from head injuries the results and data have made these issues more serious.

"March 25th, 2016, Ranger Stadium, be there to support the Drew University Women's Lacrosse team as they take on one of their biggest rivals in the conference, Susquehanna University!" That was the team motto for the entire week as the rangers prepared to take on one of their toughest opponents. It was a huge rival and they knew they had to perform. The pregame jitters lasted throughout the week as the Rangers eagerly awaited for their opponent to arrive. The blood, sweat, and tears that went into their practice they knew would be worth it in the end. They wanted to come out on top, to be the better team, and to fight until they had nothing left. Winning a Landmark Conference Championship was their desire before they graduated. Since their freshmen year it was engrained in them to practice hard in both the off -season and regular season to be the best and to play fair. The Rangers were all about playing fair and showing the highest amount of sportsmanship they possibly could. They knew that they wanted to win each game from the hard work and practice they put in, not from playing dirty or out of line.

The day had finally come and the Rangers were about to walk onto the field that sunny Saturday afternoon. It seemed as if it was the perfect conditions for a lacrosse game. All of the fans made up of friends and family gathered around anxiously awaiting for the start of the game. Before going out on the field the team put their heads together to remember why they were there. They remembered in that moment why they started playing the sport, went to that school, and committed themselves to being a part of that team. They knew they had to stick together. Getting a "W" was the only option. As the team recollected about warm-ups they knew that they had went as well as warm-ups could have gone go, but that the attention was gradually starting to focus on that first whistle of the game, the first draw of the game, the moment that ball went up in the air, and everyone was suddenly fighting for possession. As they eagerly stood next to each other with The National Anthem playing in the background, they mentally prepared themselves for what would end up being a total shift in their whole season.

The starting line-up went as usual considering they only really had enough girls to put on the field, "small but mighty," their coach would always say. The defense being the same, the offense on point, and of course the lone goalie in the back. They were pretty fortunate to have one goalie that stuck it out with them through the years as all of their other ones seemed to have disappeared. The goalie, she was the definition of a true teammate, the backbone to their structure, and the last defender on the field. She was fearless in cage, always focused, and always prepared for whatever came her way. The team knew her voice like the back of their hand especially the defense considering they were always taking direction from her. The Rangers knew listening to their goalie's every command and communicating productively was imperative that game in order for immense success and a "W" to be the end result.

The first half of the game did not go as well as they had hoped, trailing 10-3 was a deficit that they knew was getting more difficult to make a come back. The coaches expressing their frustration and fear, hoping that the team was not going to let the game slip away from them, delivered the team's half-time talk. The coaches were worried that they were really going to let the other team make them look like they were not able to compete at the same level. The goalie

could only do so much for them in the back; making saves from shots that they knew should not have even be taken. As a unit they had to put their heads together and know that the second half was going to be different, that they were all going to have to work together in order to make a come back.

The buzzer went off and they set-up to take the draw for the second half of the game. There were no more jitters at this point, it all had just turned into determination, and they knew that they were about to have themselves a competition. The ball let loose and they lost possession, allowing the other team to make the first goal of the second half. That soon became the major turning point in their overall play mentality. Well, at least they thought it was going to be considering they scored two goals in a matter of two minutes after that play had happened. What they didn't know was that something else was going to happen that would not only change the level and pace of the game, but their entire season as well.

"24:07 of the 2nd half, red card issued to player number 24, slash to the head" yelled the ref. For those who do not know what a red card is, it is an automatic removal from the current game and expulsion from playing in the following game. Usually this card is given to players who get one too many yellow cards, or players who are playing extremely out of control and aggressive, to the point where they are a danger to other players on the field. As number 24 ran off the field the Rangers solemnly stared at their goalie as she laid on the ground not moving a muscle, no response, and no recollection of what had just happened. Her helmet was a little busted and she laid there as everyone stared wondering what would happen next. As the team huddled together everyone had a look of uncertainty on their faces. All the players and fans saw the goalie get struck in the back of the head with another player's stick, but no one knew what kind of injury had really occurred just from watching the play. Most people watching knew that she most likely had suffered from a concussion, but since she was wearing a helmet no one thought it would have been extreme. At this point as the goalie still lay on the ground the Rangers were trying to fathom what decision their coaches would make next, they had no other goalie. The parents and players were all talking amongst one another, parents yelling from the sidelines and stands, questioning why that player took her stick and hit the goalie in the back of the head as hard as she could? What kind of sportsmanship was that? Many people were thinking a red card was not the only thing that should have happened to her for deliberately hitting a player to injure them.

"Can you hear me?" said the trainer, as the team's goalie started to wonder what just happened. "I'm fine, I swear, I can go back in," she said as she began to stand up. She looked fine, just a little confused, but she was ready to go back in, like nothing ever happened. The team was excited that they were still able to play with their goalie and she appeared to be fine. In fact, she even played the rest of the game without ever asking to come out or that she was having any complications. Although the Rangers ended up losing the game, the end score was only 15-13. Talk about a come back, at least for the score of the game that was, for the goalie it was about to be a whirlwind of chaos.

That night her symptoms started to kick in, a raging headache and extreme nausea, is what she was feeling at 4:11am when she woke up in hysterics because she just didn't "feel right." The symptoms became worse and soon enough she was missing practice, missing games, stuck in her room, making the trainers and coaches extremely concerned about the rate at which her symptoms were progressing.

"So these were the results of your baseline ImPACT test, let's just see where you are at now that the symptoms have progressed since the incident," said the trainer as he pulled out her

file. The ImPACT test is something all freshman athletes are required to take when they first start that gives a baseline to how quick the mind reacts to different stimuli, whether that be numbers, matching, letters, etc. According to the online source , the IMPACT test offers educational resources and tools to raise awareness regarding the importance of proper concussion management and is supported by a database of clinical research, including more than 250 peer-reviewed and 145 independent studies (ImPACT Applications, Inc. 2017). Sounds legitimate right? At least that is what all freshmen thought when they had to allot 30 minutes out of their day to complete it and none of them having any prior history of severe head injuries or concussions. They were all thinking the same thing about the topic; it is definitely not that big of a deal.

Strangely enough the goalie's results were better than her original baseline results, making things a lot more difficult to interpret, where were they supposed to go from there? Why were her results better, but her symptoms worse? This started to make the team wonder how accurate these evaluations really were and whether or not they were up to date with current research and findings. As a month came and went the goalie's emotions began to be expressed from the norm, spontaneous and persistent. Her vision also started to become a concern; sensitivity to light and adjusting to it began to give her problems. Seeking out a specialist sure enough became a necessity. According to Galletta, et al. sports-related concussions commonly affect the visual pathways and that there really is no vision-based performance measure for assessing concussions in athletes as they occur (Galletta, et al. 2015). This was crucial in the goalie's timeline post-concussion because the trainers and physicians were unaware that she was even suffering from visual post-concussion symptoms. The limited knowledge surrounding the area of concussions although has continued to advance, there is still a majority left unknown.

> The limited knowledge and data surrounding head injuries and concussions in particular has led society towards greater fear and anxiety when combating these issues surrounding the circumstances of concussions. The efficacy of data and research has continued to advance since the 19th century when concussions were first understood, but the mechanism, protocol, and proper treatment regimens are still vague (Harrison, 2014). Through the use of understanding plausible hypotheses relating to the neuromechanism of concussions and the impact of post-concussion symptoms on the quality of life of patients, society can develop a better understanding of where concussion research is headed and where it stands currently. Limited knowledge surrounding the neurmechanistic pathways of concussions, the influence of history on current protocol, and the effectiveness of treatment regimens of patients post-concussion are the key factors necessary to further explore and improve the quality of life post-concussion.

Types of Head Injuries

The concussion crisis and CTE epidemic amongst athletes and individuals has started to obtain a lot of understanding and publicity. Many of those that have suffered from concussions more specifically sports-related concussions have begun to develop long-term symptoms and permanent damage over time (Harrison, 2014). The first knowledge of the concussion outbreak has stemmed from football related tragedies that have suddenly swept every news channel and headline on every social media page (IBID). Memory deficits, mood disorders, and motion symptoms are some of the common contributing symptoms that span across many of those who

suffer from concussions (Coughlin, 2015). Researchers and medical professionals have begun to categorize traumatic brain injuries, concussions, and chronic traumatic encephalopathy as the three common types of injuries treated in sports-related instances and few of which have occurred outside of the sports realm (IBID). Understanding the history and development of how these injuries have progressed over-time is crucial in understanding where the current protocol stands and is headed along with what constitutes as a plausible treatment regimens that benefit patients and prevents future damage.

History

The history of concussions is not as easily understood due to not only the lack of knowledge behind it, but the fact that many people were unaware of the long-term damage it may have on their brain over a longer period of time (Harrison, 2014). The first reported and documented concussion was in 1883 by a Harvard football player known as William Harvey (IBID). Harvey explains the hit "knocked him insensible" (Harrison: 822). Football was big in the 1880's and the Ivy League schools dominated within this region of athletics (IBID). The sport soon took over the publicity of other college campuses and eventually every school wanted to take part in this competitive atmosphere (IBID). Considering the circumstances of this new aggressive sport, equipment was not as advanced as it is today making helmets extremely incapable of absorbing shock from detrimental hits to the head (IBID). As the rise of this sport began to consume much of society, polls were taken by coaches and players in order to generate a sense of direction regarding the safety and appeal of the game (IBID). The summer after Harvey was hit he still was experiencing symptoms and pain from the injury in the fall he explained it as being, "sick with blood gathering in the head and threatened with congestion of the brain" (Harrison: 822). The concussion had taken a toll on his brain and body and left him with these symptoms lasting over the span of many months. Despite what many may think, Harvey returned to play the follow year, although he played under a different name due the objections his family had against him going back (Harrison: 822). Harvey felt that under the present rules that had been put in place the year following his injury that, "it would be almost impossible for an injury to happen to a player, such as I experienced in '83" (IBID). Harvey hoped that by implementing polls and regulations from players and coaches that his one simple head injury would be prevented for all in years to come, despite what he may have thought, many people still believe the same is possible now (IBID). This eventually became a problem as history progressed involving even more detrimental damage to players and athletes alike.

In 2003 a report to the US Congress about concussions was identified as the "silent epidemic" (Harrison, 2014). By 2006 the Centers for Disease Control and Prevention estimated that 1.6 to 1.8 million concussions occurred annually in sports, with football presenting the highest population of those contributors (IBID). Along with this statistic it was also estimated that an average of 47 percent of high school football players suffered from concussions between practice and competitions that year in comparison to collegiate athletes at 61 percent (IBID). These statistics were calculated about 12 years ago and concussions have only continued to gain more and more attention due to the extensive damage as a result. Many claim that corporate interest groups play down the severity of concussions in former players to keep the media appeal high, while public health interest groups tend to play it up to generate more awareness surrounding the aggression and violent play (IBID). The concept of concussions first truly discovered when the game of football became popular was not really recognized due to limited knowledge and research and the long-term effects were never even considered because the cases

were so new (IBID). Harrison explains that although the crisis appeared to be quiet in the beginning, it was not because concussions simply stopped happening, but more so because researchers and advocators knew further technical research needed to be done to increase safety of players and decrease the worry in order to continue to allow the sport to grow and gain American publicity (IBID). The ultimate goal was to generate safer technical components, while reforming the way the population viewed the aggressive and violent sport (IBID). It was difficult to tell whether or not the reform of football was truly to provide better quality of safety for players and athletes or whether it appeared to be that way in order to better suit society due to football's instant gain of attention and hype that attracted many people to the events (IBID).

Much of the headlines exacerbated statements such as, "A Student Killed at Football," "Dead From Football injuries," "More Slugging Than Playing" (Harrison, 2014: 823). It is interesting to see the difference between how the headlines have shifted from the previous generations to current. The current generations express more about the act of concussion or CTE itself rather than football or other aggressive sports being of the main cause. It did not help that there was absolutely no padding and many of the athletes wore stockings on their head for decoration and team identification (Harrison, 2014). The natural age of aggression particularly in men is something that has span across generations for centuries. Football was the first initial outlet after the Civil War that researchers believe allowed men to exert their aggressive behaviors they would have more normally expressed during war and since as Harrison explains it, "the frontier was lost" many men took part in these recreational activities in order to fulfill a historiographical paradigm (Harrison: 824). Many interventions took place in the beginning years of football especially at Harvard in 1885 and again in 1895 due to the violent nature of the sport and appeal to society that football held due to thrilling aggression that took place (IBID). Charles Eliot the president of Harvard at the time described the game of football as, "the main objection lies against its moral quality…The common justification offered for these hateful conditions is that football is a fight and that its strategy and ethics are those of war, where the weaker man is considered the legitimate prey of the strong" (Harrison: 824). The accuracy behind Eliot's words is scary considering they were spoken over 123 years ago and the game has only continued to produce more drastic injuries leaving many players with long-lasting damage.

Within the ending periods of the 19th century an intercollegiate rules committee was formed to regulate and create standardized rules for the game of football including obtaining only selective persuasive evidence, technical reform and pressure on college administrators, faculty, and overall the presence of society (Harrison, 2014). The quiet period that was presented about concussions during this reform forcibly worked to limit the amount of public knowledge about concussions in order to slowly and gradually change the way of the game without abolishing it completely (IBID). This where the issue lies, within the concept of selective persuasive evidence, which further exemplifies the idea that the reform groups put in place were not all they were made up to be. One of the leaders in this reform group had published an a volume in 1894 called *Footballs Facts and Figures* that gained a lot of attention and was used as evidence to support why the game should be continued, supported by many letters from players expressing their profound love and interest of the sport (IBID). What the volume failed to include was Harvey's portion of the questionnaire that discussed his injury that "knocked him insensible" and the brain trauma that doctors had found afterwards (Harrison: 822). It was found that Harvey's original letter that is kept in the leader's papers at Yale University had the portion discussing his injury crossed out in crayon (IBID). The volume *Football Facts and Figures* had Harvey's published letter within it stating:

"Philadelphia, April 20, 1894:

> I consider football one of the grandest games that is played. My experience on the football field has stood me in good stead and has taught me self-possession and the faculty of deciding quickly and accurately. I believe that in many ways it fits a man for the business of life when comes in contact with his fellow men.
>
> I have been out of college for nine years but I endeavor, at every opportunity to see a good game of football.
>
> Yours very truly,
> W.S. Harvey" (Harrison: 825)

The reform groups disguised the original documents in order to protect the sport of football while they implemented new rules and regulations such as possession rules and creating a position for a quarterback in order to make fouls more visible to referees and reduce the full fledge momentum of plays that more often than not resulted in bloody and gruesome injuries (Harrison, 2014). The intention of this concept appears to makes sense and seem right and just, but due to the covering up of evidence in order to protect the game rather than the lives of the players and future players may have left many people during that time period feeling uneasy about the sport and reform and regulation groups. In fact the glory surrounding this so called turn around reform eventually became picked apart by the leaders in charge of player safety because they felt that the reforms led to more reforms without actually reducing the amount of injury, but more so suited for entertainment purposes and audiences around the United States (IBID). Although it is evident that the intention was there to change the way of the game for future safety, the secrecy that was hidden behind the scenes did not necessarily help this case when people began to realize the reform groups had trouble executing their alterations.

It is difficult to understand the side that these reform groups were taking during the time as head injuries in sports like football continued to happen. Some might argue that they truly were trying to gradually implement changes in rules and regulations in order to further prevent injury and the quality of life of these athletes after they graduated and went about their lives as adults, while others may argue the publicity that was gained through sports such as football became more of the driving factor for reforms groups to keep any information that would alter societies perception under the radar (Harrison, 2014). Seeing the growth in regard to improvements of equipment and the implementation of rules and boundaries leads many to believe these reform groups were truly trying their best with what they had and the minimization of leaving out data or comments from players who suffered head injuries was more used as a way to protect society from generating assumptions due to the limited data about concussions and head injuries during that time period (IBID). Even today it is evident that concussions and head injuries do have an impact on the overall quality of life of athletes and non-athletes, but limited data and research confirming the true framework of what these injuries result in leaves many physicians and researchers hesitant to release information that they do not know holds standardized value across a population of people over time.

Language

In 1906 the death of a student from Harvard University caught much of society's attention (Harrison, 2014: 825). The Harvard College team doctors released a report titled, "*The Physical Aspect of American Football"* which within it highlighted the number of injuries and severity of injuries during the 1905 season and more specifically discussed concussion of the brain (Harrison, 2014). The language of how concussions were exemplified and discussed grew as research and data was uncovered. Although researchers emphasize that the concept of concussions had been commonly found in medical usage and language for centuries, the pace at which those not well versed in medical terminology understood what it meant was completely different (IBID). During the early years of the 16th century, concussions were more commonly defined as a blow to the head resulting in "escape of blood from ruptured tissue" (Harrison: 825). By the 19th century the definition of concussions grew to being understood as an "external violence" that resulted in the "derangement of the organization of the brain" (Harrison: 825). Some could infer that alteration of vocabulary when discussing concussions grew in order to emphasize the importance of treating concussions and the outcome athletes could endure if not treated properly. Prior to the change in vocabulary many athletes found injuries especially that of concussions to be a joke (Harrison, 2014). This was most likely due to the fact that limited knowledge and data supported these explanations placed by physicians. It was also most commonly believed prior that due to the vague vocabulary presented by physicians that any external incident on the brain was more than likely not going to have an effect on the conscious and unconscious aspects of the brain (IBID). The limited data was due to the fact that physicians were unable to obtain sufficient data from small samples of players during a season to produce generalized data about concussions over a longer period of time (IBID). This especially holds true for neurologists who had not thoroughly studied the effects and onset symptoms of concussions during these earlier time periods to fully understand the extent of the conditions (IBID). It was not until the late 19th century that researchers were able to obtain data about concussions through other types of incidences such as train collisions (IBID). Due to the frequent collisions that happened within the 19th century physicians were able to draw more conclusions regarding concussions and the effect they would have on children and adults over time (IBID). This gained the attention of society and individuals playing the sport redirecting them to knew information and explanation of data that was more easily understood and relatable (IBID). One might infer that those who were not athletes had a difficult time understanding the extent of concussions and their possible effects due to the fact that they could not relate to the circumstances, but also because the research presented on train collisions was more applicable to society.

As research and data continued to be collected on concussions, researchers and medical professionals were able catch the attention of more individuals by providing data regarding the amount of concussions sustained from athletes throughout the amount of games during their season (Harrison, 2014). The change in the way researchers and medical professionals worded and organized this data provided a different outlook and perception for those trying to further understand. This became apparent when *Boston Medical and Surgical Journal (BMSJ)* released information discussing how many athletes were not even aware that they were sustaining a concussion and that in fact the surgeon on the sidelines had a better idea of when a concussion exactly occurred in comparison to the athlete due to lack of knowledge and understanding (IBID). As language changed throughout history about concussions, so did the influence of how

individuals perceived concussions. This especially began to hold true as concussions began to happen to those not competing in a sport.

