Concussion Guidelines Step 1: Systematic Review of Prevalent Indicators

Supplemental Content 14
Reliable Change Index/Estimate Methods Used in the Studies Included in the Review

Broglio 2007[1] – A significant change in concussion-related symptoms was indicated if the Day 1 summative score was 1 standard deviation greater than the baseline score. Standard deviations for symptom reports were acquired from previously reported baseline data. Clinically meaningful changes in postural control were indicated when any variable declined more than 1 standard deviation from the baseline assessment.

Broglio 2007[2] – Postconcussion cognitive scores were compared with preseason assessment results to determine changes in performance. Significant declines in performance were determined through automated calculations of the reliable change index (RCI) embedded in the ImPACT program.

Collins 1999[3] – To provide preliminary information regarding the recovery pattern of athletes with concussions relative to the control group and to their own baseline performance, standard scores were created to convert the selected neuropsychological test scores to a common metric. These standard scores were constructed so that baseline performance for each group would have a mean of 100 and SD of 15. Group differences of one-half SD (7.5 standard score units) are considered to reflect at least a moderate difference between the means. Any deviation from 100 indicates a change in performance relative to baseline for each group. The recovery pattern of players who sustained concussion across different time intervals was evaluated by standardizing all neuropsychological test results and comparing performance of the athletes with concussion with controls' performance within 24 hours, and at 3, 5, and 7 days post-injury.

Covassin 2007[4] – Reliable change indices were calculated to determine clinically significant decreases (or improvements) while reducing any effects of measurement error. The use of reliable change index is well documented, and we used the original formula proposed by Jacobson and Traux.[5]

Hinton-Bayre 1999[6] – The Reliable Change Index (RCI) is a standardized difference score that was designed to assess the effects of a clinical intervention. Any change from one testing occasion to another is considered significant if the magnitude of the change is sufficiently large in proportion to the associated error variance of the test. Error variance is calculated through accounting for test-retest reliability and variation about the mean of the test. An absolute RCI value exceeding $z = 1.96$ was regarded as a meaningful change (alpha < 0.05, two tailed).

Kontos 2010[7] – Reliable change estimates (RCEs) at the 80% confidence interval (CI) were used to determine if athletes experienced clinically significant declines in any of the ImPACT neurocognitive composites following a concussion. Odds ratios (ORs) from a series of χ^2 analyses for race/ethnicity and the RCEs were then calculated to determine risk for clinically significant declines in neurocognitive performance at 2 and 7 days post-concussion.

Van Kampen 2006[8] – An athlete's test performance was deemed to be reliably different relative to his or her own baseline if the difference between post-concussion and baseline scores on a given composite index of ImPACT was larger than the established RCI scores, as determined in previously published research by Iverson et al[9]

REFERENCES

1.   Broglio SP, Macciocchi SN, Ferrara MS. Sensitivity of the concussion assessment battery. *Neurosurgery.* 2007;60(6):1050-1057; discussion 1057-1058.
2.   Broglio SP, Macciocchi SN, Ferrara, MS. Neurocognitive performance of concussed athletes when symptom free. *J Athlet Train.* 2007;42(4):504-508.
3.   Collins MW, Grindel SH, Lovell MR, et al. Relationship between concussion and neuropsychological performance in college football players. *Jama.* 1999;282(10):964-970.
4.   Covassin T, Schatz P, Swanik CB. Sex differences in neuropsychological function and post-concussion symptoms of concussed collegiate athletes. *Neurosurgery.* 2007;61(2):345-350; discussion 350-341.
5.   Jacobson NS, Truax P. Clinical significance: a statistical approach to defining meaningful change in psychotherapy research. *J Consult Clin Psychol.* 1991;59(1):12-19.
6.   Hinton-Bayre AD, Geffen GM, Geffen LB, McFarland KA, Friis P. Concussion in contact sports: reliable change indices of impairment and recovery. *J Clin Exp Neuropsychol.* 1999;21(1):70-86.
7.   Kontos AP, Elbin RJ 3rd, Covassin T, Larson E. Exploring differences in computerized neurocognitive concussion testing between African American and White athletes. *Archives of Clinical Neuropsychology.* 2010;25:734-744.
8.   Van Kampen DA, Lovell MR, Pardini JE, Collins MW, Fu FH. The "value added" of neurocognitive testing after sports-related concussion. *Am J Sports Med.* 2006;34(10):1630-1635.
9.   Iverson GL, Lovell MR, Collins MW. Interpreting change on ImPACT following sport concussion. *Clin Neuropsychol.* 2003;17(4):460-467.