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SPECIAL ISSUE

Assessing Second Impact Syndrome Concussions in Junior Hockey Utilizing the QEEG

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The use of the quantitative electroencephalography (QEEG) in assisting the trainer to assess the impact of a second concussion to previously concussed players is studied. Four case studies are presented, illustrating the use of this technique and its value.

Introduction

Trainers in junior hockey are required to make a determination as to when to allow a player to return to the ice post-concussion. This is made even more difficult when a player has a second concussion.

Secondary impact syndrome (SIS) "is simply [when] an individual that has sustained an initial brain injury, who while still symptomatic, sustains another brain injury" (Cantu, 2014, p. 28). This second blow may occur minutes, days, or weeks after an initial concussion, and even the mildest grade of concussion can lead to SIS (Cantu, 2014; Cifu & Drake, 2006; Quintana, 2016). The question of the definition of *symptomatic* becomes important as symptoms of concussion (i.e., postconcussion syndrome) can last for years (Yeates, 2014). The leading skeptic of SIS, McCrory (2001), blames diffuse cerebral swelling, using virtually all his own work as evidence.

Several factors may affect the trainers' decisions. Confusion abounds, particularly when the symptoms of a hit are considered out of proportion to the severity of the hit. Players often will tell the trainer they are fine and in some instances fake the results of testing. Further compounding the situation, the player may have had a previous concussion outside of hockey and not recognized or reported it.

Echlin et al. (2010) studied 67 junior hockey players (ages 16–19 years) for one season. The authors reported that 17 players (25% rate) received concussions and 5 out of the 17 received a second concussion. In a second study, Echlin et al. (2012) studied 45 male and female varsity hockey players. Concussions were documented at a rate of 20%. Interestingly, the incident rate for females was almost twice that for males. Kontos et al. (2016) studied 397 players (ages 12–18 years), and found that 37 players (9.3%) sustained concussions. Unfortunately, in the latter two studies, SIS rates were not reported.

The brain is the only organ in the human body that modern medicine cannot physically examine. Standard and conventional visually read electroencephalograms (EEGs) and conventional magnetic resonance imaging scans (MRIs) are not sensitive or reliable in their detection of mild brain trauma, nor are they helpful in predicting outcome and gradations of severity (Thatcher et al., 2001; Trudeau et al., 1998). Therefore, the QEEG was chosen as the instrument to measure concussions due to its extensive use in the field of brain functions and reliability. Thatcher et al. (2001) reported that the QEEG has a discriminative accuracy as high as 95.67% in detecting mild traumatic brain injury, and 75.8% or greater in predicting outcome one year after injury.

Methodology

A baseline assessment was conducted on all 23 members of a junior hockey team. The team was followed throughout the season (2016–2017). Any player suspected of being concussed during the season was recommended by the trainer for retesting. In total, four players were retested over the course of the year. One of these players was tested a total of three times due to multiple injuries; another was tested five times.

The TBI Severity Index (Thatcher, 2012; Thatcher et al., 2001) using discriminant analysis was chosen as the indicator of injury due to its validity and reliability. Although the QEEG cannot determine how many concussions have occurred, or when they occurred, it can determine the effect of damage and depict the current functioning of a player's brain. Thatcher et al. (2001), when comparing the severity index to the Glasgow Coma Scale, produced results that differentiated between mild and severe head injury. These results showed a classification accuracy of 96.39%, a sensitivity score of 95.45%, and a specificity of 97.44%. The index produces values that ranged from 0 to 10 with 10 being severely injured.

The QEEG was administered and scored following standard procedures. See Thatcher (2012) for details. Administration of the QEEG took one hour on the average and all sites were under 5k ohms for resistance.

Results

Case Study 1

Test 1: Player 1 tested positive during baseline assessment (September 21, 2016)

Test 2: Received second concussion and was tested (December 12, 2016)

Test 3: Received third concussion and was tested (January 3, 2017)

Results

Table 1. Probability and Severity Scores for Player 1

Test No.	MTBI Probability Score (%)	Severity Score
1	75	2.72
2	70	1.72
3	85	3.13

The second QEEG was administered only as a matter of precaution. The player had received a glancing blow on the side of the chin, was momentarily stunned, and complained of headaches and neck pain. The next day he was symptom free except for a sore neck. Whiplash was diagnosed and treated. With the second QEEG data lower than the first, the incident was deemed not to have created or made worse his concussion status.

In early 2017, he had his head rammed into the boards and exhibited several symptoms consistent with the diagnosis of concussion. The QEEG confirmed this and he was not allowed to play. His symptoms had not resolved by the end of the season.

Case Study 2

Test 1: Player 2 tested positive during baseline assessment (September 28, 2016).

Test 2: Received second concussion and was tested (December 1, 2016).

Results

Table 2. Probability and Severity Scores for Player 2

Test No.	MTBI Probability Score (%)	Severity Score
1	99.5	4.11
2	95.0	4.81

This was a player who was on the bubble for being recommended for treatment and restricted from playing. During a game, he sustained a glancing blow to the side of the head that led to a significant return of his concussion symptoms. The extent of the symptoms seemed out of proportion to the nature of the assault. The trainer, on the basis of these results, with agreement with the player, removed the player from further games.