It is even relatable to the present time how language plays an important role in not only concussions, but other diseases and disorders that patients can endure. It is very common to be admitted into a hospital setting with symptoms and have absolutely no understanding of what the physicians are explaining. This is a continuing problem in today's society because as research and data continues to be more thoroughly understood, it can also become more complex. Finding a common ground amongst patients and professionals that simplistically explains conditions and circumstances without clouding the patient of medical jargon that could induce fear and anxiety would be the smartest approach moving forward in terms of language.

Chronic Traumatic Encephalopathy:

"Concussion is a frequent occurrence in contact sports: 1.6 to 3.8 million sports-related concussions occur annually in the United States (McKee, et al., 2009: 709). The severity of concussions can vary from with a recovery time of a few days to weeks, while repetitive cases of concussions can lead to severe traumatic brain injury (TBI) or even prolonged chronic traumatic encephalopathy (CTE) (IBID). Many researchers would describe any type of concussion as a mild TBI due to the intracellular components that can progress into long-term damage or CTE if continuously injured (Giza, et al. 2018). The intracellular components that effect damage post-concussion have not been fully understood. With that being said, there is no concrete evidence-based practice or treatment plan post-concussion, in turn this frustrates many patients and their families with the level of potential care they receive and may in fact indirectly lead them towards further repetitive injuries if they are not educated and or monitored properly (Smith, 2016).The cascade of events that are understood post-concussion intracellularly can help to provide further understanding on effective treatments options such as weighing the options between alternative approaches to treat symptoms or biomedical intervention, especially for patients more prone to head injury such as athletes. Understanding what happens in the brain intracellularly post-concussion may also provide further information and input about CTE and how physicians and staff can better treat those who suffer from it. The cascade effect also provides a different perspective on how alternative medicine may be a plausible treatment option for symptoms that effect emotional and mental health.

CTE was originally thought to only affect those who took part in professional boxing, due to the "punch-drunk" technique that many would use (McKee, et al. 2009: 710). CTE was originally defined as *dementia pugilistica* and the *psychopathic deterioration of puglists* (McKee, et al.: 710). Puglist refers to a boxer originating in the 1920's, one who specifically was well known and competitive (IBID). CTE was originally found and studied on autopsies of patients after they died because it was not easily seen or diagnosable on CT scans, the population that was most effected by CTE pertained to professional athletes, 46 out of 51 CTE cases (IBID). Many common symptoms allowed physicians and researchers to gain a better understanding of how the disease progressed and what could typically be expected. Many found that the first symptoms of CTE generated by deteriorations in attention, concentration, and memory, along with disorientation, confusion, dizziness, and headaches (IBID). The problem with common first symptoms in CTE is that they are also the common first symptoms of any head injury, concussion or TBI (IBID). This is why physicians and researchers were unable to distinguish the difference amongst the three different types of injury, post-injury and throughout recovery. Many of the severe cases of CTE seen in a few professional athletes over the years revolved around

three stages the first stage showing symptoms of affective disturbances and psychotic symptoms; the second stage social instability, erratic behavior, memory loss, and initiation of Parkinson's disease symptoms; and the last stage consisting of general cognitive dysfunction eventually leading into dementia with speech and gait deformities (IBID).

When studied and compared, football players had an average age at death of 44.0 years, while boxers had an average age at death of 60 years (McKee, et al. 2009). With that football players had a range of symptoms 3-10 years while boxers had 5-46 years (IBID). A few factors could play into the interpretation of this data including the amount of repetitive concussions over time, the severity of each concussion, the rest time between multiple concussions if any, and age at which concussions began in the athletes life. All of these factors are highly specific to each athlete and are not understood in the data provided by McKee, et al., but based on the scientific information of the intracellular cascade, one could infer that each type of concussion athletes suffered from impacted the severity leading to CTE (IBID). The ways in which football players use their heads in comparison to a punch or blow to the head in boxing could impact the severity of the concussions leading to the difference in age at death and range of symptoms. To further support this point, boxing is the most frequent sport associated with CTE and the disease duration is the longest in boxers with most being demented compared to football players who most commonly presented with mood disorders, aggression, irritability, apathy, confusion, agitation, and reduced concentration (IBID). The difference in consistent and long-term symptoms along with duration of symptoms and average age at death proposes the idea that not all concussions can be understood as impacting the same regions of the brain (IBID). With that being said, although not all concussions can be implied to effect the same areas of the brain, the intracellular cascade that is applicable to the stretching of axons and microtubules post-concussion may still be a common denominator in both cases.

Using CTE as an example of what can progress post-concussion presents a problem within the medical field pertaining to diagnostic testing and treatment options for patients suffering post-concussion. The discrepancies shown within the data in the McKee, et al. study only scratch the surface for other possible underlying factors that may influence the severity and damage of concussions (McKee, et al. 2009). Finding a common ground to work from such as the intracellular cascade model and looking at alternative approaches to treating symptoms may provide more information on preventative treatment approaches and post-concussion treatment options for patients suffering with the variation of symptoms to increase overall quality of life.

Due to the description and variation of symptoms post-concussion it is difficult to say that those simple symptoms of disorientation, sadness and anxiousness may not turn into chronic symptoms over time eventually being classified as a disease or disorder. For example, a patient post-concussion who has been suffering from extreme sadness or fatigue since the injury would most likely be prescribed an anti-depressant at some point by their physician, especially if the symptoms of depression have been persisting over time. This concept leads towards a completely different treatment plan compared to just resting and limiting the amount of light one is exposed to because the symptoms some of these patients experience begin to effect their everyday function in their everyday life, transpiring how they lived prior to their injury mentally, emotionally, physically, and even spiritually (IBID). Understanding this domino effect in regard to symptom progression for some patients is crucial and also imperative that physicians provide patients with treatment options that balance the weight of treating all realms of the patient mentally, emotionally, physically, and spiritually to ultimately increase their overall quality of life. One way that this can be achieved is by incorporating or providing alternative treatment

options in conjunction to the biomedical model to give patients options that can positively influence other areas of their life and give them the satisfaction of having a choice.

Considering the limited research around overall treatment options and treatment protocol for concussions it would not be fair to imply that the biomedical model would be the only effective treatment option. This especially holds true for the idea that specific patterns in the cascade mechanism during a concussion and post-concussion mimic that of other diseases and disorders, yet not much research has been tested using similar biomedical treatment options. Therefore, it leaves the area for concussion treatment wide open because no one has really taken advantage of the fact that there is no specific treatment. This means that no particular area of treatment, alternative versus the biomedical model holds a bias or is placed at a higher advantage over the other, making it an equal playing field for both plausible areas of treatment to provide positive results in patients post-concussion. With that being said if researchers are unable to come up with a specific treatment regimen for patients post-concussion to inhibit progressive mechanisms found in the cascade effect because the variability in research and data is too large, it would be in the patient's best interest to focus on what can be treated, their mental, emotional, and physical symptoms.

The large amount of alternative research looking at those experiencing or suffering from depression, anxiety and chronic headaches, focuses on how the use of alternative approaches benefit the patient, might actually provide insight or spark other ways of treating symptoms post-concussion from a biomedical perspective. If research is limited when it comes to fully understanding what happens during initial head injury and post-injury it would benefit the quality of life of patients to at least find ways to treat their symptoms and do it in a way that increases their overall quality of life without them feeling dependent on the biomedical model. To say one treatment method is greater than the other is rudimentary because the advancements in both research and technology have provided society with the understanding that there is not just one way achieving success. Alternative options may work for some patients and not others, while the biomedical model may only work for some patients and not others, the point remains around the fact that both are being presented to patients and in most cases may even be used in conjunction to one another to provide the upmost and highest quality of life for patients following any circumstance or injury.

Media

Social media plays a prominent role in today's society for many reasons including advertising or providing awareness of the many popular news headlines and current upkeeps of societies culture. The accessibility that has been gained by generating social media outposts has provided researchers, journalists, and activists a place to implement their data and share it with others in similar communication. Although social media and media in general have provided a format to deliver information, the accessibility can be damaging when the information provided is invalid or not supported by data that is directly visible to those engulfed within the content. Often times individuals perceptions can be skewed through the media if content is consistently combating one another. The understanding of head injuries through the media can be misleading if the headlines invoke emotional or biased interpretations (Kuhn, et al. 2015). "The public's perception of sport-related concussion and CTE is likely not based on the totality of empirical data, but rather on highly publicized and emotionally charged events" (Kuhn, et al.: 1732). Media's influencing factor and display of information regarding head injuries creates within it controversy amongst researchers and medical professionals when effectively trying to diagnose

and generate preventative measures towards the future treatment and protocol of head injuries not only on society absorbing it, but also the patients being effected by the convoluted opinions.

Influence of the Media:

It is easy for a researcher studying the brain of an athlete that was diagnosed with CTE during their lifetime and eventually committing suicide to say that the effects of their CTE were the cause of this outcome, but as previously discussed there could be so many predisposed genetic factors that could have played a role in this phenomena and due to limited knowledge it is elementary to draw conclusions. Kuhn, et al. states that although CTE is a neuropathological diagnosis more commonly diagnosed in athletes and individuals with repetitive head injuries, the underlying mechanism, how it develops, the relevant comorbid factors associated with genetics, cardiovascular health and substance abuse, and even the generally seen clinical presentation of CTE are still fully unknown (Kuhn, et al. 2015). Due to the severity of these headlines when the media releases these stories, it makes sense as to why society and other athletes alike suffering from similar symptoms could jump to conclusions about their own state of being. The same concept holds true for other diseases that have more concrete data than head injuries, concussions, and CTE. Cancer for example is made up of a wide range of different types of cancers, varying locations, expression of different modalities, and even the influence of differing genetic makeup. Despite the more concrete data used by researchers and physicians when diagnosing patients presenting with these symptoms, there is still always room for error making it difficult for patients who are expressing these symptoms not to fully convince themselves that their case may be worse or better than what is clinically being seen. It is imperative that data continue to be produced and studied regarding head injuries, concussions, and CTE, but to say that eventually there will be a cure to preventing these cases overall is like saying all cancers will eventually be prevented and abolished. These diseases and disorders adapt and grow as society continues to change making it difficult to make a one-stop treatment similarly seen with vaccines and antibiotics. It is more plausible to say that by consistently uncovering more concrete data relating to theses cases can provide better prevention and treatment options for those who present with similar symptoms.

Abolishing the play of specific sports in order to further manage these types of injuries appears to be extreme because these types of injuries can happen in those individuals who are not involved with sports whatsoever. The concussion and CTE epidemic has been present and growing for some time, concussions originally noticed in 1883, while CTE having the first discovery around the 1920's (Kuhn, et al. 2015). These cases have been a prominent part of athletes and individuals for quite some time now, but due to the increase in media and societies access to media, it appears to be more prominent now than it was before. Media has the ability to generate one-sided news that can impact the feelings of those surrounded by it or those that feel they can directly relate (IBID). This can be a benefit and downfall to society depending on the topic. Considering the high influence of sports on society at all ages, highlighting the tragedies associated with head injuries, concussions, and CTE tend to have a large impact that can induce fear-based perceptions if not supported effectively (IBID). This is not just seen in the common sources of social media much of society uses today, but also within the research realm. If one researcher produces data that downplays concussions, another researcher is going to counteract that data by producing an article denouncing why the other researchers data may be skewed or incorrect (IBID). This in turn results in the media to capitalize on these flaws and become skeptics of the research altering the perception of whatever it is trying to be argued or proved

(IBID). Kuhn, et al. suggests a three-pronged approach to disconnecting science and the media revolving around sports-related concussions and CTE, which could more likely than not be applicable to other diseases and disorders that carry with them an extended amount of controversy (IBID).

The first step proposed in reducing the amount of influence science has on media and visa versa is to educate society on the influence of belief bias and the backfire effect (Kuhn, et al. 2015). Often times individuals will stand closely to their own beliefs and common-sense conclusions rather than understanding the concrete evidence produced to support or denote a specific topic (IBID). To those not well versed in the area of research may be more vulnerable to the illusion of validity regarding the quantity of research in comparison the quality of that research (IBID). For example, if a researcher publishes an article depicting how the ingestion of dark chocolate daily can decrease one's risk of developing cancer, that headline in itself can draw attention to society, one because cancer is a largely researched and influential topic on the many lives of those suffering from it or associated with those who are combating it, and two because chocolate is an easily accessible commodity that tends to be inexpensive. The researcher of this article may even produce statistically significant results that support this hypothesis. The illusion of validity is the one concept that can stand in the way of someone believing or not believing this proposed area of research. Someone who is well versed in understanding data may look at the data and recognize that the researcher uses a small population of people all who are considered to be healthy individuals, with no history or genetic predisposition to cancer. This would then make the validity of the data sparse due to the choice in population of where the data was derived.

Due to the easily acceptable choices of media, many of those reading the articles may not fully take the time to understand and do research of their own on whether or not the data holds a strong sense of validity. This is the second part of the three-pronged approach; researchers and medical professionals should be more focused on educating the media and encouraging attendance of large events such as conference and academic seminars in order to provide further clarification on the recent findings of valid data (IBID). If researchers and medical professionals can get a better grip surrounding what the media portrays they may be better equipped when diagnosing patients because everyone involved in the process would be on the same page. That is assuming that the data and research these conferences and academic seminars are presenting is high in validity and quality of information. The third part of the three-pronged approach revolves around the collaboration of data within a large conference setting as opposed to going back and forth denouncing others data through journal articles, headlines, and other media influences, which can easily sway readers' opinions and perceptions (IBID). Large academic conferences have the ability to squash non-sense and invalid data at a larger level, reducing the future influence of it at a higher level (IBID). Overall, the fact that researchers and medical professionals are seeing the influence of media on these widely discussed topics such as head injuries, concussions, and CTE makes it easier to address the epidemic surrounding these cases because it shows that researchers and medical professionals are trying to generate research that can help the population of those suffering from them. It also shows that they care enough to limit the amount of invalid data highlighted in order to produce more effective results in patients. This tactic used currently by researchers and medical professionals may have been the tactic that reform groups in the past tried to achieve, but considering the advancement in technology and scientific achievements overall, it makes sense as to why it is more effective now than it may have been in the past.

In the 1880's and 1920's much of the data was related to patient's own symptoms and narratives rather than being backed up by concrete data like we see today (Harrison, 2014). The area of research has definitely developed a more exponential growth in what constitutes as valid data and effective data in comparison to that of which was found or presented in the past.

Neurological Mechanistic Pathway

The neuromechanistic pathway of concussions and other related head injuries is comprised of hypotheses with no distinct or concrete analysis of the exact pathological explanation (Giza, et al. 2018). Concussions are classified as movement of the brain displaying clinical symptoms post-injury, with no biomarker associated or evident and dramatic brain malformations making it difficult for physicians to thoroughly exam, image, and test what is happening in the brain post-concussion and resulting in variation from case to case (IBID). Despite the limited knowledge surrounding the exact mechanism, researchers have been able to gather similar correlations across many cases post-concussion producing data that supports what they hypothesize to occur post-concussion. The rapid release of neurotransmitter and the ionic disequilibrium are two of the most commonly studied hypotheses that have gained much validity with the recent years of research (IBID). Many research articles supporting or denoting these tendencies post-concussion support their data through proposed mechanistic pathways based on what is already understood regarding neuronal communication and structure (IBID). Figure 1 below exemplifies the proposed mechanism post-concussion intracellularly that is support by the data provided in Smith, 2016 (Smith, 2016).

Figure 1: Cascade of Concussion's Intracellularly

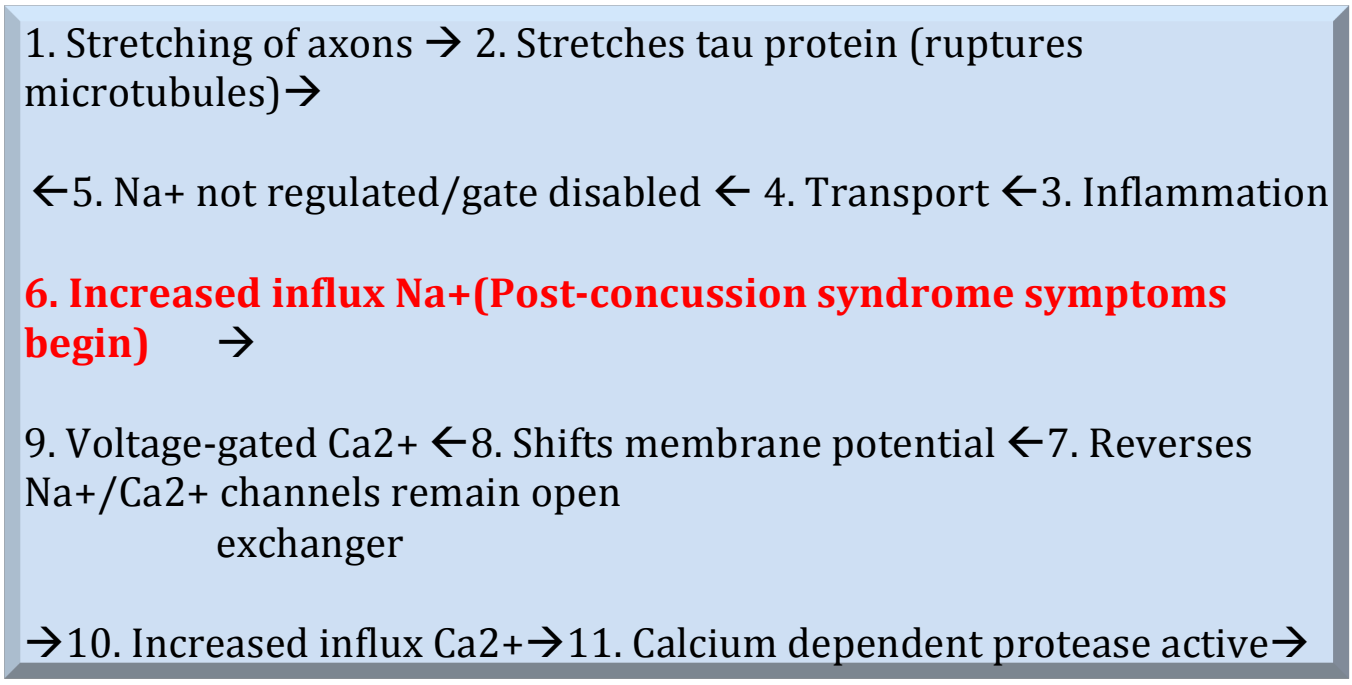


Figure 1. The proposed mechanistic pathway post-concussion intracellularly. Data generated using information provided from *Neuromechanics and pathophysiology of diffuse axonal injury in Concussion* (pgs. 2-5), by Smith, D. H. 2016, *Bridge Washington, DC: 1969*, *46*(1), 79.

