**Adapted Primary Literature for Teaching**

# Sideline Test for Concussion

Galetta, K. M. et al. 2011. The King-Devick tests as a determinant of head trauma and concussion in boxers and MMA fighters. Neurology, 76: 1456-1461.

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## Abstract

The authors remind us that contact sports like football, boxing, and so on can cause concussions in the athletes. Concussion can cause brain damage that may be permanent. One test for concussion, the King-Devick (K-D) test measures the speed of rapid number reading. Other researchers had shown that the K-D test reflects eye movements, attentiveness, language, and other aspects of thinking ability. In this present study, the researchers tested whether the K-D test would be useful in quick sideline screening of boxers and martial arts fighters. Those with test scores indicating concussion could be pulled from the match.

## Introduction

Concussion is rather common in contact sports. We know that frequent concussions can cause long-term symptoms, disability, and brain damage like that seen with Alzheimer's Disease. Other studies have shown that early detection of concussion can reduce long-term brain damage if the athlete is rested and given time for the brain to heal.

The authors knew about a test for concussion called the King-Devick (K-D) test. It only takes two minutes to run the test. Thus, it might be useful for sideline use to determine if an athlete can safely remain in the contest. The K-D test scores are affected by brain functions that are impaired in concussion. These functions include eye movements, attention, and language.

The idea was to test if boxers and martial arts athletes who received many head blows or were knocked unconscious during matches differed in their K-D scores after the fight, compared to before.

## Methods

The test subjects were amateur boxers and martial arts fighters. They fought 3-round matches under supervision with standard helmets and other gear of the sport. All subjects gave written consent to their participation.

The K-D test involves reading aloud a series of single digit numbers from left to right on three test cards. Each card shows five rows of five numbers. One card had lines between each number and arrows showing to read it left to right, top to bottom. The test cards had eight rows of five numbers per row. The first test card showed the numbers with lines connecting each number to guide eye movements. The other two cards removed the lines and the third

card was made harder to read because the rows were squeezed together (Fig. 1, not shown here).

The test is normally completed in less than two minutes. Subjects had to read the cards as fast as possible without making any errors. The final test score was the total of the time spent with each card. They also recorded the number of errors.

To compare results with another test, they tested martial arts fighters with a more complicated test used by the military, the Military Acute Concussion Evaluation (MACE) test. This took 15-20 minutes to run.

**Testing Boxers.** All boxers were tested with K-D at ringside just before the fight. Boxers read a practice card first, followed by the three cards used for scoring. Fighters could wear glasses if their close-up vision was limited. To measure test-re-test reliability, each boxer took the test twice within 15 minutes before starting the match.

After the three rounds (lasting a total of 9 minutes), the boxers were tested again once with K-D. The MACE test was given to those who were knocked out (fell down without movement) or who were "out on their feet." Also MACE tested were those who received strong head blows, as judged by a physician who had experience in officiating in boxing matches.

As much as possible the researchers scoring the K-D test did not know were a fighter's condition during the fight.

**Testing Martial Arts Fighters**. Fighters took the K-D test in the way used with boxers. They also took the MACE test.

**Data Analysis.** Because the data were obtained in a similar way for each type of fighter, the data were lumped together ("pooled"). Total number of participants was 39, with only one being a woman. For each athlete, researchers compared the before- and after-fight K-D score for those that had to been judged to have received head trauma. They also compared scores between those who had been knocked out versus those who had not been. This test design is called "paired" and has the advantage that variation in the data is reduced because the data are compared within each subject. This process is often described as each subject serving as his/her own control.

Researchers used an appropriate statistical test to see if chance events could explain the data differences. The test used was a "non-parametric test" which is required any time the data are skewed (that is, the range is large and the mean would be a misleading value). Such tests rank the values for statistical testing and express the results as median and range.

## Results

All but one of the participants was male. Boxers numbered 27. There were 12 martial arts fighters. Ages ranged from 16 to 53. Thirty-five were Caucasian and four were Hispanic. Seven were identified with clear signs of head trauma, as was one of the fighters (Table 1. Not shown here).

High test-re-test reliability was demonstrated. Mean pre-fight K-D scores were similar on both tests, but slightly lower on the second testing (Table 2). Post-fight scores were higher (worse) in those with head trauma (59.1 seconds versus 41 seconds). An even greater score difference occurred in those who had been knocked out (65.5 seconds versus 52.7 seconds). The change in scores from pre-fight to post-fight in those who did not have head trauma was minor (a 1.9-second improvement).

Of those given the MACE test after the fight, five of the seven with head trauma failed. None of those without head trauma failed. There was a statistically significant correlation ($r = 0.90$, $p < 0.0001$)[1] between poor post-fight K-D scores with post-fight MACE scores.