Case Study 3

Test 1: Player 3 tested positive during baseline assessment (September 14, 2016).

Test 2: Received second concussion and was tested (November 21, 2016).

Results

Table 3. Probability and Severity Scores for Player 3

Test No.	MTBI Probability Score (%)	Severity Score
1	90.0	1.99
2	97.5	1.93

We were not overly concerned about this player, as the severity score was so low. He received a blow to the head and neck, leaving him nauseated and a little disorientated. The QEEG showed minimal changes in the scores, and as the symptoms disappeared, he decided to return to the ice.

Case Study 4

Test 1: Player 4 tested positive during baseline assessment (September 14, 2016).

Test 2: Received second concussion and was tested (September 19, 2016).

Test 3: Received third concussion and was tested (January 16, 2017). Player requested a repeat QEEG questioning the results of Test 3.

Test 4: Test 4 was conducted on same day as #3 (January 16, 2017).

Test 5: Player requested another QEEG after treatment (February 2, 2017)

Results

Table 4. Probability and Severity Scores for Player 4

Test No.	MTBI Probability Score (%)	Severity Score
1	70.0	4.42
2	75.0	2.61
3	97.5	5.23
4	85.0	5.27
5	Not significant	NA

The change in the data between the second and third tests is strikingly consistent with the on-ice issues of several blows to the head. The repeated testing on the same day reconfirmed the presence of a concussion. It was on the basis of these results, along with the reported symptoms, that it was recommended he not play until symptoms disappeared, and the QEEG returned to not significant. Several different treatment types were given, with results allowing him to return to the ice. Current research suggests a time period of at least five days to allow for confirmation of the improvement (Yeates, 2014). He returned to complete the season.

Conclusion

Figuring out when a player is ready to return to action is difficult, to say the least. Many players want to participate at the expense of their health. Current written paper and pencil tests can be faked, and the player can minimize the magnitude of the symptoms. Further complicating the trainers' problem, current research shows the physical manifestation of a brain injury does not always match the nature and type of injury. Symptoms often disappear before the healing process is completed.

This paper should be considered a pilot study and needs to be replicated on a larger sample, as it is limited to one team's season. While the reinjury rate is similar in magnitude to other studies when utilizing observational techniques (i.e., trainer's opinions), the use of the QEEG adds an empirical measure to the information available to the trainer. This is the first study that provides empirical evidence as to the brain's status in SIS situations, rather than observational techniques.

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References

Cantu, R. C. (2014). Chapter 2: Consequences of ignorance and arrogance for mismanagement of sports-related concussions: Short and long-term complications. In S. M. Slobounov & W. J. Sebastianelli (Eds.), *Concussions in athletics: From brain to behavior* (pp. 23–33). New York: Springer.

Cifu, D. X., Drake, D. F., & Steinnetz, B. D. (2017). Repetitive head injury syndrome. Retrieved from http://emedicine.medscape.com/article/92189-overview.

Echlin, P. S., Skopelja, E. N., Worsley, R., Dadachanji, S. B., Lloyd-Smith, D. R., Taunton, J. A., . . . Johnson, A. M. (2012). A prospective study of physician-observed concussion during a varsity university ice hockey season: Incidence and neuropsychological changes. Part 2 of 4. *Neurosurgical Focus, 33*(6), 1–11.

Echlin, P. S., Tator, C. H, Cusimano, M. D., Cantu, R. C., Taunton, J. E., Upshur, R. E. G., . . . Skopelja, E. N. (2010). A prospective study of physician-observed concussions during junior ice hockey: Implications for incidence rates. *Neurosurgical Focus, 29*(5), E4.

Kontos, A. P., Elbin, R. J., Sufrinko, A., Dakan, S., Bookwalter, K., Price, A., . . . Collins, M. W. (2016). Incidence of concussion in youth ice hockey players. *Pediatrics, 137*(2), e20151633. doi:10.1542/peds.2015-1633

McCrory, P. (2001). Does second impact syndrome exist? *Clinical Journal of Sports Medicine, 11*(3), 144–149.

Quintana, L. M. (2016). Second impact syndrome in sports. *World Neurosurgery, 91*, 647–649.

Thatcher, R. W. (2012). *Handbook of quantitative electroencephalography and EEG biofeedback* (1st ed.). St. Petersburg, FL: Anipublishing.

Thatcher, R. W., North, D. M., Curtin, R. T., Walker, R. A., Biver, C. J, Gomez, J. F., & Salazar, A. M. (2001). An EEG severity index of traumatic brain injury. *Journal of Neuropsychiatry and Clinical Neurosciences, 13*(1), 77–87.

Trudeau, D. L., Anderson, J., Hansen, L. M., Shagalov, D. N., Schmoller, J., Nugent, S., Barton, S. (1998). Findings of mild traumatic brain injury in combat veterans with PTSD and a history of blast concussion. *Journal of Neuropsychiatry and Clinical Neurosciences, 10*(3), 308–313.

Yeates, K. O. (2014). Predicting postconcussive symptoms after mild traumatic brain injury in children and adolescents. In S. M. Slobounov & W. J. Sebastianelli (Eds.), *Concussions in athletics: From brain to behavior* (pp. 273–287). New York: Springer.

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