Microtubules:

The intracellular effects post-concussion typically involve damage to the axon specifically referred to as diffuse axonal injury (DAI) (Smith, 2016). During initial trauma, regions of the brain push and pull against each other causing it to change shape and deform (IBID). This push and pull effect can be narrowed down to damage among the axons that connect to the neuron cell body, responsible for conducting electrical signals throughout the neuronal pathway (IBID). Areas of the brain that are highly effected in DAI such as white matter, are placed at a higher risk for damage due to the complexity and highly organized neuronal pathways (IBID).

To gain a better understanding of DAI it must be understood how the axon functions and the components. Microtubules create structure for the axon and have been shown to be the components directly affected during initial trauma (Smith, 2016). Microtubules have many roles in cellular mobility and migration, but the role it plays in concussions focuses on cell polarity and protein transport (Smith, 2016; Howes, et al. 2018). During initial injury the axons in the surrounding areas stretch causing breakage in the microtubule structure preventing it from its natural sliding motion (Smith, 2016). This stretching generates a cascade effect for other microtubules in surrounding areas preventing the sliding of adjacent microtubules to return back to their relaxed straight orderly shape (IBID). In one sense, one over-stretched microtubule can affect surrounding microtubules from properly working in cohesion with one another and ultimately causing them to rupture or disconnect (IBID).

The rupture effect of microtubules can be further understood and supported by the displacement of the tau protein, responsible for stabilizing parallel microtubule arrangements (Smith, 2016). The natural sliding motion that microtubules undergo is stabilized from the placement and function of tau protein (IBID). When the axon is stretched and the microtubules are slid beyond their normal loading flow, tau protein stretches and unfolds from their resting confirmation (IBID). The extension of the tau protein results in breakage of the hydrogen bonds within it making the protein incapable of keeping up with stabilizing the consistent and rapid microtubule sliding, ultimately causing it to rupture (IBID). When rupture occurs, places of disconnect directly influence the proper transportation of proteins along the microtubule (IBID).

One of the main jobs of microtubules involves the transportation of proteins (Smith, 2016). Microtubule associated proteins (MAPs) are important for carrying out organization of the axonal network and coordination of function (Howes, et al 2018). Microtubules act as a track for the transportation of proteins from point A to point B (Smith, 2016). When the microtubule or surrounding microtubules rupture resulting in disconnect, proteins can pile up at locations of disconnection causing varicose swelling throughout the injured axon resulting in what is described post-concussion as inflammation (IBID). Evidence does not support that all protein transportation is stopped once swelling occurs, but it can be understood that if protein transport is able to continue through the swelling, the protein will most likely be displaced further along the axon due to microtubule disconnection, reducing the effectiveness of the proteins intended function (IBID). This theory along with the observation of activated microglia responsible for emitting and activating immune-response processes post-concussion may offer more insight to the initiation and underlying cause of inflammation in the brain (Giza, et al. 2018).

Ions:

Along with the disconnection of microtubules comes a secondary disturbance to the ion concentration found within the channels of the membrane (Smith, 2016). Stretch injury on microtubules and dysfunction of tau protein has been shown to also impair the regulation of axonal sodium channels (IBID). The stretching of the microtubules within the axon impairs the inactivation gate that regulates sodium influx decreasing the channels ability to properly regulate the amount of sodium flowing through the channel (IBID). Unregulated sodium influx into the membrane can cause hyperexcitability of the cell and affect the proper firing of an action potential (Atkin, et al. 2018). It is proposed that the loss of axonal sodium function to produce an action potential can cause delay in signaling throughout neuronal networks (Smith, 2016). Increased sodium influx creating an effect of hyperexcitability in the cell has commonly been associated with seizure behavior, while loss of function of sodium channels overtime due to unregulated increased influx can result in loss of consciousness, decreased signaling speed, and memory impairments (Smith, 2016; Stafstrom, 2007).

The ionic equilibrium that is disrupted due to the high influx of sodium channels is also affected by the high influx of calcium into the membrane that accumulates damaging the cytoskeleton (Giza, et al. 2018). The high influx of sodium directly effects the charge in membrane potential reversing the sodium-calcium exchanger resulting in the voltage-gated calcium channel to remain open producing the high influx of calcium in the membrane (Smith, 2016). Calcium at high levels can become toxic to cells generating irreversible damage. The high levels of calcium induce the release of calcium-proteases leading to secondary cytoskeletal disruption (IBID). The brain is unable to properly restore this ionic equilibrium post-concussion due to lack of energy supply (Giza, et al. 2018). Cerebral blood flow is reduced after concussion, while calcium accumulates within the mitochondria of the cells further delaying the oxidative metabolic processes (IBID). This implies that not only is calcium playing a role in damage to areas of the axon, but also is also directly affecting the cells ability to metabolize and restore energy (IBID).

An in-vitro model experiment demonstrated that even with mild injury of axons in vitro although only little sodium and calcium influx were induce there were still more sodium channels being activated and by adding a second mild stretch injury a day later resulted in massive influx of both sodium and calcium allowing researchers to infer that sodium channelopathy might play a role in the period of vulnerability post-concussion (Smith, 2016). Understanding the role of sodium post-concussion may lead to a better understanding of the cascade effects that follow with calcium and the prolonged damage that has been seen to occur after a concussion.

Protocol

The protocol required for patients post-concussion especially athletes post-sports related concussion is minimal due to the complex factors and delayed on-set of common symptoms post-injury. Neuropsychological testing has become the strongest form of measurement post-concussion and post-sports related concussion due to its extensively researched functionality and mobility within an athletic setting (Maerlender, et al. 2016). This test is designed for post-concussion use in order to compare the athlete's baseline test taken prior to any injury with the results of their current state post-injury (IBID). This form of testing is relevant to providing further explanations regarding clinical symptoms, but fails to truly exemplify the findings of what happens in the brain post-concussion. The protocol implemented for concussions also

varies based on the severity of symptoms presented at the patient's current state, making it difficult for researchers, medical professionals, and reform groups to develop and exact protocol regimen.

Concussion Protocol and Treatment Maintenance

Testing for the severity of a concussion and monitoring the symptoms post-concussion are processes that have shown more surface level value and provided less understanding of the intracellular components (Asken, et al. 2018). The amount of devices or ways of measurement to really identify the severity of the concussion and the exact location in which it exhibits damage because all parts of the brain are interwoven and connected has not been fully implemented in the medical based practice (IBID). General predictive factors and symptoms studied from many patients backgrounds, history, and medical records have led to consistent patterns and observations that have generated a common protocol to identify the symptoms of a concussion (IBID).

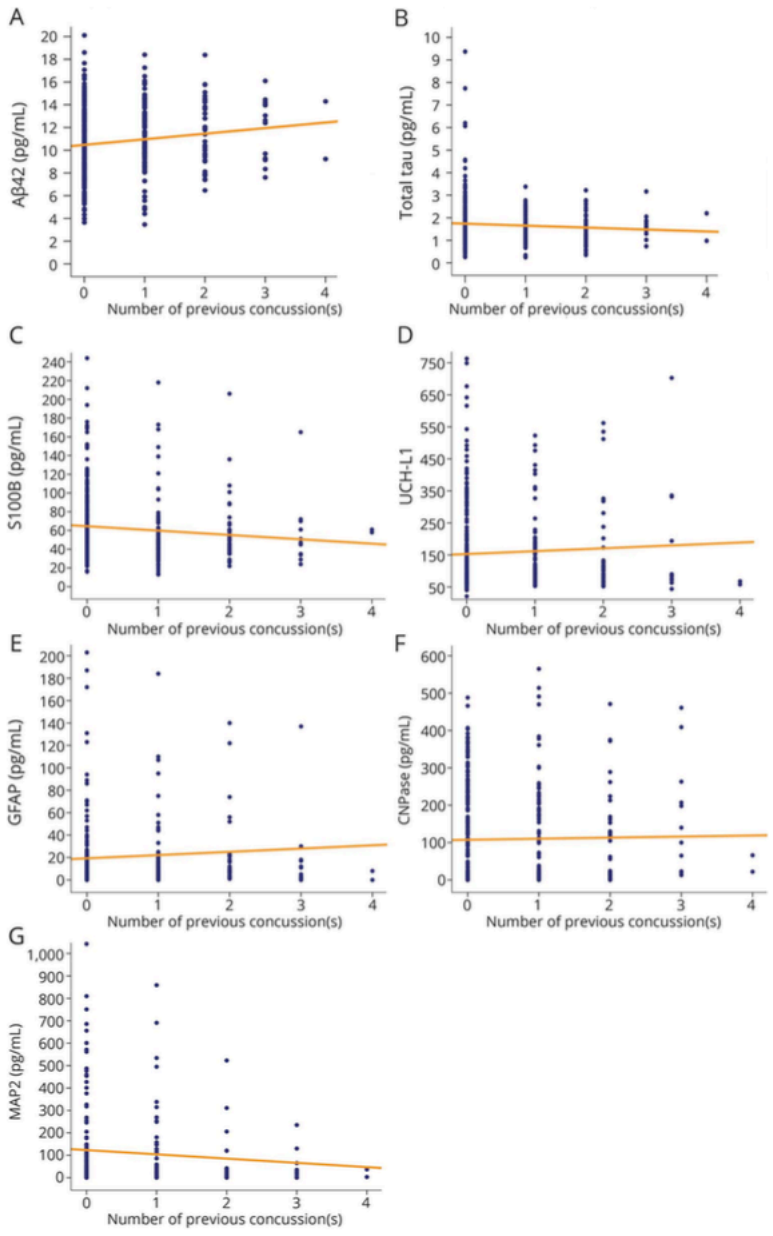
A common test used to monitor for symptoms of a concussion outside of the physical symptoms is referred to as the Immediate Post-concussion Assessment and Cognitive Test (ImPACT) (Asken et al. 2018). This test is most commonly used by athletic trainers for sports teams and even implemented in school medical settings as a quick and efficient way to identify symptoms of a concussion within 72 hours after it happens (Aken, et al.: 1). " Computerized neuropsychological testing has become an important tool in the identification and management of sports-related concussions; however, the psychometric effect of repeat testing has not been studied extensively beyond test-retest statistics" (Maerlender, et al. 2016: 1). The ImPACT test is given to students or athletes prior to the beginning of their season when they are considered non-injured, retesting in most cases every two years to provide a standard and baseline of their overall cognitive function on a normal scale (IBID). This test is then used as a measurement to show any cognitive symptoms that might be missed or not demonstrated physically post-concussion (IBID).

The testing standards and range of scores was originally generated by using a population of 333 non-injured collegiate athletes over a period of four years and testing them on each component of the test, verbal memory, visual memory, visual motor speed, and reaction time (Maerlender, et al. 2016). After gaining a range of scores from these non-injured athletes over a period of time the developers of the ImPACT test were able to create a standard unit of measure for this test to be used for future athletes post-concussion (IBID). Although this test provides significant insight to administrators and athletic trainers about the severity from a physical scale of post-concussion symptoms, it does not fully identify or provide a thorough understanding of the intracellular damage happening inside the brain. This form of measurement only provides implied or predicted insight about whether or not the cascade effect is progressing or digressing in different brain locations and regions (IBID). Not only does the ImPACT test fail to address complications going on within the brain, but it also cannot be used for those admitted to the emergency room after a fall or head injury because ImPACT testing is not required in a standard yearly check-up to provide a baseline for everyday people. Even if the ImPACT test was a standard of care or protocol for a majority of people tested by their primary care physicians, considering the fact that it is not regulated and kept up to date like vaccines or other disease prevention tests the timeline of the results may be inconsistent or skewed.

There is a type of testing that was used in the same study done by Asken et al. where they took biomarker specimens of the β-amyloid peptide 42 ($A\beta_{42}$) which can give indication about

the levels of tau protein within the blood comparing it with the concussion history of participants seen in reference Figure 1A-G below (Asken, et al. 2016). The analysis of this type of test analyzes tau through ultrasensitive immunoassay digital array technology (IBID).

Figure 1 Relationship between number of previous concussions and baseline serum biomarker concentrations



A significant but weak association was found between more previous concussions and higher baseline $A\beta_{42}$ levels (A). No other significant correlations were noted (B–G). $A\beta_{42}$ = β-amyloid peptide 42; CNPase = 2′,3′-cyclic-nucleotide 3′-phosphodiesterase; GFAP = glial fibrillary acidic protein; MAP2 = microtubule associated protein 2; S100B = S100 calcium binding protein B; SRC = sport-related concussion; UCH-L1 = ubiquitin carboxy-terminal hydrolyzing enzyme L1.

Figure 1A-G, Relationship between number of previous concussions and biomarkers from *Concussion BASICS II: Baseline serum biomarkers, head impact exposure, and clinical measures* (p. e2127), by Asken, B. M., Bauer, R. M., DeKosky, S. T., Houck, Z. M., Moreno, C. C., Jaffee, M. S., ... & Clugston, J. R. 2018. *Neurology*, *91*(23), e2123-e2132.

The data of Figure 1A from Asken et al. demonstrated a significant, but weak association between the $A\beta_{42}$ levels and those with a history of concussions showing a slight increase of $A\beta_{42}$ in those who had previously experienced multiple concussions prior to the blood-draw (Asken, et al. 2016). With that being analyzed and shown, this test does still not provide enough evidence of what may be happening intracellularly within the brain due to the lack of correlations between the properties and intentions of $A\beta_{42}$ under normal conditions (IBID). This form of testing does not provide an immediate or direct understanding of the severity and potential damage post-concussion and can not be easily used as an evaluation technique for those entering an emergency room or meeting with their primary care physician. In other words, this type of analysis and testing will only lead to more testing, which again leaves patients frustrated and hopeless with the standard of care for concussion protocol and treatment options influencing the overall quality of life.

Quality of Life

The quality of life in patients post-concussion is not fully understood, especially in adolescents when symptoms progress over an elongated period of time (Russell, et al. 2019). The limited knowledge and data supporting the overall mechanism of post-concussion treatment regimens is minimal, which can directly impact the patient's overall quality of life. In order to better understand what impacts the quality of life in patients of all ages post-concussion it is crucial to gain some sort of understanding of the influencing factors even if the data presented only targets a single population. Often times it is more beneficial to have some data rather than no data, in which researchers and medical professionals can draw from to generate other conclusions about patients presenting with similar symptoms. Considering the research supporting long-term symptoms and damage presented in patients post-concussion it was imperative that a form of measurement be created in order to gain a better understanding and baseline post-concussion that could provide more thorough and accurate timelines of treatment for patients post-concussion. The Health Related Quality of Life measurement was generated to produce a multi-dimensional patient report encompassing patient's perception of physical, mental, and social functioning post-concussion or medical condition (IBID). This form of measurement is not only isolated for patients post-concussion, but can span across many patients with varying medical conditions by exposing the more subtle influencing factors post-injury that are not as easily seen or observed by traditional measures (IBID).

Health Related Quality of Life and Sports-Related Concussions

Although anyone can suffer from a concussion or TBI a majority of research and studies have focused on sports-related injuries. One can infer that sports-related head injuries are one of the biggest populations for those who suffer from concussions or TBI's and have only continued to increase. Providing the right quality of treatment for patients is difficult when there are so many factors that can come into play. The mental, emotional, physical, and spiritual effects of a disease or ailment can impact and influence patients differently including their quality of life. Caring for every aspect of the patient during their journey is a lot for physicians to take in and manage in any acute or chronic condition, not just TBI's or concussions. Health Related Quality of Life (HRQOL) has really begun to grow in the clinical and research setting due to the immense need to treat and understand the patients beyond just the clinical diagnoses and measures (Russell, et al. 2019). The purpose of HRQOL is to expose the factors that contribute

to the perception of disease or ailment altering the physical, mental, and social functioning of patients (IBID). These factors are commonly hidden and not as easily seen or studied in comparison to the measurable clinical outcomes (IBID). As referred to previously the complexities surrounding TBI and concussions especially intracellularly make it extremely difficult to possibly analyze, treat, and be attentive to all symptoms. Sports-related concussions were found to be an influential group to study the effects of HRQOL (IBID). Researchers analyzed how HQRL can be further implemented to improve the quality of life in patients suffering from not only TBI's and concussions, but also other diseases and ailments that demonstrate complex diagnoses and treatment protocols (IBID).

The symptoms occurring neurocognitively due to the intracellular breakdowns and delays are most commonly seen as physical symptoms such as disturbances in sleep, cognitive, and emotional functioning (Russell, et al. 2019). In most cases patients suffering from sports-related concussions usually return to their normal routines and sense of self after 1-4 weeks assuming that they had proper medical assessment, education, with gradual exposure back into school and sport-related activities (IBID). This simple regimen is not always the case for all patients suffering from a sports-related concussion and many are seen to experience a delayed recovery elicited as post-concussion symptoms (PPCS) (IBID). PPCS requires more than just the general overview and maintenance seen in less severe TBI or concussion injuries; PPCS requires a multidisciplinary therapeutic approach that addresses the causal pathophysiological and psychosocial effects (IBID). One could infer that PPCS could be more highly associated with more severe head injuries and possibly even those who have experienced repetitive concussions due to the elementary knowledge and measuring methods available to physicians that accurately assess all elements of the head injury, intracellularly, pathophysiological and psychosocially. To develop a method that measures all three accurately may be difficult, but creating a method of measurement or developing a tool that can accurately depict one of the three may provide further understanding about the patterns and behaviors of the other two.

The technique and intention of the HRQOL analysis provides a further understanding of all components of disease or trauma that may be effecting patients (Russell, et al. 2019). This can be especially helpful in children and adolescents suffering from mild, moderate, and severe TBI, where HRQOL was predicted to be negatively impaired either temporarily or persistently (IBID). The study done by Russell, et al. focuses on comparing longitudinal HRQOL outcomes among adolescents who sustained acute sports-related concussion or sports-related extremity fractures with included follow-up physician documentation (IBID). This study also intended to identify the clinical factors associated with a negative HRQOL outcome among adolescent patients sustaining a sports-related concussion (IBID).

This study showed that adolescent patients 1-week post sports-related concussion suffered from meaningful impairments in physical, school, and overall HRQOL and worse cognitive HRQOL in comparison to those who were healthy participants (Russell, et al. 2019). This testing was found to be helpful because the severity of HRQOL impairments observed in sports-related concussion patients initially was found to be correlated with the length of time associated with physician-documentation in clinical recovery (IBID). In turn, those who showed delayed recovery based upon physician-documentation also showed significantly worse cognitive HRQOL scores during the initial testing in comparison to those who showed normal recovery as seen in Table 5 (IBID). Indicating the attentiveness of physicians during the first few weeks post-concussion has significant impact on the outcome of HQRL scores.