Table 2. Concussion Scores

| Data Groups | Total Subjects, n=39 | # No Trauma, n= 31 | # With Trauma, n=8 | Loss of Con-sciousness, n=4 | P value* |
|---|---|---|---|---|---|
| Pre-fight, K-D test 1 (median & range) | 46.8 (36.5-59.4) | 45.0 (36.5-59.4) | 50.8 (40.7-55.2) | 50.8 (40.7-52.5) | |
| Pre-fight, K-D test 2 (median & range) | 44.6 (32.0-58.2) | 42.7 (32.0- 58.2) | 45.9 (40.1-51.7) | 47.0 (41.9-51.7) | |
| Post-fight K-D (median & range) | 43.0 (30.9-69.4) | 41.5 (30.9-58.8) | 59.9 (50.9-69.4)a | 64.9 (62.9-69.4)b | <0.0001[a] <0.02[b] |
| Change in pre- and post-fight K-D | -0.59 | -1.91 | 1l.1 (5.5-28.7) P = 0.01 | 18.0 (11.2-28.7) P=0.06 | 0.0001[a] 0.02[b] |
| Post-fight MACE (median & range) | 26.5 (25-29) | 28 (25-29) | 18 (15-26) | 16.5 (15-21) | 0.002* 0.0001** |
| Percentage failing MACE test | 5 of 18 | 0/11 | 5 of 7 | 4 of 4 | |

[a] comparing head trauma versus no head trauma
[b] comparing loss of consciousness versus no loss of consciousness
*comparing MACE scores in those with head trauma versus no head trauma
** comparing
P value interpretation: there was less than a 0.01% chance that the difference could be explained as a chance event.

Some overlap existed in the distribution of post-fight K-D scores in the participants with and without head trauma (Fig. 2). However, no overlap occurred in changes of scores from pre-fight to post-fight. Those with a score worsening of only five seconds or more could distinguish those with head trauma.

[1] R stands for correlation value. This is calculated mathematically. It ranges from zero (no correlation at all) to 1.0 (perfect correlation).

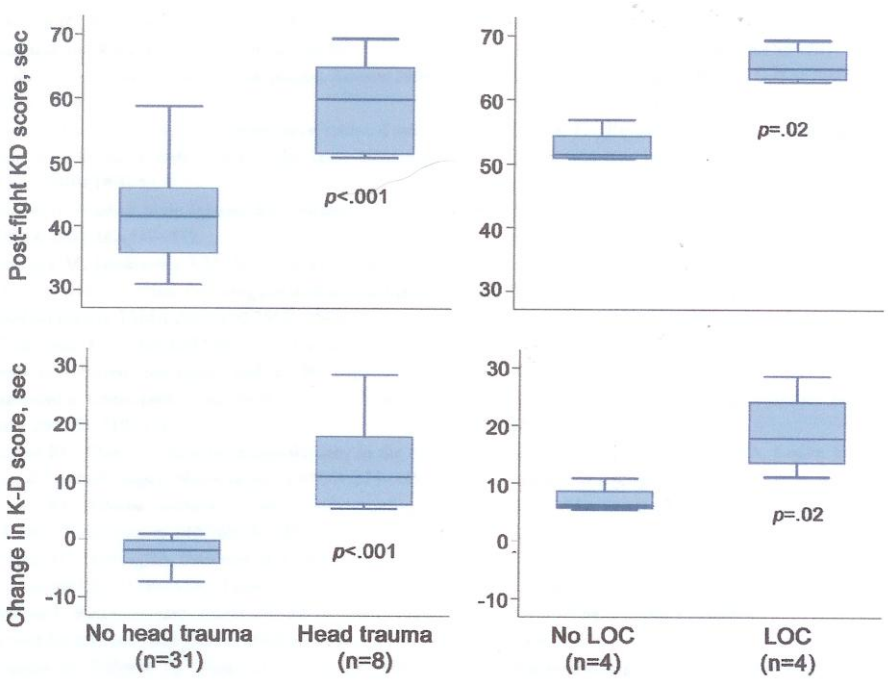


Fig. 2. "Box plots" of the range of post-fight K-D time scores (top half of figure) and changes in K-D scores between pre—fight and post-fight K-D scores (lower half). Horizontal lines in each box represent the median. Vertical size of the box represents the percentage of subjects that ranged from 25% to 75% of all values. T bars represent the total range of values. P values are based on a non-parametric ranking test of the scores (Wilcoxon rank-sum test). LOC refers to the number that had "loss of consciousness" (were knocked out).

## Discussion

The authors claim the data show that K-D tests are accurate and reliable for identifying athletes with head trauma. Because the test can be conducted so quickly, they think it could be useful for screening tests on the sideline. For example, it could be used to decide when a fight should be stopped or when a football player must be pulled from the game in order to protect them from further brain damage.

The data also showed that those athletes who had been scored by impartial observers as having received head trauma during the match had definitely worse post-fight K-D scores. This was also seen in the data of the difference in pre-fight and post-fight scores. The change scores were even greater than post-fight scores between those with head trauma and those without.

They concluded that a K-D score difference of 5 seconds or more could be used to decide whether or not to pull an athlete from the contest. Other sports where they think this test could be useful are football, soccer, rugby, and hockey.

They cite reports from others showing that sport-related concussion in the U.S. is somewhere between 1.6 to 3.8 million each year. In a given sport season, as many as 20% of the athletes may have had at least one concussion incident. Virtually all such concussions are in young people.

They cite research showing that a person usually recovers from concussion, but the danger is greatly increased by a second concussion. Brain damage is greater if a second concussion occurs before recovery from the first incident. The evidence for these conclusions was based on reports that had used brain scans, brain-wave recordings (electroencephalogram) and formal tests of thinking ability ("neuropsychological tests").

The authors point out that contact sports in general have no clear rules for deciding when to pull an athlete from the contest. Decisions are made by the opinions of a contest official. There are ways to diagnose concussion that are more reliable than K-D tests, but these have to be done in a clinic setting and are not practical for instant sideline decisions during the contest. Also, having objective test scores makes it harder for an athlete or a coach to argue against a decision to remove athletes from the contest.

One reason the authors thinks the test works is that scores depend on well-controlled eye movements. Concussions are well known to have a special disrupting effect on accurate eye movement. They discussed some of this literature.