TABLE 5. Number of clinic visits and days to both initial assessment and clinical recovery

Factor	Patients	Median No. (IQR)	p Values*
No. of appointments	All SRC patients	3 (3 to 5)	<0.0001
	Delayed recovery	5 (4 to 6)	<0.0001
	Normal recovery	2 (2 to 3)	0.6164
	SREF patients	2 (2 to 3)	—
Days to initial assessment	All SRC patients	6 (5 to 10)	0.0107
	Delayed recovery	8 (5 to 13)	0.4056
	Normal recovery	6 (4 to 8)	<0.0001
	SREF patients	8 (7 to 10)	—
Days to physician-documented clinical recovery	All SRC patients	26 (17 to 49)	0.1189
	Delayed recovery	51 (34 to 83)	<0.0001
	Normal recovery	17 (13 to 23)	<0.0001
	SREF patients	31 (23 to 42)	—

* In comparison with SREF patients.

Table 5, Number of clinic visits and days in comparison to initial assessment and recovery from *Health-related quality of life following adolescent sports-related concussion or fracture: a prospective cohort study* (p. 7), by Russell, K., Selci, E., Black, B., & Ellis, M. J., 2019, *Journal of Neurosurgery: Pediatrics*, *1*(aop), 1-10.

Table 5 demonstrates the number of clinic visits and days to both initial assessment and clinical recovery highlights the significant p-values with a strong population size generating results that are valuable (Russell, et al. 2019). Much of the studies that focus on concussions currently use testing methods that may not fully pinpoint the correlations between specific variable impairments post-concussion and the length of recovery time. Although this study specifically uses sports-related concussions as the target of interest, it does provide keen insight on how the severity of impairments can directly correlate to a delayed or normal recovery, while taking into consideration the influence of consistent physician-documentation to every test and date as a key component to the results. Physicians who documented initial symptom burden during the first appointment were able to identify that initial symptom burden was the strongest predictor of delayed recovery (IBID). This raised a question as to whether or not the patient's attitude and outlook post-concussion has an effect on the overall recovery process or if there are underlying factors such as cognitive and emotional deficits that may play a role (IBID). One might propose the intracellular cascade effect is a contributing factor. If the initial symptom burden was in fact related to the intracellular cascade effect it could explain why the results of this study also showed that those who had a history of previous concussions also demonstrated worse physical, emotional, social, and overall HRQOL (IBID). To take this study a step further one could look at the correlation between those who reported initial symptom burden, delayed recovery, and whether or not they had a history of previous concussions.

By analyzing the correlation between those who elicited initial symptom burden, delayed recovery, and whether or patients had a history of previous concussions would allow researchers to identify whether or not underlying psychological factors had an effect on the delayed recovery process. This in turn would allow physicians to draw conclusion regarding the role of previous concussions to the progressiveness of those underlying psychological factors and decreased quality of life. For example, if a patient showed signs of anxiety and depression prior to their concussion, were the symptoms of these disorders exacerbated through the cascade effect

happening intraceullarly from the concussion resulting in a decreased quality of life? If high influx of ions whether it be Na+ or Ca2+ has been correlated with symptoms such as, dizziness, photophobia, phonophobia, cognitive dysfunction, depression, anxiety, and sleep disorders, it would be appropriate to infer that patients who already suffer from any of these common symptoms prior to the patient's concussion, would be more prone to the increased effects of these symptoms post-concussion, driving delayed recovery (Giza, et al. 2018).

Figure 6.1 displayed in the Giza, et al. article discussing the pathology and clinical translation of concussions demonstrates a similar cascade outline and theory as previously discussed with the addition of the effects of glutamate release post-concussion (Giza, et al. 2018). Placing a plausible additional factor into the cascade theory could provide researchers and physicians with a better understanding in the prediction of recovery post-concussion and even provide more accurate diagnoses and treatments options to preserve a patients quality of life.

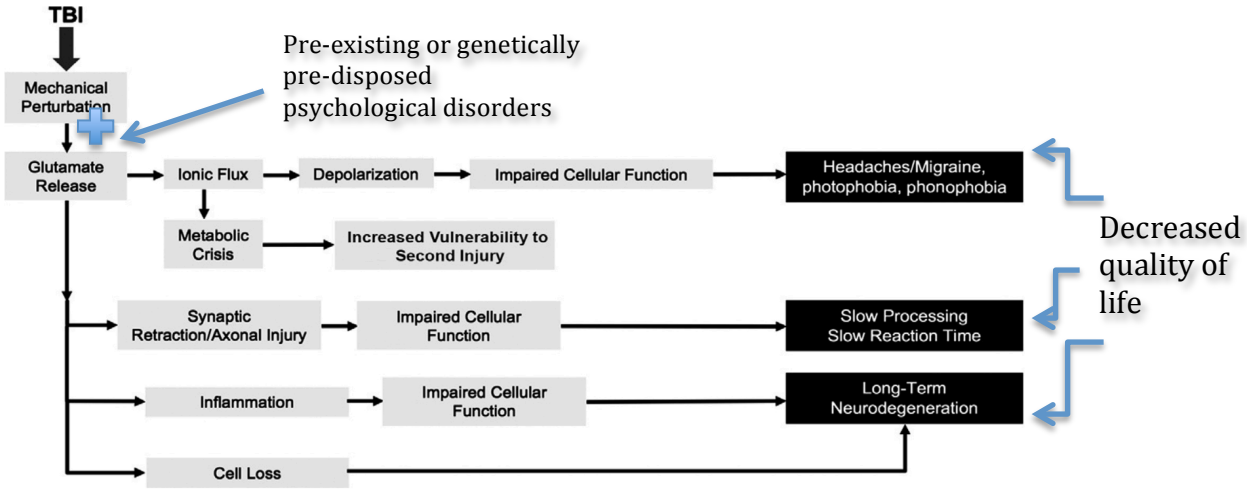


Fig. 6.1. Neurometabolic cascade of concussion. TBI, traumatic brain injury.

Figure 6.1, Neurometabolic cascade of concussion, all data generated and referenced from figure 6.1 in *Concussion: pathophysiology and clinical translation* (p. 53), by Giza, C., Greco, T., & Prins, M. L. 2018, In *Handbook of clinical neurology* (Vol. 158, pp. 51-61). Elsevier.

Applying a visual addition to this figure of what it may look like when pre-existing or pre-disposed psychological factors are incorporated into this process of understanding can change the entire direction of what physicians predict to be expected for patients-post-concussion (Giza, et al. 2018). This can lead to a more thorough diagnosis and treatment regimen maybe even reducing the common symptoms of initial symptom burden seen in patients experiencing delayed recovery (Russell, et al. 2019). This figure also raises an important question as to whether or not those who suffer from delayed recovery indirectly increase their neuronal damage long-term due to delayed intervention of the intracellular cascade.

The visual addition proposing that the effects from this cascade effect directly correlate with a patient's decreased quality of life helps researchers and physicians to focus on the main outcome of what is at a detriment post-concussion or TBI (Giza, et al. 2018). Setting aside post-concussion symptoms, intracellular cascade, and the possibility of pre-existing or pre-disposed psychological factors the main importance is always the patient, their quality of life, and the care they receive despite the severity of injury (IBID). The patient's quality of life is affected in all of these circumstances no matter how many factors are involved. It is important to understand and

gain knowledge to find treatment options that reduce the neuronal long-term damage and prevent future complications, but the main concept that should be taken into consideration is how all of these factors may directly affect the patient's quality of life in the present and future.

Health Related Quality of Life and Post-Concussion Symptoms

Focusing on sports-related concussions and analyzing the quality of life in patients post-sports-related concussion does provide insight on the timeline of concussions. Plausible damage in correlation to the severity, and the length of potential treatment are key relationships to be examined. Due to the isolated population of adolescents studied in sports-related concussions, Russell, et al., fails to incorporate the influence of data on older populations of adults (Russell, et al. 2019). The Russell, et al. study also only provided data within a one month range post-sports-related concussion providing enough time to make predictions and implications about the differences between delayed recovery and normal recovery, but had very little focus on post-concussion symptoms and health related quality of life (IBID). The ideas and inferences made regarding possible predisposed neurological diseases and disorders may better fit into the study performed by Voormolen, et al. which looks at the health related quality of life in patients between the ages of 27-57 and post-concussion symptoms within a six month period post-concussion (Voormolen, et al. 2018). Russell, et al. briefly touches upon this correlation when discussing the effects of initial symptom burden, but again analyzes it within a minimal timeline and a specific age population, making it difficult to draw distinctive conclusions about a majority of post-concussion patients (Russell, et al. 2019).

Table 1 in the Voormolen, et al. study provides a thorough understanding of the characteristics used to present stronger validity of conclusions and correlations drawn about the majority of patients post-concussion (Vooremolen, et al. 2018: 4). All of the data within the study relates back to post-concussion symptoms, but when multiple symptoms are persistent over a period of three months, it is classified as post-concussion syndrome (Vooremolen, et al. 2018). Separating the data of varying symptoms can provide further clarification on how these symptoms may effect every patient differently and provide a better understanding of each individual's proposed treatment plan.

Table 1
Characteristics of the study population.

	Total	PCS	No PCS	P-value
N	731	283	448	
Gender (male)	463 (63.3%)	161 (56.9%)	302 (67.4%)	<.01
Age[1] (years)	44 (27-57)	45 (31-56)	43 (26-57)	.14
Education				<.01
Primary education	21 (2.9%)	6 (2.1%)	15 (3.3%)	
Secondary education	336 (46.0%)	142 (50.2%)	194 (43.3%)	
Higher professional education	108 (14.8%)	32 (11.3%)	76 (17.0%)	
Academic education	84 (11.5%)	18 (6.4%)	66 (14.7%)	
Unknown	182 (24.9%)	85 (30.0)	97 (21.7%)	
Injury Mechanism				.03
Road traffic accident	351 (48.0%)	139 (49.1)	212 (47.3%)	
Fall	240 (32.8%)	96 (33.9%)	144 (32.1%)	
Sports	77 (10.5%)	19 (6.7%)	58 (12.9%)	
Assault	41 (5.6%)	22 (7.8%)	19 (4.2%)	
Other/Unknown	22 (3.0%)	7 (2.6%)	14 (3.3)	
Injury severity				
ISS[1]	6 (4-14)	8 (5-16)	5 (4-13)	<.01
AISH[1]	2 (2-2)	2 (2-3)	2 (1-2)	<.01
Head AIS 3	93 (12.7%)	42 (14.8%)	51 (11.4%)	
Head AIS 4	57 (7.8%)	30 (10.6%)	27 (6.0%)	
Head AIS 5	11 (1.5%)	6 (2.1%)	5 (1.1%)	
Comorbidity[2]				<.01
No pre-existing disease	329 (45.0%)	102 (36.0%)	227 (50.7%)	
1 comorbid disease	92 (12.6%)	36 (12.7%)	56 (12.5%)	
2 comorbid disease	33 (4.5%)	13 (4.6%)	20 (4.5%)	
3 or more comorbidities	40 (5.5%)	24 (8.5%)	16 (3.6%)	
Unknown	237 (32.4%)	108 (38.2%)	129 (28.8%)	
CT scan				.20
No CT scan	46 (6.3%)	18 (6.4%)	28 (6.3%)	
CT scan, no abnormalities	591 (80.8%)	223 (78.8%)	368 (82.1%)	
CT scan, abnormalities	94 (12.9%)	42 (14.8%)	52 (11.6%)	
Hospitalization[2]				
Hospital admission	373 (51.0%)	180 (63.6%)	193 (43.1%)	<.01
Number of days hospitalized[1]	3 (1-8)	4 (1-9)	3 (1-6)	.37
ICU admission	35 (4.8%)	22 (7.8%)	13 (2.9%)	<.01
GCS[1]	15 (14-15)	15 (14-15)	15 (15-15)	<.01
13	40 (5.5%)	22 (7.8%)	18 (4.0%)	
14	152 (20.8%)	71 (25.1%)	81 (18.1%)	
15	539 (73.7%)	190 (67.1%)	349 (77.9%)	
RPQ total score[1]	4 (0-15)	18 (12-28)	0 (0-4)	<.01

Abbreviations. ISS = Injury Severity Score; AISH = Abbreviated Injury Scale of the Head; AIS = Abbreviated Injury Scale; CT = Computed Tomography; ICU = Intensive Care Unit; GCS = Glasgow Coma Scale; RPQ = Rivermead Post-Concussion Symptoms Questionnaire; TBI = traumatic brain injury.
[1]Data are displayed as median, with the first and third quartile given within brackets.
[2]Comorbidity was defined as the presence of any co-existing diseases or disease processes additional to injury that the TBI patients sustained. The following diseases were assessed as comorbid disease: asthma, chronic bronchitis, chronic non-specific lung disease (not questioned), heart disease, diabetes, back hernia or chronic backache, osteoarthritis, rheumatoid arthritis, and cancer. [3]Hospital or IC admission for one day or more after arrival at emergency department.

Table 1, Characteristics of study group, from *The association between post-concussion symptoms and health-related quality of life in patients with mild traumatic brain injury* (p. 4), by Voormolen, D. C., Polinder, S., Von Steinbuechel, N., Vos, P. E., Cnossen, M. C., & Haagsma, J. A. (2018).. *Injury*.

Voormolen et al. identifies that mild TBI (mTBI) patients with post-concussion syndrome had 20% lower HRQol on average than those who had mTBI and no post-concussion syndrome (Voormolen, et al. 2018). Indicating that post-concussion symptoms do have an impact on quality of life in patients up to 6 months post-injury. Relating this statistic back to Russell, et al. one can see that those who demonstrated initial symptom burden had significantly lower HRQol

scores in comparison to those who did not (Russell, et al. 2019). Although the Voormolen, et al. study does not discuss the idea of initial symptom burden, it does in fact discuss post-concussion symptoms and with initial symptom burden being a symptom it provides possible insight as to whether or not initial symptom burden was an indirect symptom being measured within the Voormolen, et al. study taking into consideration the mental and emotional factors being measured in Table 2 (Voormolen, et al. 2018: 5). One might also question whether or not initial symptom burden could have been the driving factor behind the post-concussion symptoms seen within a 6-month period post-injury due to the data found in Russell, et al. exemplifying that those who experienced initial symptom burden post-concussion had increased chances of experiencing delayed recovery in comparison to those who did not (Russell, et al. 2019).

Table 1 makes it difficult to fully draw conclusions to this possible correlation between initial symptom burden and post-concussion symptoms among all age groups and varying types of concussions, while bringing it back to the over all quality of life because Table 1 only shows the difference between certain factors and whether or not those patients demonstrated post-concussion symptoms (Voormolen, et al. 2018). Taking that study a step further by analyzing whether or not the patients who demonstrated post-concussion symptoms were also exhibiting symptoms of initial symptom burden might provide more indication on if these two factors correlate in identifying the success of patients overall quality of life.

Another way in increase the validity of this study when trying to understand the correlations between post-concussion symptoms and quality of life, one could look at the number of hospital admissions and days hospitalized in comparison to those who demonstrated initial symptom burden to see whether or not their was a correlation psychologically between being admitted and severity of post-concussion symptoms. In Table 1 one can interpret from the data that an average of four days was seen to be the amount of time spent in the hospital post-concussion for patients who were hospitalized and demonstrated post-concussion symptoms, while an average of three days was seen in those who did not demonstrate post-concussion symptoms (Voormolen, et al. 2018). The differences in these numbers are not significant enough to draw a conclusion as to whether or not the amount of days hospitalized is a strong indicator of the severity of post-concussion symptoms or whether or not initial symptom burden could have been a factor, but one can see a significant difference in data when looking at the number of patients hospitalized demonstrating post-concussion symptoms versus those who did not (IBID). It is interesting to see that those who demonstrated post-concussion symptoms and were admitted into the hospital was around 63.6% of patients, while those who did not possess post-concussion symptoms was around 43.1% leading again back to the possibility that initial symptom burden seen in Russell, et al. could have been indirectly measured within the mental and emotional components in the Voormolen, et al. study tying neuropsychological factors either current or predisposed back to the patients overall quality of life.

The Voormolen, et al. study highlights an area of comorbid disease in the characteristics of the study population table presenting data that could be more thoroughly understood with the ideas proposed regarding the possible influence of pre-disposed neuropsychological diseases on recovery time and severity of post-concussion symptoms (Voormolen, et al. 2018). The data presents one, two, and three or more comorbidities reported for those who demonstrated post-concussion syndrome or no concussion syndrome within a six-month period (IBID). When analyzing the data one can see that those who expressed having one comorbid disease in the post-concussion syndrome category was 12.7% of the total, those having two comorbid diseases at 4.6% and those showing three or more at 8.5% of the total (IBID). Although the numbers do

not make up a majority of the total 283 patients demonstrating post-concussion syndrome it is interesting to see that those who had three or more was higher than those showing only two (IBID). The reason why it is interesting is due to the fact that many comorbid diseases can be correlated with each other, for example, anxiety, depression, bipolar disorder, PTSD, etc. Those being treated for one are most likely being treated for others, providing a better understanding of the complexity of impact of comorbid and neuropsychological diseases and disorders (IBID). One could infer that the accuracy of the amount of comorbidities might actually be varied based upon the patient. If one classifies themself as being treated for anxiety, they might in fact actually be treated for both anxiety and depression, skewing the accuracy of the results and leaving room for error when understanding the effectiveness of these comorbidities on the patients recovery and severity of symptoms. To further understand the accuracy of comorbidities on patients suffering from post-concussion syndrome it would be more beneficial to follow the data of each patient individually over the six-month period to really understand and see how the amount and magnitude of these comorbidities and symptoms can effect each patient. This idea is more thoroughly understood by Table 2 and Figure 1 in the Voormolen, et al. study exemplifying SF-36 scores (IBID).

Table 2
Data on health-related quality of life at six months after mTBI.

	PCS				No PCS					
	N	Observed range	Mean (SD)	Median (IQR)	N	Observed range	Mean (SD)	Median (IQR)	Unadjusted mean difference (95% CI)	Adjusted mean difference (95% CI)*
SF-36 (0-100)										
Physical Functioning	277	0-100	68.9 (27.9)	75 (50-95)	432	0-100	88.7 (20.4)	100 (90-100)	19.8 (16.2-23.4)	15.2 (11.7-18.8)
Role Physical	279	0-100	40.0 (42.1)	25 (0-75)	437	0-100	82.2 (33.1)	100 (75-100)	42.2 (36.7-47.8)	36.4 (30.7-42.1)
Bodily Pain	283	0-100	58.8 (25.6)	62 (41-74)	446	0-100	82.8 (21.5)	100 (72-100)	24.0 (20.5-27.4)	20.3 (16.7-24.0)
General Health	281	5-100	56.9 (22.0)	57 (40-72)	442	6-100	77.6 (18.5)	80 (67-92)	20.7 (17.7-23.6)	19.1 (16.0-22.1)
Vitality	283	0-100	49.2 (18.7)	50 (40-65)	443	15-100	73.0 (16.7)	75 (60-85)	23.8 (21.2-26.4)	22.2 (19.5-25.0)
Social Functioning	283	0-100	61.5 (27.0)	63 (50-87.5)	447	25-100	89.7 (16.1)	100 (75-100)	28.2 (25.0-31.3)	25.9 (22.6-29.2)
Role Emotional	279	0-100	58.2 (42.3)	67 (0-100)	438	0-100	92.6 (22.6)	100 (100-100)	34.4 (29.7-39.2)	31.9 (26.9-36.9)
Mental Health	283	0-100	62.2 (20.3)	64 (48-76)	443	28-100	81.7 (13.7)	84 (76-92)	19.6 (17.1-22.0)	19.1 (16.5-21.7)
Physical CS	271	9-69	43.2 (11.4)	44 (35-53)	423	16-70	52.5 (9.0)	56 (49-59)	9.2 (7.7-10.8)	7.3 (5.8-8.9)
Mental CS	271	7-66	41.1 (12.5)	43 (32-52)	423	16-73	52.7 (7.5)	54 (50-58)	11.6 (10.1-13.1)	11.6 (10.0-13.2)
PQoL (0-10)	192	1-10	6.5 (1.9)	6.7 (5.3-7.8)	347	0-10	8.4 (1.5)	8.6 (7.7-9.5)	1.9 (1.6-2.2)	1.6 (1.2-1.9)

*Variables adjusted for: gender, age, education, ISS, comorbidity, hospital admission, GCS and yes/no PCS.
Abbreviations. mTBI = mild Traumatic Brain Injury; PCS = post-concussion syndrome; IQR = interquartile range; CI = confidence interval; SF-36 = Short-Form-36; Physical CS = physical component score; Mental CS = mental component score; PQoL = Perceived Quality of Life; ISS = Injury Severity Score; GCS = Glasgow Coma Scale.

Table 2, Data accumulated of health-related quality of life six-months post-concussion, from *The association between post-concussion symptoms and health-related quality of life in patients with mild traumatic brain injury* (p. 5), by Voormolen, D. C., Polinder, S., Von Steinbuechel, N., Vos, P. E., Cnossen, M. C., & Haagsma, J. A. (2018).. *Injury*.

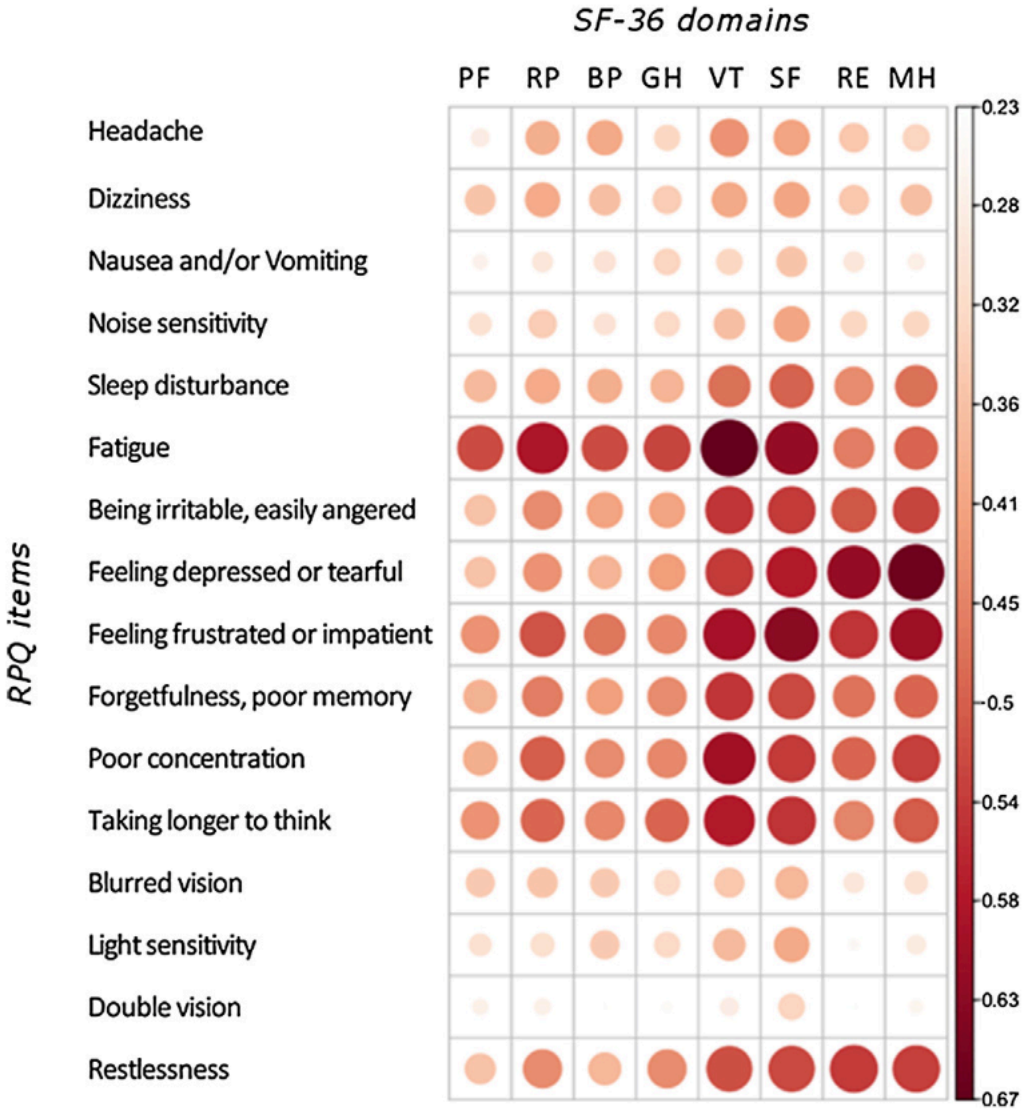


Fig. 1. Correlation RPQ items and SF-36 domains.
Abbreviations. SF-36Short-Form-36; RPQRivermead Post-Concussion Symptoms Questionnaire.

Figure 1, Correlation of SF-36 data in Table 1 and RPQ symptoms groups, from *The association between post-concussion symptoms and health-related quality of life in patients with mild traumatic brain injury* (p. 5), by Voormolen, D. C., Polinder, S., Von Steinbuechel, N., Vos, P. E., Cnossen, M. C., & Haagsma, J. A. (2018). *Injury*.

Table 2 depicts data regarding the patients quality of life six months post mTBI (Vooremolen, et al. 2018: 5). The SF-36 is a self-reported multidimensional survey incorporating 36 items that represent physical, mental, and social functioning in patients with post-concussion

syndrome and those with no post-concussion syndrome (IBID). The 36 items are grouped in eight categories of physical functioning (PF), role limitations related to physical functioning (RP), bodily pain (BP), general health perception (GH), vitality (VT), social functioning (SF), role limitations related to emotional problems (RE), and mental health (MH) (IBID). Table 2 provides direct data on how much these categories affected patients over a six-month period (IBID). The sum and formula used to generate concrete data about the patient's symptoms amongst these categories within Table 2 was then used to directly identify whether or not their symptoms increased or decreased their overall quality of life (IBID). The higher the domain number within the mean region of the table demonstrates to severity of influence of these symptoms within that group on the patients overall quality of life (IBID). Patients who presented no post-concussion syndrome had lower domain scores on the SF-36 data in comparison to those who presented with post-concussion syndrome six-months post mTBI, which was to be expected considering the argument within the study was meant to exemplify how post-concussion syndrome and post-concussion symptoms have an effect on the overall quality of life of the patient throughout and post six-months of the injury (IBID). Physical functioning, social functioning, and mental health were three of the domain groups that more highly effected after six-months post-mTBI (IBID). The comorbidities category reported in Table 1 could lead researchers to infer whether or not patient's who suffered from any dis-functioning amongst those three categories prior to their elicited higher numbers of these domain groups due to their pre-injury illnesses and disorders (IBID).

Figure 1 takes the sf-36 data in Table 2 to further understand the severity of these post-concussion symptoms at a six-month follow-up (Vooremolen, et al. 2018). The RPQ analysis technique describes 16 post-concussion symptoms that were most commonly reported after a TBI that includes headaches, dizziness, nausea/vomiting, noise sensitivity, sleep disturbance, fatigue, irritability, depression, frustration, forgetfulness, poor attentiveness, blurred vision, light sensitivity, and restlessness (IBID). The RPQ scale aims to measure the severity of these patient's symptoms 24 hours prior to their six-month follow-up appointment to further exemplify whether or not these symptoms had continued to persist since their initial visit (IBID). It is interesting to see that physical functioning which was reported to have the highest SF-36 score in Table 2 showed less severity of all RPQ items in comparison to vitality, which had one of the lower scores in the SF-36 data, but demonstrated the most severe of the RPQ symptoms in Figure 1 (IBID). Social functioning, which was reported to have a higher SF-36 score, resembled that data when looking at the severity of symptoms in the RPQ items along with the mental health section (IBID). It would be beneficial to use the SF-36 analysis post-initial injury and post-injury over a period of time to obtain data as a baseline, which can then be further understood and analyzed in the RPQ analysis giving physicians a better understanding of how symptoms may or may not have persisted in severity over time. Generating an RPQ analysis would allow physicians to draw more in depth conclusions about the patients symptoms and where or how they might be persisting to provide more effective treatment regimens over a period of time. This may even allow physicians to think outside of the biomedical model of medicine by proposing treatment options that incorporate alternative approaches to treating the patient's symptoms, especially those expressed in the mental health section.

Alternative Approaches

The interest in alternative remedies has become more attractive to patients as the biomedical model of medicine has continued to advance, due to many inconsistencies in drug treatment compatibility and increased side effects of these prescribed medications. Although the readability and efficacy of new generation pharmaceuticals has contributed tremendously to the treatment of many patients suffering from varying diseases and disorders, and the instantaneous solutions and treatment plans have been of great value, it presumably only masks the disease rather than working to reverse it or manage it.

Alternative medicine is viewed to show more therapeutic results and effects, typically backed up by qualitative data as opposed to the quantitative and evidence based data supporting the biomedical model, making it difficult to render respect and acknowledgement when proposed as an effective treatment option (Chopra, 1994). Alternative medicine can be used in lieu of some biomedical treatment options and can be more appealing to patients who feel general medicine has failed them, but most importantly alternative medicine can be used in conjunction to the biomedical treatment plan giving patients the care they need mentally, emotionally, and spiritually as well as targeting and treating the symptoms of disease directly (IBID).

When it comes to understanding concussions there really are no known treatment options as previously discussed. Most of the treatment revolves around resting and limiting the amount of light the eyes are exposed to, especially cell phone use and television (Russell, et al. 2019). Many of those who suffer from head injury or concussions develop effects such as headaches, nausea, dizziness, difficulty concentrating and feeling disoriented (McKee, et al. 2009). Much of these symptoms are treated once and disappear due to the fact that many of these symptoms become secondary problems or effects from something more severe such as having a cold or the flue and even the “stomach bug” can produce symptoms such as these, all of which are usually treated with a temporary medication prescribed by the doctor because symptoms usually subside within a few hours or days. Most of the illnesses that produce these symptoms do not become chronic. However, those who suffer from head injury sometimes experience these symptoms for days, weeks, and even months, some even get to the point where it becomes part of their everyday life and it is unclear to physicians as to why this happens (IBID). In the event of symptoms becoming chronic and persisting many researchers and physicians link it to repetitive concussions or even possibly the development of CTE (IBID).

Headaches:

Headaches can present themselves in different ways for each patient post-concussion. The intensity of pain or location from which the pain is coming from usually are two of the main factors (McKee, et al. 2009). As mentioned before, light can a play a role in a patient's recovery post-concussion or head injury (IBID). Light can irritate the eyes and even lead to headaches if exposed to too much or too bright right after a concussion. As described in the narrative, the symptoms the goalie was experiencing were directly resulted from her in ability to fully rest and stay away from exposure to light due to her limited knowledge about what was going on in her brain, even the physicians were not really clear about her condition. She ended up suffering from permanent vision damage, which could have been a result of where she got hit in the occipital lobe, but also the fact that she played the rest of the game in the scorching sun and continued to go to practices and games until she realized she was not getting better and was actually getting worse. There is no correct answer for a lot of these plausible conclusions, but regardless it

appears to researchers that a lot of influencing factors can play a role in symptoms and recovery of concussions, headaches being one of them.

According to Dr. Robert Milne, M.D. usually headaches are merely a symptom of another health problem as seen in the example described of patients post-concussion (Chopra, 1994). When it comes to treating headaches it is imperative that physicians carefully diagnose the location of disturbance that is actually causing the headache pain (IBID). The difficulty with this concept regarding concussions is that physicians are not accurately able to locate where the pain is originating from, unless they know exactly where the patient hit their head. Due to the limited research on these assumptions it is difficult to fully come to a conclusion about whether headaches are a direct effect from the concussion itself or is a symptom of some other factor like stress and tension.

Considering headaches share a wide variety of expression amongst patients in the way that they come about and how they present themselves, many types of headaches can be described or expressed differently in all patients post-concussion making it difficult to give an accurate diagnosis or treatment option. Setting aside that headaches post-concussion may be different than others types of headaches physicians treat patients for typically there are three most commonly seen types of headaches, tension headaches, migraine headaches, and cluster headaches (Chopra, 1994).

Tension headaches usually begin in the back of the neck or head and disperse themselves outwards producing a vague non-throbbing type of pain (Chopra, 1994). Typically this is a result from excessive tension in the muscles of the face, head, and neck that most commonly remain consistent (IBID). Dr. Milne concludes that,

> This pain evolves from two mechanisms relating to muscle contraction: nerve compression within the muscle caused by poor posture, spinal misalignment, or physical and emotional stress; and nerve irritation caused by a buildup of metabolic wastes resulting from decreased blood and lymph circulation due to poor diet, constipation, or other digestive problems (Chopra: 691).

From having a more thorough understanding of the neuromechanisms post-concussion one may infer that many head injury headaches could be a result of muscle tension in the back, face, and neck post-impact or trauma. This would make sense considering most head-injuries can be correlation with the effect of whiplash or other spinal injuries based upon the severity.

Migraine headaches typically affect 15 to 20 percent of men and 25 to 30 percent of women (Chopra, 1994). The reason that migraine headaches are typically more common in women in comparison to men is due to the fact that many migraine headaches can be triggered by hormonal releases during a woman's menstrual cycle (IBID). One may question why this could be relevant to concussions, depending on the age and type of menstrual cycle a woman may experience; the extra release of specific hormones may in fact increase the severity of one's concussion symptoms similarly seen during their menstrual cycle such as migraines and mood fluctuations (IBID). This is important when understanding and managing the treatment of a patient, more specifically a woman because it could either effect the severity of current concussion symptoms, or could lead physicians to misdiagnose the severity of a patients concussion because they mistakenly think the symptoms due to a women's menstruating period are actually symptoms of the patient post-concussion or head injury. Considering there is still limited knowledge in the exact mechanism of concussions, it is crucial that something as simple

as this does not negatively impact the patient such as prescribing them a mood stabilizer to treat hormonal symptoms and having it effect the healing process of the brain, if that patient does in fact have a concussion and their hormonal symptoms are increasing the severity of post-concussion symptoms. Prescription medication may have its benefits with a symptom such as migraines, but with limited knowledge on the exact neuromechanism post-concussion it is difficult to say whether or not it would be safe to introduce a drug that can potentially have neurochemical altering effects while the brain is still in a vulnerable state.

The last type of headache that physician's treat patients for is called a cluster headache (Chopra, 1994). These headaches are more commonly seen in men in comparison to women and typically fit a certain type of lifestyle or personality, type A personality, hard working, always striving, and usually under a lot of stress (IBID). These types of headaches are not as common as migraines or tension headaches, but do still have an effect on the lives of those who suffer from them (IBID). There is no link between cluster headaches and headaches seen post-concussion, but due to the environment or lifestyle in which these headaches can come about it is important to discuss that they still could affect patients post-concussion (IBID). Many athletes, especially those who compete at the professional level live a lifestyle of constant pressure to perform in order to maintain their status, lifestyle, and contracts they are given (Harrison, 2014). Considering cluster headaches have not been found to be genetic or correlated with a specific gene, it is possible that someone like a professional athlete could suffer from cluster headaches post-concussion as a symptom. It may not be directly correlated with the concussion itself, but could be a direct effect of their lifestyle and contributed to the fact that they are forced to rest and be cognizant of properly taking care of their brain post-concussion.

According to Dr. Milne, stress is the most common cause of headaches (Chopra, 1994). This idea can be contributed to all three of the types of headaches: tension, migraine, and cluster headaches. This is especially applicable to patients post-concussion because stress can come about from many different factors including, patients inability to fully understand the severity of their concussion, how long and what type of treatment would be most beneficial for them, and the biggest factor being that it may even change their lifestyle and everyday quality of life temporarily or even permanently (IBID). As discussed in regard to tension headaches stress can cause the muscles to tense up and contract for long periods of time reducing the amount of oxygen to the muscles (IBID). In conjunction to the reduction of oxygen supply, stress can even cause the body to release chemicals like histamines allowing them to accumulate, which can initiate inflammation and force neurons to fire muscle contracts resulting in pain (IBID). The psychological aspect behind this domino effect can continue if the patient develops a fear or expresses anxiety around the possibility of experiencing another painful headache (IBID). Considering the limited knowledge when diagnosing concussions and treating patients post-concussion, it is possible that those who experience headaches post-concussion could work themselves up thinking about whether or not their symptoms are getting worse. Dr. Milne also emphasizes that stress can be due to mental and emotional exhaustion relating to pressures accumulated in everyday life (IBID). This especially holds true for patients' post-concussion because head injuries do have the ability to hinder one's daily routine.

Treatment of Headaches:

It is easy to assume that the best treatment for pain overall would be a prescription medication that relieves pain, a painkiller (Chopra, 1994). This is fact may not be the best option for patients post-concussion, especially those who are suffering from headaches due to the fact

that excessive use of painkillers can cause a rebound effect intensifying the pain, particularly if they contain caffeine (IBID). Even over the counter medications such as Aspirin or Advil may only provide temporary relief and do not exactly target the direct underlying condition (IBID). Considering the vagueness surrounding post-concussion symptoms and the exact mechanism in which symptoms or progressing the best approach would be a more holistic or alternative approach.

There are many nutritional supplements and herbal medicine that have been used for centuries to treat the symptoms of headaches, but due to the limited knowledge post-concussion it is not safe to say that those would be the best alternative due to the conflicting factors they may induce in patients. On the contrary alternative approaches such as bodywork, relaxation techniques, hydrotherapy, and of course rest and limited time spent in the light and on electronics may be a better benefit to patients post-concussion suffering from headaches (Chopra, 1994).

As previously discussed, the constant muscle contractions and tension produced from stress on the body can affect not only the brain, but the body as well (Chopra, 1994). Bodywork is a treatment method that incorporates many different types of techniques; the types of techniques most applicable to headaches and patients suffering from them post-concussion would be more focused on the Rolfing, Feldenkrais Method, the Alexander technique, the Trager approach, polarity therapy, and acupressure (IBID). The most commonly sought out technique is acupressure because patients can administer this treatment on their own without the help of professional (IBID). Acupressure consists of using points within the body that relate to pressure points most commonly accumulated tension from stress (IBID). Acupuncture or acupressure focuses on the idea that body has within it different meridians where fluid travels different from the pathways of blood flow and the lymphatic system, but can influence one another when one is triggered (IBID). In the 1960's a researcher by the name of Kim Bong Han attempted to research the existence of meridians and found that they were a series of tubes that had their own pathways connecting themselves to different regions of the body, separate from blood vessels and the lymphatic system (IBID). It was unclear whether or not at that time if meridians resided within the vascular and lymphatic system until a French researcher, Pierre De Vernejoul discovered the idea to inject radioactive isotopes into the acupoints of humans and tracked the movement and pathways they compromised (IBID). He found that within minutes the isotopes traveled through their own pathway within the body formulating around the acupuncture meridians which have been practiced for centuries prior (IBID). To further conclude on his study, Pierre De Vernejoul decided to inject the isotopes into the blood vessels rather than acupoints and discovered that they did not travel within the same pathway distinguishing that the acupoint meridians, vascular system, and lymphatic system worked on separate grids (IBID). The interesting part about this discovery is that although the pathways were concluded to be separate they still influenced one another and the fluidity of the acupoint meridians correlated with the fluidity in the lymphatic and circulatory systems (IBID).

Acupuncture and acupressure have been proven to be successful treatments in reducing pain by not only increasing fluidity within the lymphatic and circulatory system, but also initiating the release of endorphins and enkephalins within the body that act as natural chemical painkillers (Chopra, 1994). Any type of activity that releases these natural "feel good" neurotransmitters results in one feeling a sense of satisfaction or happiness, which in turn has the ability to alter one's perception of the pain in which they are experiencing. For example, those who find enjoyment in working out after a long day, may find that they feel a sense of calmness post-workout due to the release of endorphins they experienced, altering one's perception of

stressors or pain they may have experienced throughout the day. Although the effects of acupuncture and acupressure may provide immediate relief after performance, this treatment must be continued throughout a period of time to experience constant relief as the body adjusts and creates these effects through habit, almost like "re-training" your brain and body.

The GB20, GV16 with B2, and L14 are the pressure points typically targeted for reducing pain caused by headaches (Chopra, 1994). The GB20 pressure point is located at the base of the skull and can be accessed by placing one's thumbs on either side of the hollow area at the base of skull, a pressing up motion from that area can allow more blood flow and circulation reducing the tension that can accrue within that region (IBID). The GV16 with B2 points are two different regions where pressure should be applied in conjunction to one another (IBID). The GV16 region is located directly in the center of the hollow area at the base of the skull, while the B2 area resides in the upper hollows of the eye sockets near the bridge of one's nose (IBID). The combination of these two pressure points allows more blood flow and circulation to those regions commonly resulting in tension from overstimulation of the eyes and neck (IBID). These three pressure points are points that need to be addressed on the face to access where tension might reside due to constant facial muscle contraction (IBID). This is important when understanding headaches patients might suffer from post-concussion because the eyes which are constantly stimulated in one's everyday life now have to be controlled and monitored post-concussion in order to reduce the amount of overstimulation that might occur in the brain while the brain is attempting to rest and heal from a head injury. The last pressure point L14, is not located on any part of the face, but is actually located in the web region of the hand, acupuncture and acupressure works on the belief that all areas of the body are correlated with one another in some way shape or form and certain points in the feet and hands can explain a lot about what is happening with symptoms such as headaches located on a completely different region of the body (IBID).

Figure 2: Locations of acupressure points for treatment of headaches

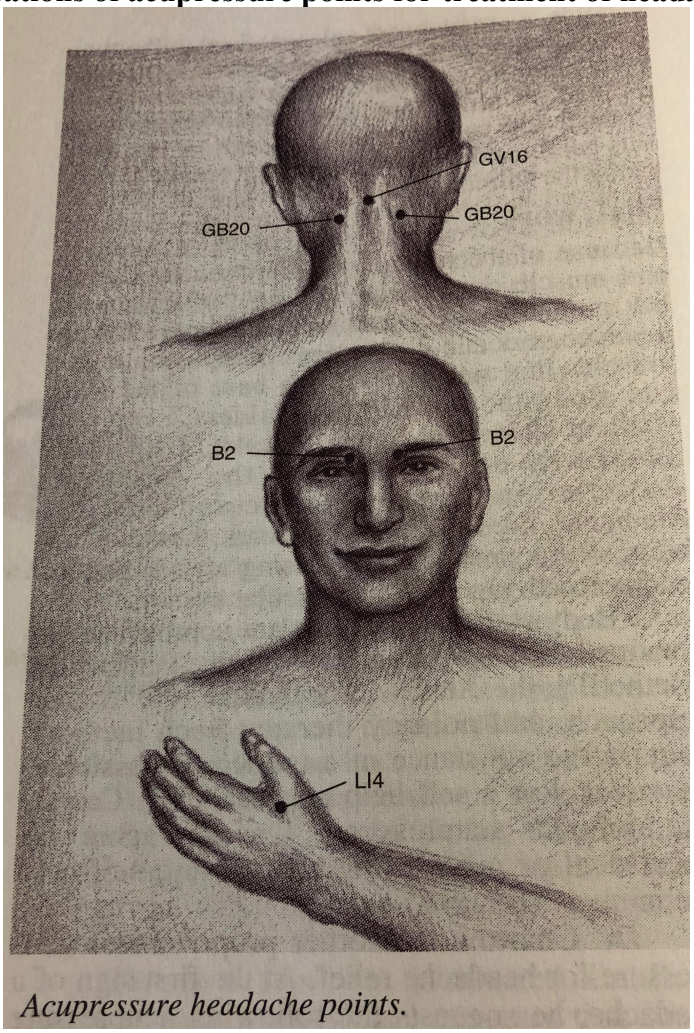


Figure 2, Imagery for location of acupressure headache points, from *Alternative medicine, the definitive guide* (p. 698), Chopra, D. 1994. *Future Medicine Publications, Puyallup,Washington*, *1*(9), 9.

Relaxation is a wellness technique that many people use in their everyday lives to reduce stressors that appear frequently in their daily routine or regimen. Many people find different techniques to be more beneficial than others and often times these techniques end up catering to preferences of the person. Sometimes the type of relaxation results in a complete lifestyle change, working fewer hours, and creating more time for one's own self to enjoy life (Chopra, 1994). Others may find relaxation by incorporating biofeedback or yoga into their life (IBID). Biofeedback is a technique used to teach someone how to regulate his or her own heart rate (IBID). The device works on a mechanism of flashing and beeping which allows one to focus on those flashes and beeps and change their heart rate. The training incorporated in using this device lasts long after the device has been dispensed due to the change in unconscious behavior (IBID). The constant monitoring of the device subconsciously works to reprogram the rate at which the person using it slows down their heart rate and induces a sense of calmness and relaxation into their body and mind (IBID).

Biofeedback is especially helpful for stress-related disorders such as insomnia and migraines (IBID). The discovery of biofeedback as an effective treatment for migraines happened by accident when researchers were using it to monitor a woman's body temperature during her migraine episodes, they found that suddenly when using the device not only did her heart rate slow down and her body temperature decreased ten degrees, but also, her headache disappeared (IBID). This led researchers to believe that this device would be effective in treating migraines because there was a correlation between heart rate, body temperature, and the feeling of head pain (IBID). This in turn also provided evidence that by using this device one could ultimately reduce the amount of medication used to treat migraines (IBID). This is a beneficial technique of relaxation that can be used to treat headaches in patients suffering from post-concussion symptoms because if stress in fact does play a role in the severity of post-concussion symptoms and headaches are more of a result from stress to the head and throughout the body this can allow patients to relax within themselves and regulate the physical responses that present from stress. Due to limited knowledge and research about post-concussion symptoms this is a big opportunity for biofeedback to make a breakthrough as an alternative approach in a biomedical driven society.

Yoga, another type of relaxation was originally studied using the biofeedback technique in order to study how their mind and body approach to achieving union within themselves directly reduced thyroid output and heart rate (Chopra, 1994). The scientific results of biofeedback allowed other alternative uses of medicine like yoga to receive efficacy in the biomedical realm of medicine, where it may not have been understood before due to the physiological and psychological nature and measurements it has the ability to produce on paper in research (IBID). The word yoga means in itself union and the practice of yoga works to incorporate the balance of the mind, body, and soul (IBID). Patanjali first documented yoga in the second century B.C. in what he categorized as the "Yoga Sutras" (Chopra: 469). The feeling that yoga emits within the body is a sense of grounding and peace because all attention is focused on every movement and element of the body. When practicing yoga one analyzes and feels what each pose expresses while also providing a sense of satisfaction and relaxation as the body molds and takes a different form. Practicing yoga as a form of relaxation post-concussion may not only reduce the amount of stress within the body, but may also indirectly allow the brain to heal faster by practices specific forms of yoga such as restorative poses. Restorative poses are relaxing poses used not necessarily as a "workout", but rather as a form of meditation or relaxation for the body (IBID). By placing the body in specific poses meant to increase blood flow to specific areas or lengthen the muscles that may typically be tense from everyday activities it opens the door for more healthy functioning throughout all systems of the body including, digestive, lymphatic, circulatory, and the nervous system (IBID). The meditative and restorative practices of yoga seek to provide proper alignment for the spine and head, which directly increases blood flow to all areas of the body including the brain (IBID). As previously discussed with tension headaches, the constant muscle contracts in the neck and face either specifically due to injury or accumulated through stress can be over time possibly reduced with the practice of yoga. These meditative practices had such an effect on the status of medicine that in 1984 the National Institutes of Health pushed for meditation over prescription medication (IBID). For yoga to have such a profound effect on science during the 1980's suggests that the benefits exhibited by practicing it may in fact be applicable to those suffering from headaches post concussion (IBID). This holds true because it has not yet been verified whether or not prescription medication is the best alternative to treat headaches post-concussion and alleviating

painful headaches that may be experienced post-concussion through an alternative approach will not only reduce further unforeseen complications, but also may indirectly increase the patients overall quality of life. Yoga has the ability to produce a purifying and detoxifying effect on the body, which can be beneficial for patients suffering from headaches post-concussion because if in fact their headaches are triggered by stress from the head injury, the high cortisol levels can produce toxic effects within the body inhibiting the proper function of other systems (IBID). So not only can yoga induce relaxation for patients post-concussion, but it can also have an eminent beneficial physical effect on their overall well being and functioning.

Hydrotherapy, the last type of relaxation best suited for those suffering from headaches incorporates forms of water in variations, liquid, ice, steam, and the regulation of temperature, hot and cold (Chopra, 1994). By using contrasting variations of water it produces different effects for the body, hot temperatures elicit relaxation, while cold produces stimulation (IBID). Similar to the detoxifying effects that yoga can have on a person, hot water has the ability to trigger the immune system and cause white blood cells to travel outside of where they typically reside in blood vessels and enter the tissues to clean up toxins and excrete waste products (IBID). Hot water also has a relaxing effect that similarly to yoga has an effect on the overall functioning of other organs in the body (IBID). This is why it is common for people to take a hot bath after a long day because not only does it provide relaxation, but a majority of people feel better and less tense in their overall being. The use of cold water in hydrotherapy produces a shock sensation to the body, restricting the blood vessels and making them less permeable, which in turn can reduce inflammation that may be caused due to stress or injury (IBID). This is important when considering alternative treatment options for headaches post-concussion because much of what has been studied in regards to the mechanism behind concussions revolves around the idea of inflammation, that the brain is experiencing some type of inflammation due to the head injury, which in turn causes the release of ions that can be toxic at high levels. Using hydrotherapy to treat headaches post-concussion may have the ability to indirectly reduce inflammation in the brain through vasoconstriction of the blood vessels that are causing inflammation (IBID). Although this has not been studied and no research can necessarily back up this inference, it is plausible that considering all regions in the body are correlated with one another in some way, reducing the permeability of blood vessels in other regions may have an effect on the permeability of blood vessels going to the brain that may possibly be inflamed. It is often times not thought of to immediately place ice on the head post-concussion or when one experiences headaches, but due to the nature of ice and contrast used for sprains and strains, who is to say that it would not have the same effect on the brain? More research would need to be done in order to provide a proper technique that would target the inside of the brain and not just the surrounding surface area. A technique that targets inflammation in the brain through natural remedies such as ice and contrast could limit the amount of medication most commonly prescribed for inflammation reduction (IBID).

Depression

Depression is defined as a disease, which is classified as an illness, affecting more than 15 million US adults and causes substantial emotional, physical, and economic burden on the affected individuals, their families, and their communities (Gerhard, et al. 2017). The epidemic surrounding mental health and more specifically depression has continued to grow over the past few years, affecting people of all ages. Research on depression has continued to grow altering previous ways of identifying, diagnosing, and treating it (IBID). Many researchers have veered

away from the idea that the onset of the disease can be classified as either psychological by nature or genetically predisposed (Chopra, 1994). Although these factors still hold true to the onset and development of the disease, it has been shown that other factors can contribute. Other illnesses, along with stress, both physical and emotional, exposure to environmental stresses like chemicals, toxins, and electromagnetic fields can also play a role in onset and progression of depression (IBID). A major psychiatric symptom post-concussion that patients suffer from is depression (Coughlin, 2015). A study done of a retired NFL player found that depression and other cognitive deficits were most attributed to his autopsy report in comparison to other healthy colleagues (IBID). It is difficult to conclude whether or not the neuromechanism post-concussion is directly contributed to the outcome of patients developing depression symptoms, or if it is more directly due to the cognitive deficits that patients suffer from post-concussion that make them feel defeated, which induces the onset of depressive symptoms. Much of the cognitive deficits that patients suffer from revolve around memory loss, slurring of speech, distractedness and even fatigue (IBID). Those who tend to suffer from those symptoms post-concussion are experiencing a drastic change in their normal lifestyle, which can initiate frustration and upset in anyone experiencing it (IBID).

Depression is most likely one of the largest topics studied in psychiatric medicine due to the role it plays in many people's lives (Chopra, 1994). The variation of symptoms, the length of time it persists, and the many treatment options provided for it make it difficult for patients to truly understand how to combat the disease. When it comes to identifying symptoms, many individuals elicit depression differently and although there are common symptoms like fatiguing, sadness, fear, hopelessness, worthlessness, despair, loss of appetite, loss of interest in activities in everyday life, there are also many ways in which people suppress their mental illness to carry on with their everyday activities (IBID). This in turn can alter the chemical make up within a person magnifying the degree and severity of the disease under all circumstances, post-concussion or battling an illness that is genetically predisposed (IBID).

According to Giza, et al. the magnitude and duration of depression can increase with the severity of the head injury and age, which have been correlated and studied through the use of behavioral recovery in animal models (Giza, et al. 2018). Evidence that supports the animal model discussed relates to neuroimaging used on retired professional football players that found those who were experiencing cognitive difficulties and depression showed changes in neuroimaging of white-matter and cerebral spinal fluid (IBID). Researchers found that these differences measured continued to show up through data even after the acute period of time typically expressed post-concussion (IBID). The prevalence of those experiencing depression post-concussion even a year post-injury was 30-40% greater than what is generally seen in the overall US population (IBID). The timeline of depressive symptoms for patients post-concussion varies for each patient, as previously discussed, those who may have had a genetic predisposition could be more inclined to suffer from depression post-concussion for longer periods of time in comparison to those who do not share the gene (Smith, 2016). It has been proven that it is common for patients to be significantly depressed day one post-concussion, but typically recover out of that phase within three days of the injury with proper care (Giza, et al. 2018). This is not to say that a patient experiencing a second concussion would produce the same results. This is where a lot of disconnect lies between depression symptoms post-concussion because creating a study that looks at depression in patients post-concussion after one single head injury over a period of time could be very different than if they experience multiple concussions or have experienced prior concussion that may have even gone untreated (IBID). Monitoring concussions

had not always been a priority of athletes and even non-athletes because researchers and physicians did not really know the significant effects that it could have on a patient (Harrison, 2014).

Concussions have been overlooked until recently because they seemed to be an event that many people thought would just go away with time (Harrison, 2014). As patients and specifically professional athletes began to get worse throughout their careers, it became evident to researchers and physicians that more needed to be done to understand what was really going on (McKee, et al. 2009). The turning point began in concussions research when many individuals began to attempt suicide, attracting the attention of society on headlines (IBID). It was common to hear about these stories on the news, "professional athlete committed suicide, researchers linking it to CTE or multiple concussions within their career." These common headlines began to flood the media of society bringing to the attention that concussions were causing greater harm than previously thought (IBID). A case done on a professional football player who had played ten years in the national football league died unexpectedly after an accidental gunshot wound to the chest while cleaning his gun, researchers expressed that he was never formally diagnosed with concussion symptoms throughout his life, but his family began to notice by the age of 40 years old that he was experiencing minor impairments to his short-term memory, attention, concentration, and speech (IBID). The five years leading up to his death these symptoms began to worsen and as a result began to express behavioral symptoms of anger and verbal aggression (IBID). He was less emotionally stable and began to consume more alcohol, but yet was reported to not show any signs of depression and his family history was negative for dementia and psychiatric illnesses (IBID). The statement regarding his increase in alcohol consumption, but no signs or symptoms of depression appears to be misleading from physician records due to the fact that one could link an increase in addictive behaviors to the onset of depressive symptoms (IBID). As previously mentioned about the differences in the way that patients illicit depression symptoms it is not necessarily fair to say that he was 100% free from signs of depression. Depression can be a symptom post-concussion, a cause of a traumatic event, or even just genetic predisposition that presents differently from one patient to another (IBID). Considering the research on this individual was done in 2009 explains why there may have been some disconnect in conclusions drawn about the history of his behavior, but now with current research being so strong, it is imperative that symptoms such as this one be monitored throughout a patients life because there really is no concrete answer explaining whether or not his gunshot wound was an accident (IBID). Looking at the description and data presented one might infer that the gunshot was in fact intentional and could have been correlated to the fact that he was presenting depressive and suicidal symptoms.

A similar case of 40 year old professional wrestler who had a history of multiple concussion and even a cervical fracture during his career began to experience similar symptoms as the gunshot wound case around the age of 36 years old (McKee, et al. 2009). It first began when he started to experience problems within his marriage and had a history of periods of depression (IBID). By the age of 40 years old he was having violent behavior episodes and eventually killed his wife and son and then committed suicide himself (IBID). He had a history of using anabolic steroids and prescription narcotics (IBID). This is not to say that his drug use was the cause of his traumatic episode, but with a history of multiple concussions that went untreated and his continuation within his career it is quite plausible that this contributed to the severity of his symptoms. An interesting aspect about this specific case revolves around the fact that at the age of 6 years old this man was part of a severe car accident that required three days of

hospitalization for a mild TBI, but due to the limited research surrounding head injuries and concussions the neurological maintenance and monitoring was not documented (IBID). One could presume that this had an effect on his overall brain development contributing to his natural aggressive tendencies, but the various concussions within his career could have also been a contributing factor to his overall decline in behavior, depression, and physical complications.

Treatment of Depression

Depression is a complex illness that often times contains physical, emotional, and scientifically driven based evidence to describe and understand the diagnosis and progression of the disease (Chopra, 1994). This is why many of the popular treatment options for depression come from pharmacologically driven data and scientific based evidence on the mechanism and pathway depression identifies. Most clinical practical guidelines suggest second-generation antidepressants (eg, selective serotonin reuptake inhibitors or selective serotonin norepinephrine reuptake inhibitors) as a first-line therapy for depression (Gartlehner, et al. 2017). Gartlehner and his colleagues state that about, "63% of patients on second-generation antidepressants experience adverse events, with 7-15% of patients discontinuing treatment" (Gartlehner, et al. 2017: 1). This means that only about 37% of patients actually find this type of pharmacological treatment successful as a first-line therapy (IBID). Some researchers propose that this could be due to mis-prescribed or inadequately treated depression, considering antidepressants have a significantly higher treatment- specific constraint in comparison to a non-pharmacological approach (IBID). Clinical practice guidelines for depression treatment aim to aid physician decision making at various stages of treatment, including following an inadequate response to a first-line therapy, but many researchers, like Glenda MacQueen have found that most clinical practical guidelines for first-line pharmacological treatments have failed to meet the criteria on rigor of development, applicability, and editorial independence (MacQueen, et al. 2017).

This is not to say that the suggested first-line treatment options proposed by the clinical practical guidelines cannot be successful, but it does mean that this form of treatment for depression is not fit for everyone especially those suffering from head injuries with limited data and knowledge supporting the neuromechanistic effects that can be altered through prescription medication such as antidepressants (Smith, 2016). With both cases described above, each patient was different and because of that expressed different types of symptoms. Due to the limited research of depression post-concussion and whether or not the exact mechanism mimics the same seen in those who are genetically predisposed or are experiencing depression due to other changes within their lifestyle or environment, prescription medication might not be the best avenue to take when proposing treatment options for patients. In the case that selective serotonin reuptake inhibitors or selective serotonin norepinephrine reuptake inhibitors, are not successful, or not preferred by patients there are many non-pharmacological treatment options available (Gartlehner, et al. 2017).

Alternative approaches to treating depression post-concussion might be the best avenue to take considering the circumstances of limited knowledge and the effect depression can have on patients within varying ages. Other than predisposing psychological symptoms and genetic disorders, physicians also use a patient's dietary regimen as a predictor to gauge the severity of the patient's mental state (Chopra, 1994). Foods that are processed tend to contain chemicals that can alter neurochemicals within the body such as serotonin (IBID). Being cognizant of how certain foods can alter the mood of patients and increase or decrease the severity of their mental disorder may reduce the effect of the disorder on patients post-concussion (IBID). Sticking to a

diet that is richer in healthier organic foods may limit the amount of external additives that could be possibly having an effect on patients post-concussion. Depression has also been assimilated with low iron levels (IBID). Consuming foods with higher levels of iron could also be of benefit to those suffering from post-concussion depressive symptoms. With that being said, researchers have found dating back as early as the 1950's that traces of metal imbalances within the body were closely related to the effect of mental outburst such as aggressive and violent behaviors in both children and adults (IBID). These types of influences that can take part in even a normal persons everyday life would most definitely have an effect on a patient's mood or depressive state post-concussion because the brain is in an even more vulnerable and sensitive state. One of the interesting discoveries made by Dr. Walsh in the book authored by Deepak Chopra M.D. was related to the fact that individuals with mental disorders who exhibited violent outbursts and tendencies often also had extremely low levels of sodium, potassium, and manganese within their system (IBID). This is an interesting observation because many of the cases revolving around patients who suffered from multiple concussions throughout their life eventually in their later adult years exhibited violent outbursts and even committed extremely aggressive and gruesome crimes. With that being said, it could be a possibility that if a high influx of sodium is in fact a part of the neuromechanistic pathway post-concussion it is plausible that due to the high influx of sodium either over time or for an extended period of time could have caused patients to reverse their inability later in life to produce proper balances and influxes of sodium once the brain was considered healed (Smith, 2016). For example, when people take a specific drug that allows the body to either produce or increase the amount of neurotransmitter serotonin in the brain over an extended period of time, they eventually go through a down period where they experience sadness or depressive like feelings because they have either exulted the surplus or supply of that neurotransmitter that the brain has produced, or have to readjust to the normal rate at which those neurotransmitters are released. Keeping track of foods that can regulate certain ions may further help patients with post-concussion symptoms to better control their mood disorders such as depression.

Biofeedback and relaxation techniques are also beneficial for regulating depressive symptoms because it allows the patient to feel in control of their body and mood (Chopra, 1994). Doing an activity such as exercise releases those "feel good" neurotransmitters such as serotonin that someone with depression may not be producing and thus leave patients with the feeling of satisfaction and control (IBID). The physical awareness aspect and reduction in stress are the main benefits of biofeedback and relaxation for patients undergoing depression or depressive like symptoms temporarily like someone may experience post-concussion. It has been shown that non-depressed person breathes in six times more the amount of air in comparison to a depressed person showing that physical changes in the body are accurate for those who suffer from mental disorders such as depression (IBID). The reduction in oxygen for depressed patients may or may not also play a crucial role in the brain's healing process post-concussion, which is why it is very important for patients to partake in activities that induce relaxation and reduce overall stress (IBID).

Magnetic field therapy is also a technique that can be used to treat depression because of its ability to provide electromagnetic balance (Chopra, 1994). Electromagnetic field therapy uses magnets and electrical devices to control magnetic fields within the body by properly manipulating the positive and negative magnetic polarities of magnetic fields (IBID). It was discovered that negative magnetic fields have a beneficial effect on the body where as positive fields can induce stress (IBID). This may be a beneficial therapy for patients post-concussion

because sodium is an ion that is positively charged and in excess it is not only toxic to cells, but it may induce physical, mental, or emotional symptoms of stress on the body as well (Smith, 2016). This is important to understand especially considering the fact that researchers have hypothesized that high influxes of sodium accrue while the brain tries to heal itself post-concussion (IBID).

If researchers can provide further accuracy and understanding of this underlying mechanism it may provide patients with alternative options post-concussion during the healing process of the brain by reducing the amount of sodium released in comparison to having patients take a prescribed sodium channel blocker medication, which could possibly negatively effect the healing process. Providing a choice for patients generates a better quality of life and environment for them because it makes them feel as if they are in control of their situation and illness rather than being told or forced to handle scenarios in specific ways increasing their overall quality of life.

Anxiety

"Anxiety disorders, including phobias, affect roughly 10 million people" (Chopra: 744). Anxiety is described as being a "fundamental phenomenon" that is the "most pervasive psychological phenomenon of our time" (Spielberger, et al.: 145). Anxiety is typically classified as symptom to another triggering factor either genetically predisposed or more commonly stress that exemplifies an emotional reaction or state of being that varies with severity in fluctuations (Spielberger, et al. 1971). The symptoms are commonly seen as increased feelings of tension and apprehension that excites the autonomic nervous system forcing it to work in overdrive (Spielberger, et al. 1971). Anxiety can also elicit symptoms of unease, fear, and panic commonly seen through physical associations such as "chest tightness, hyperventilation, heart palpitations, and gastrointestinal problems" (Chopra: 744). Closely related with similar triggering mechanisms as depression and often times associated with depression post-concussion, anxiety can present symptoms that provide physicians with an unclear understanding of what is exactly triggering the anxiety (Yang, et al. 2015). It is difficult to interpret whether or not anxiety symptoms are due to predisposed genetic traits or is caused by the trauma associated with the concussion itself (Yang, et al. 2015). It is even understood that social and cultural factors may influence the onset of anxiety like symptoms as well as age, gender, nutritional deficits, allergies and food sensitivities, alcohol and drug additions, prescription drug addictions, and even medications used to treat the mental illnesses can influence the effect it has on the overall mental illness of the patient (Chopra, 1994). Due to the large amount of influencing factors of this mental disorder, it is difficult to treat based on the fact that the chemical make-up and environmental factors of every individual is different, especially post-concussion when the brain is in a vulnerable state (Smith, 2016). Expression of these symptoms has been identified in patients of numerous case studies post-concussion and seems to be a common symptom of many post-concussion (McKee, et al. 2009). With that being said, it means that it is most likely one of the most commonly treated symptoms post-concussion in conjunction to headaches and depression. Due to the conflicting factors surrounding symptoms post-concussion it is again imperative that physicians treat patients with the proper care that upholds their overall quality of life without increasing the severity of post-concussion symptoms. A more holistic approach to treating anxiety post-concussion would be the safest and beneficial way to uphold the patient's highest overall quality of life.

Treatment of Anxiety

Energy medicine would be a beneficial form of treatment for patients suffering from anxiety post-concussion because it uses devices that work within an electromagnetic field in order to detect energy levels within the body to prevent the body from generating future chemical imbalances (Chopra, 1994). Considering the electrically charged ions that researchers propose are being released in the brain post-concussion it might be beneficial to use energy medicine not only to detect the energy levels post-concussion for further indication about what is going on in the brain, but may also provide relief for post-concussion anxiety by allowing physicians to treat the symptoms before it progresses into a chemical imbalance that is more difficult to reverse and typically is treated by the use of prescription medication (Smith, 2016). The energy medicine devices work on the principle of the acupuncture meridian discussed previously for post-concussion depression (Chopra, 1994). The MORA instrument was created by Franz Morrel, M.D. who believed that all biological processes function on an energy level or frequency and when these frequencies are functioning out of their normal wave rhythm it can be an indicating factor that there are imbalances going on within in the body (IBID). The MORA device works to detect those energy frequencies and manipulate them if they are functioning out of the norm by regulating the wavelength until they eventually equal out to their natural rhythm (IBID). This can be beneficial for patients suffering from post-concussion anxiety because anxiety can effect heart rate and respiratory function which normal flow at a specific rate when the patient is calm and relaxed (IBID). By manipulating the wavelengths in those suffering from anxiety post-concussion one might propose that their symptoms can eventually be naturally reduced without the intervention of prescription medications, while also increasing their overall quality of life by producing instantaneous results even if they are just temporary.

Aromatherapy is another holistic technique used to relief symptoms of anxiety by stimulating the sense of smell and or tactile receptors through the use of essential oils that have been studied throughout centuries to have healing and medicinal properties (Chopra, 1994). Many of the essential oils used in aromatherapy have “antibacterial, antiviral, and antispasmodic properties that can be used as diuretics, vasodilators, and vasoconstrictors” (Chopra: 53). The essential oils used to stimuli the sense of smell would be most beneficial for patients with post-concussion anxiety because they have the ability to target the limbic system which has direct effect on mood and emotions (Chopra, 1994). The limbic system is directly correlated with areas of the brain that control heart rate, blood pressure, breathing, memory, stress levels, and hormone balance, which are many factors that can be effect post-concussion (IBID). In regards to anxiety essential oils that target memory, heart rate, blood pressure, breathing, and stress levels can provide patients with a sense of calmness and focus during their periods of anxiousness including reducing heart rate and lowering breathing if they are suffering from a panic attack (IBID). Essential oils such as lavender, mandarin, roman chamomile, and ylang-ylang have relaxing and antianxiety properties that can induce a more relaxed and sedative state for those suffering from high anxiety or stressful emotional reactions (IBID). Everlast, another essential oil is not necessarily used for relieving anxiety, but contains within it properties that reduce inflammation and can prevent swelling post-sport injury (IBID). Although the inflammation occurring post-concussion is located within the brain and it is impossible to directly put essential oils on the brain, it may have beneficial properties through the nasal cavity on the stress and inflammation occurring under the skull. It has not been studied and it is unclear whether or not the effective properties of this oil are truly only beneficial applied topically to the skin, but it would be worth

further investigating to see whether or not the beneficial properties it contains can effect areas deep within the body.

Considering the proposed hypotheses about the patient state of mind post-concussion and how their thoughts may influence their perception of their current condition and proposed treatment, mind/body medicine may be a beneficial modality of therapy for patients post-concussion (Chopra, 1994). This may hold especially true for those suffering from anxiety, which may consist of compulsive thoughts or worry about the trauma they experienced (IBID). The western view of medicine focusing on scientific data and knowledge has influenced the way many diseases and disorders are treated today within the United States, but more research has been identified that western medicine may not be the only option available to patients (IBID). The mind/body medicine approach focuses on the idea that mood, attitude, and beliefs can alter any chronic illness (IBID). Many researchers have found that the way and how one thinks about their own illness may in fact detect the outcome of their well-being and future health (IBID). Due to impact some head injuries and concussions may have on patients, especially sport-related concussions, it is imperative that an approach such as mind/body medicine be utilized in order to maintain the patient's positive mood and thoughts that may otherwise be conflicted by anxiety.

Looking at the future of possible treatment protocols for patient's post-concussion especially those suffering from sports-related concussions and exhibiting signs of anxiety, requiring a psychologist or holistic practitioner for the monitoring and treatment of post-concussion psychological symptoms might in fact reduce the amount of work physicians have to do because it could indirectly decrease the amount of stress and mood alterations seen in patients post-concussion. A future approach to treating all illnesses, diseases, and disorders should incorporate some type of holistic approach because in collaboration with what physicians are already using and treating it could be of benefit to increase the patient's overall quality of life, providing them with a sense of satisfaction and control about their role on the journey of healing and recovery.

Conclusion

Imagine experiencing something so traumatic that it shakes your whole routine, your whole rhythm to which you make every decision and go about your everyday life. Think about having the life you want and one day suddenly not being able to speak for yourself. This may not necessarily be because you have lost the ability to communicate properly, but more catered towards the idea that due to limited knowledge and research your physicians cannot provide you with the proper treatment or care you may need. It is at this moment you realize you have lost your voice, your ability to communicate your wants, needs, and desires. Often times those who suffer from a distressing experience such as a traumatic brain injury become engulfed within their own illness struggling to figure out not only what is wrong with them, but also whether or not their life will ever be the same (Chopra, 1994).

One could attribute limited knowledge to the loss of voice especially considering the circumstance revolving around traumatic brain injuries and concussions. The limited knowledge not only in the research fields, but also within the hospital environment creates controversy for patients when it comes to understanding their signs and symptoms. Due to the fact that physicians are not capable of easily understanding what is exactly going on in the brain it often times takes many days in a hospital setting, if severe enough, to come to some sort of conclusion about what they believe to be happening. Sometimes by the time physicians even come to a conclusion, the damage within the brain has already progressed drastically leaving patients with

even less of a voice than when they were first admitted both physically and mentally. The disconnect between advancement in technology and limited knowledge pertaining to any type of traumatic brain injury hinders the patients overall ability to express voice, decreasing their quality of life.

Picture a situation in a hospital setting: a patient is admitted to the emergency room due to expressing symptoms of epilepsy. The patient has no history of being epileptic and no one in their family carries those traits. The patient appearing to be a bit scared because for split seconds their muscles begin to spasm uncontrollably and when they arise back to consciousness they have no recollection of what occurred. The family questions whether or not there is something externally related to the cause of these seizures, could the patient be suffering from addiction? Do they have an autoimmune disorder that suddenly expressed symptoms by attacking the patient's body? Does the patient have a tumor hidden within the brain that is triggering these epileptic attacks? All possibilities begin to take over within the physician's mind, eagerly trying to fight for an explanation in order to diagnose and properly treat the symptoms. Unfortunately, this process spans across a timeline of about three days, the physicians have been treating the patient for obvious physical signs they can recall from imaging studies and the patient's scores on baseline exams. The physician's conclude the patient has swelling in the brain. One might think, they found a reason so now they can treat it and the patient will go back to the way they were living before being admitted. The problem with this solution is that swelling in the brain is an effect of an even bigger underlying issue and the seizures that the patient was exhibiting is another symptom of an even bigger issue (Smith, 2016). The timeline has now just gone from a three-day range to spanning a little over a week. Physicians eagerly target the swelling in the brain by prescribing a medication that induces a coma in order to prevent the patient from creating further damage while the physicians struggle to uncover the cause.

At this point the patient is on multiple medications to regulate their normal bodily functions and keep all systems within the body stable and moving while they are in an induced state of comatose. The patient went from being able to exhibit signs of consciousness through blinking of the eyes, slow physical movement, and even the ability to make out certain words and express what they were feeling to nothing at all. The quality of life of this patient has drastically dropped due to the limited amount of knowledge physicians are not quite sure exactly what she needs and what diagnosis needs to be presented in order to place the patient back into their normal state. The state of comatose buys the physicians time, while the brain attempts to heal itself in a very induced sleep state. The family has no idea what is happening the terrified look on their faces expresses with what little they do know, it does not look promising. Anyone who sees a ventilator come out knows that time is becoming very limited because at this point the patient is not breathing on his or her own. The patient goes from coming in expressing signs of epilepsy that eventually progressed into swelling of the brain, to now being placed on a ventilator having a machine breathe for them.

The patient still remains in an induced comatose state, hooked up to a ventilator, and physicians still can not figure out what may be going on in her brain or what caused the random bout of seizures and epileptic like symptoms. At this point the timeline has increased over a two-week span, racking up extremely high hospital bills and yet the patient's family still does not have satisfaction because the conclusion still remains unknown. Throughout all this time, not only does the family not necessarily comprehend what is going on, but also the possible diagnoses keep changing. The patient on the other end has lost all control to express their wants, needs, and desires, not only due to their comatose state, but they have been out of the loop over

the past few weeks with all medical conversations being discussed. To explain all the information when the patient wakes up would be information overload, but also physicians at this point are unclear about the state the patient will be in once the physicians reduce the medication. The patient has lost their voice, the family has lost their voice, and it has nothing to do with the fact that the physicians are limiting the patient and family's input, but rather the circumstances of the case has a majority lost in medical jargon, mixed with a feeling of hopelessness, and unclear about what the patient would want at the end of the day. Many people do not draft up legal contracts to express their medical needs and wants at a young age, unless diagnosed with a disease that has the potential to elicit damaging effects temporarily or long-term within a patient's life. In fact many people may even look at drafting up a legal contract about one's medical wants, needs, and desires as bad luck, or opening that door for bad medical karma to come swooping in. The reality of the situation is, many people do not know what they would want, need, or desire especially because a circumstance such as this one could not have been foreseen. This makes it extremely difficult for the patient and their families to even comprehend because it was nothing that they could have prepared.

The hospital brings in a social worker, someone who can alleviate some of the stress because placed on the patient and their family by further explaining the medical jargon and the current state of the patient. Sometimes physically the patient looks healthy and that they are coming back around, but more often than not when this happens, the patient actually takes an unexpected turn and declines. In the interim, physicians still struggle to understand the cause of all these symptoms, since they cannot see inside the brain fully to understand what is happening, generating a diagnosis becomes more difficult. Physicians took an MRI, a CAT scan, and even an fMRI to see whether or not the patient had a tumor, fractures within the skull, and the overall gauge of activity in the brain to see if physicians could possible draw some conclusions about the patients state of being. The social worker cannot present the family with the conclusion that physicians just do not know what is wrong with the patient because it presents a sense of hopelessness, fear, anxiety, and brings external stressors into the environment that already present tension. Also, the family and patient are relying on the physicians to take care and "fix" the patient, bringing them back to their normal state of being.

At this point one month has gone by and physicians are finally beginning to draw conclusions. Through numerous tests and studies physicians have discovered an neurotransmitter receptor complication stemming from the patients ovaries that essentially resulted in seizures, triggering swelling in the brain, placing the patient in the current state that they were in. The family relieved that they were given some type of answer, but still questioning whether or not it was the full story. Again, the social worker is presented to discuss the medical jargon because what is an neurotransmitter receptor anyways, and how does a complication stemming from the ovaries express itself all the way up to the brain? Physicians hypothesized that complications within the ovaries may have triggered an influx of ions that at high levels can be toxic to the body, hindering the patients ability to properly send messages, causing a build-up of swelling the brain due to inflammation caused by the misfiring of neurons, most likely contributed or closely relating to those ones associated with the neurotransmitter receptors and ion receptors and pathways, leading to cell death within the brain due to the prolonged mistreatment and unclear diagnoses, resulting in the patients current state of being (Smith, 2016). The patient at this point, once they wake up from the comatose state will have to start all over again, learn to walk, talk, as if the patient is starting over from infancy.

This idea is taxing to the patient and their family because now all the family sees within their mind is dollar signs. How are they going to be able to afford this? Who in this world can afford continued physical therapy for an adult over a prolonged period of time? Although this idea is second in their mind to the life and longevity of their adult child, it is still a factor weighing in their minds. Looking back on the first day the patient was admitted they had no idea what they would be getting themselves into. The family expresses their frustration and upset to the social worker explaining to them that they were forced to sit in this waiting period hoping physicians would find answer to their child's unexplained symptoms and in turn their inability to express their voice due to limited knowledge and limited knowledge surrounding the patient's wants, needs, and desires has now left them in a place to make decisions they were not prepared to make. They were never given the full drawn out possible conclusions in the beginning to be prepared to understand they place they are at currently. The social worker explains that due to limited knowledge and technology surrounding physician's ability to really identify complications in the brain when the patient was first admitted, it ended up taking longer than expected. The family frustrated explains that all of these testing devices such as MRI, CAT scan, and fMRI were used to gain a better understanding, costing them hundreds of thousands of dollars, and yet they were not efficient enough to find the source of the problem? The social worker stuck in a very difficult position simply stresses to the family that traumatic brain injury, concussions, and other brain disorders are difficult to isolate because physicians cannot just open up the brain and look inside. The damage done, the surgery required, all make it difficult and unethical to administer on patients because those tasks become extremely risky and is not in the patient's best interested to just go digging around in their brain. The other common factor that lies within those tasks is that many of the research done on the brain post-concussion, CTE, or any type of traumatic brain injury involves performing a total autopsy on the patient's brain, slicing and staining sections in order to understand where the damage has occurred. Those are processes, which cannot be done while the patient is still alive.

The story posed above, exemplifies real life scenarios of similar patient's stories when being admitted to the emergency room. Many symptoms and complications that end up being a part of the nervous system tend to effect pathways leading to the brain (Smith, 2016). More often than not symptoms seen like the case above initially are correlated with some time of mishap within the brain, but due to limited knowledge and technology patients are not able to seek the help they need because physicians have to find other avenues around other diagnoses and symptoms that may be presenting (IBID). Physicians actually have to work harder to piece together symptoms and plausible diagnoses based on other underlying factors within other symptoms of the patient's case in order to try and draw a conclusion (IBID). Physicians want to be able to find an immediate answer, they want to be able to diagnose a patient and cure them right away, but when it involves complications within the brain and nervous system it becomes almost impossible to instantly target the source of the problem. The long drawn out processes surrounding the official diagnose of some of these patients becomes taxing and distressing on patients and their families. Once a diagnosis has been concluded and families can finally understand what may be going on, sometimes the damage has progressed immensely making the situation a lot more complicated and difficult to bear than what it may have been like if it was caught in the beginning. Finding an avenue or a solution to targeting the source of many of these problems immediately once the patient is admitted is crucial in order to prevent further cases like this from happening in the future. Researchers and developers must find a way to advance the physician's diagnoses by providing them with evidence of complications going on in the brain

immediately when the patient is admitted to provide more thorough information that physicians can use to draw conclusions. A plausible solution to this problem revolves around creating a machine that can easily target and identify the source of complications from an ion level and neuronal pathway level within the brain without being invasive similar to the types of imaging already used such as MRI, CT, and fMRI. This proposed mechanism can prevent cases from happening and posed above, but also help to better target the areas of the brain involved post-concussion that physicians cannot readily see or analyze (IBID).

The Way of the Future

Magnetic resonance imaging (MRI) generates an image based upon interaction between radio waves and hydrogen nuclei in the body within a strong magnetic field (Bradley, 2002). MRI uses a contrast mechanism between the background of the image and the actual place of projection (IBID). MRI is used to capture images of tissue and intricate details of that tissue (IBID). For example, if someone tears a ligament or area of tissue within the body, MRI can capture that area and allow physicians to see where the area of damage lies and how intense the damage may be in order to generate a proper diagnosis and treatment plan. For patients being admitted into the emergency room for symptoms as described in the above case, MRI would only be beneficial for physicians if the symptoms being presented were directly caused by tearing or deterioration of tissue within the brain. This could give physicians more information as to where the symptoms are generating from, but not the overall back-story to how they came about.

X-ray computed tomography (CT) scan is another type of machine typically used by physicians to try and gauge a better understanding of what might be going on in the brain that creates images by using the plane of gantry in the axial or semi-coronal regions of the brain through ionizing radiation (Bradley, 2002). This is typically less safe in comparison to MRI and generates images only located to a particular region limiting the amount of information that physicians can obtain (IBID). As opposed to MRI, which reflects the density of hydrogen in a mobile setting, CT reflects just the electron density at a more sedentary placement (IBID). Although a CT scan may show similar contrast imaging like MRI, due to the stagnant image generated, physicians are unable to move within the image to get a better understanding of the area of damage.

Functional magnetic resonance imaging (fMRI) is an imaging machine that generates a picture with magnetization similarly to the other types of machines, but instead creates an image through oxy- and deoxyhaemoglobin (Arthurs and Boniface, 2002). fMRI is the one of the closest imaging systems on the market today that can be used to measure neuronal brain activity (IBID). The neuronal activity within a brain when presented with a stimulus generates a haemodynamic response, which is then picked up by the fMRI system (IBID). Often times patients undergoing an fMRI study will be prompted to think about specific instances, read certain words, or perform specific listening tasks in order for physicians to contract images that may increase their quality of understanding about what it is they are trying to understand in a patient's brain (IBID). For example, if a patient is having difficulty comprehending words or phrases, a physician might require an fMRI study to be done in order to develop a better understanding about the activity in the brain for the locations responsible for developing, formulating, and comprehending words and phrases.

Overall, these three types of imaging are not the only types of imaging used by physicians and researchers, but they are three of the most commonly used imaging techniques in order to gauge a better understanding about lesions, tears, and activity within the brain tissue and

surrounding areas (Bradley, 2002). There is yet to be a machine created that can directly target the activity and location of ions within the brain important for stabilizing and generating the proper functioning of neuronal pathways. A proposed mechanism that may enable physicians to further understand complexities within the brain regarding neuronal functioning immediately once a patient is admitted into the hospital would be creating a machine that can track the activity of ions through neuronal pathways. Creating an imaging machine like this might be able to give light to the amount of influx in certain areas of the brain in which these ions may be going or residing that could potentially be causing damage or harm elicited in the symptoms the patient presents with as soon as they are admitted.

This type of imaging must be able to track the activity of ions and the influx. Generating a device that is able to create mobile images like that of an fMRI or MRI so that physicians are more readily able to maneuver through them and see the image at all angles and along all types of planes. Having an image like this that is flexible in the reading will be more beneficial to physicians because they can gauge a better understanding of the intent of these ions and better predict what the outcome may be over time. The high influx of specific ions over time such as sodium and calcium as previously discussed can be more easily targeted and understood by physicians through an imaging system that can directly monitor this activity without being invasive, resulting in a more thorough diagnosis and treatment regimen (Smith, 2016). If physicians were presented with an imaging technique such as this for the case regarding the patient admitted eliciting signs of epilepsy, the physicians would have been better able to recognize that there was more going on in the brain rather than just produces seizures. Physicians might have been able to catch what was happening early on and been able to administer some type of channel blocker to inhibit the release of specific ions that may or may not be causing damage. It is unknown whether or not the mechanism of concussions truly revolves around all of the proposed neuromechanistic hypotheses due to many of the hypotheses still being uncovered, but if this were to be exact, a machine that can detect this post-concussion or traumatic brain injury would not only given physicians a better diagnosis, but also could buy them more time to uncover what is actually happening in a safer way by limiting the amount of excess damage that could be accumulating during the waiting period of discovery (IBID).

At high levels ions such as sodium and calcium can be toxic to cells causing them to die, which is why it is crucial to develop a mechanism that can detect this while the patient is still in a somewhat normal functioning state (Smith, 2016). Overtime the death of specific types of neurons and neuronal pathways that cannot regenerate can lead to permanent damage of areas of the brain responsible for performing important tasks such as memory, movement, and the functioning of speech (IBID). A machine that can detect these types of interactions and activity would most likely have to be designed to measure the weight and frequency at which these ions move.

Considering other devices detect the density of specific molecules, a machine that can be used might measure the density of sodium and calcium, while also generating some type of image based on their activity and rate of influx (Smith, 2016). If researchers can verify that certain ions flow at a specific speed over time, they might be able to create a machine that will be able to detect when certain ions are accumulating at a higher rate, or at least generate an image that can show where the accumulation is occurring. If monitoring activity of these ions is too difficult, just being able to generate an image of the accumulation if they are in fact moving in influx, would give a better understanding to physicians about the damaging potentially being done. Most other types of imaging have been created using some type of magnetic technique and

due to the electromagnetic characteristics that specific types of ions like sodium generate, it may be plausible to incorporate a type of machine that uses a magnet to draw an image of where these ions are residing (Bradley, 2002). Just as people are able to see blood flow within arteries in the body, researchers and engineers might be able to create a machine that tracks the flow of ions through the neuronal pathways leading to the brain. The rate which neurons fire is extremely fast, making it difficult to possibly target the frequency and firing rate at which these ions are moving, but with the being said, the fact that they still are moving may provide a different perspective to gauge. Taking the normal density of these ions and seeing the change in density across a wider range of location may provide researchers with further understanding of the rate at which influx is happening.

Another technique that can be used might be creating some type of dye similarly to that which is used to see if cancer has spread or not with patients. Generating a dye that can react off of the imaging produce may be able to show clusters of ions allow physicians to infer where the influx may be occurring and providing more avenues on how to target it (Smith, 2016). For example for the patient who was admitted into the emergency room with symptoms of epilepsy, if a dye was already created to see within the neuronal pathways of brain and pick up on the density of specific ions, physicians may have been able to administer a drug that reduced the amount of influx to see if in fact the influx of those ions were causing the physical symptoms seen within the patient.

A machine that can generate images using all of the above criteria would be beneficial for patients post-concussion because it would allow for physicians to be presented with more information that they can use to monitor and create treatment regimens for patients post-concussion. The development of a machine that can target and draw on all this information would allow researchers to verify whether or not their hypotheses about the activity of these ions post-concussion are accurate, which would then allow physicians to come up with a more general treatment protocol for all patients post-concussion or traumatic brain injury. This could then reduce the amount of lag time between the presentation of the patient's symptoms and the effectiveness of healing within their brain. Giving physicians a better tool that provides more clear data about what is happening during the brain's healing process and the rate at which damage may or may not be accumulating would be beneficial for many different types of scenarios that are presented within the hospital not just applicable to those post-concussion or traumatic brain injuries.

Not only is developing technology a necessity for the advancement of treating patients post-concussion and traumatic brain injuries, but it is also necessary to develop ways that further increase a patient's quality of life when they are in a similar state of being. Having a sense of voice is difficult for patients and their families when they are placed in these states post-concussion due to the lack of knowledge. Finding ways to educate patients and their families post-concussion is crucial to the diagnosis and recovery process in order to further give the patient the quality of care they want, need, and desire. Incorporating updated protocol to detect the onset of symptoms while developing ways to further understand the neurological and neurochemical components being presented within the brain post-concussion can directly influence the effectiveness of treatment regimens by providing alternative and biomedical options to patients giving them a sense of voice and control over their current state. This in turn has the ability to increase their overall quality of life while providing a sense of relief and optimism towards the future of their recovery.

Narrative Works

The limited knowledge surrounding concussions and the progression of post-concussion symptoms can often leave patients feeling without a voice and unsatisfied with the trajectory of their recovery. This in turn affects the patient's overall quality of life by limiting the positive beliefs they may or may not have about the future (Chopra, 1994). With that being said, the language and medical jargon utilized can also throw patients off when trying to further understand their own symptoms in conjunction to what the physician is diagnosing (Harrison, 2014). For example, if a patient is told that depression is one of the most common symptoms post-concussion, even if they are not exhibiting signs of depression currently they might try to convince themselves that they are in order to gain a better understanding of their current condition. It is almost as if the process of convincing is a subconscious mechanism in order to try and make sense of the condition and provide a sense of validation regarding the event or trauma that had recently occurred. On the other side of this possibility many patients may be so distraught from their head injury or concussion that they are unable to fully understand their own symptoms and effectively communicate them to the physicians making it even more difficult to come with a diagnosis and treatment regimen that best suits the patient due to not only limited knowledge surrounding concussions and post-concussion symptoms, but also limited knowledge being documented from the patient revolving around their symptoms.

The use of narrative provides a sense of expression that can be used to depict feelings or emotions that one may not be capable of effectively describing to someone else. Narrative and writing allow for individuals to have an open page to write freely about what they want or what they are feeling. The use of narrative in patients post-concussion may provide not only a sense of release and comfort during their difficult recovery mentally, emotionally, and physically, but also provide input for physicians to further understand their symptoms on a deeper level. The structure, word usage, and topic of writing can provide physicians with further understand about their patient's mental state and how their recovery is going. It can provide physicians with a better understanding about the rate at which the patient is recovery and any deeper hidden emotions or symptoms they may be hiding or having difficulty expressing. Narrative can be utilized in many different settings and environments, which can produce varying results. For example if a patient writes a narrative during their appointment with their physician and writes again alone in their room, there may be some interesting findings about how the patient feels in either environment giving the physicians insight as to whether or not they are fully meeting the patients wants, needs, and desires. The works depicted below are meant to exemplify how post-concussion symptoms may effect a patient's overall quality of life and how the detailed oriented structure can provide further insight on these symptoms may or may not be effecting the patient's everyday life and routine.

The News
By Cailyn Breski

The sound of the pen scratching against the translucent white sheet of paper,
The light flickering above,
Catching my attention out of the corner of my left eye,
The sound of plastic cleats,
Stomping against the tile floor,
Background noise.

Focused on the computer test in front of me,
Trying to match pictures in a repetitive pattern,
Unsure if the last picture matches with the current,
Slowing down on my accuracy,
Exhausted.

The pounding in my head,
The shakiness of my fingers,
The fogginess of my memory,
Will my life ever be the same?

Thoughts cross my mind about the future of my athletic career,
Telling myself it is all temporary,
Painted by my vague perception of reality,
I know this is worse than what the trainers had expected,
Hopeless.

Focused on my breath,
The rising and falling of my chest,
The slow inhalations and exhalations,
I feel my heart rate gradually releasing,
Peace.

The nauseous feeling deep in the pit of my stomach,
The opaqueness in my hazel eyes,
The emotionless look wiped across my sunburnt face,
Do I even have a chance this season?

The inconsistency of my test results,
The loss of accurate hand-eye coordination,
Absent in the nuanced list of symptoms,
Defeated.

Depression
By Cailyn Breski

The beeping sound,
Piercing through my ears,
Disrupts my train of thought,
I roll over to shut it off,

Another day,
Another outfit,
Another job,
Hoping to find joy in my morning coffee,

I look in the mirror,
Covered in dust and toothpaste specks,
Thinking to myself,
Will I ever be the same?

Today will be different,
I will come out of this place,
Still trying to remember how to tie my shoes,
The dark place inside me convincing me to stay home,

The trees are in full bloom,
As I drive to my job,
Counting down the hours until closing,
I have not yet arrived,

Blue skies tempt me with joy,
Immediately reverting back to my old ways,
Dissatisfaction my best friend,
Despair my second,

I was told it was temporary,
The medication would work,
This is my third one,
Repetition of the same cycle,

Today will be different.

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