Reviewer: Stephanie Tow, MD   AACPDM Adapted Sports/Rec Committee
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Article
Richard J, Lin Y-S, Wernet, L, et al. (2020). Is the King-Devick test a reliable tool in wheelchair athletes? A preliminary prospective study in wheelchair basketball. *Clin J Sport Med, 00*, 1-5. https://doi.org/10.1097/JSM.0000000000000889.

Adaptive Sports/Recreation Topic Categories
- Concussion
- Wheelchair athletes
- Wheelchair basketball

Research Question
- Primary Question: What is the reliability of the King-Devick (KD) test among wheelchair basketball athletes across a season?
- Secondary Questions:
    - What is the learning effect of the KD test on repeated testing over time among adult wheelchair basketball athletes?
    - What percentage of wheelchair basketball athletes sustain a suspected concussion across a season?
    - What are the KD test time changes when comparing wheelchair basketball athletes with and without a clinically suspected concussion?

Methodology
- Participants: 29 (15 male and 14 female) intercollegiate (Division 3) wheelchair basketball athletes from a single institution.
    - All athletes were nonconcussed during study enrollment.
    - Ages: 18 years or older (average age 23.3 ± 5.25 years)
    - English-speaking.
- Prospective, observational study.
- Athletes were prospectively monitored for concussions throughout the 2018-2019 season.
    - Concussion was suspected if there was a witnessed or reported head trauma.
    - KD test then performed, and if positive, athletic trainer completed detailed evaluation to assess for any new symptoms consistent with concussion.
        - If one or more new symptoms consistent with concussion were reported by the athlete, they were diagnosed with a clinically suspected concussion and treated per standard concussion protocol.
            - The next planned KD test was not repeated and was not used for reliability testing if:
                - Concussion occurred within 30 days of next planned KD test.
                - The athlete remained symptomatic.
                - The athlete had not yet been cleared to return to full sport.
- More information about the KD test (for those not familiar with this test):
    - This test comes in either paper (cards you flip) or electronic versions and is composed of a rapid, number-naming sequence that assesses visuospatial discrimination, evaluating for changes in saccadic rhythms, which may be disrupted in concussion.

- o Participants flip through 3 card that progressively are harder to read the sequences aloud by making visual cues or spacing of the numbers more difficult with each card.
  - o Total time to complete each card and number of reading errors are recorded.
  - o Slower times or more errors on the test after a clinically suspected concussion support the diagnosis.
  - o The test is useful for baseline measures and sideline screening evaluation for concussion.
- • Primary outcome measures:
  - o KD testing performed during the following times (best of 2 trials each time):
    - ▪ <u>Preseason</u> *(within 2 weeks before season start).*
    - ▪ <u>Midseason</u> *(for athletes with no suspected concussion; over a span of 1 month).*
    - ▪ <u>Postseason</u> *(over 2-week span).*
    - ▪ <u>After clinically suspected concussions</u> *(at the time of event or report).*
    - ▪ Performed by same certified athletic trainer who had received training for KD test administration following the KD test protocol.
  - o 2-way random effects intraclass correlation coefficient (ICC) to evaluate test-retest reliability of the KD test.
  - o Friedman signed-rank test and pairwise comparison with Bonferroni correction to compare for KD test change/learning effect over time.
  - o Mean KD times and standard deviations for preseason, midseason, and postseason.
    - ▪ Compared between athletes with and without suspected concussion.
  - o Change in KD test times between each testing interval.
    - ▪ Compared between athletes with and without suspected concussion.
- • Secondary outcome measures:
  - o Athletes completed a preseason demographic and medical questionnaire.
    - ▪ Included age, gender, body mass index (BMI), impairment type(s), years of wheelchair basketball participation, age of onset of impairment, basketball position, and concussion history.
  - o At end of season, certified athletic trainer also completed a survey for each athlete providing information on:
    - ▪ Number of practices attended.
    - ▪ Number of games played.
    - ▪ Number of injuries and illnesses reported throughout the season.
    - ▪ Type(s) of injuries and illnesses reported.

Results
- • Athlete demographics
  - o Played wheelchair basketball for an average of about 8 ± 5 years
  - o About 93% had a primary mobility impairment
  - o About 7% had a primary cognitive impairment (with about 3% having a coexisting visual impairment)
  - o Common diagnoses: acquired spinal cord injury (24%), spina bifida (24%), limb amputation (17%), congenital limb defect (10%), traumatic brain injury (10%), and cerebral palsy (7%).
- • KD test demonstrated good test-retest reliability across time among athletes without a suspected concussion (2-way random-effects ICC = 0.826).
- • Among participants <u>without</u> concussion:

- - o There was a significant decrease in mean KD test time from <u>preseason</u> to <u>midseason</u> (-3.3 seconds).
    - o There was a significant decrease in mean KD test time from <u>preseason</u> to <u>postseason</u> (-3.3 seconds).
    - o There was no significant difference in mean KD test time from <u>midseason</u> to <u>postseason</u>.
- Among participants (6 participants) who had concussion (7 concussions, all sustained during sports-related activities):
  - o Each athlete demonstrated an increase in KD test time compared to their most recent baseline KD test.
    - Mean increase from 44.3 ± 9.5 seconds to 53.7 ± 12.8 seconds.
  - o KD test times returned to or below baseline by postseason (mean 40.2 ± 8.4 seconds)
- Overall concussion incidence rate of concussion over one season: 20.6%.

Discussion/Conclusion
- KD test shows good reliability among wheelchair basketball athletes without a concussion, with reliability consistent with previous literature among athletes without disabilities.
  - o A learning effect is demonstrated initially but plateaus on subsequent testing, suggesting that this learning effect stabilizes when the test is repeated multiple times.
    - Studies of other athlete populations have shown a learning effect, but not a plateau.
- Wheelchair basketball athletes with a clinically suspected concussion showed an increase in the KD test time, unlike wheelchair basketball athletes without a concussion.

Article Strengths
- First study to assess test-retest reliability of the KD test for sideline concussion assessment among a cohort of adaptive athletes.
- Results from this study show preliminary promise for using the KD test to evaluate for concussion with good reliability in wheelchair athletes.
- The authors chose a great clinical tool to study for concussion screening in wheelchair athletes:
  - o The KD test is a very practical (cost- and time-effective).
  - o The KD test is great for wheelchair athletes as other assessments (e.g. balance testing, Buffalo concussion treadmill test, etc) may not be possible or have not been modified for use in individuals with mobility impairments.

Article Weaknesses
- Small sample size.
- Heterogeneous patient population representing a diverse spectrum of underlying medical conditions/diagnoses and impairment severity, making it difficult to report the diagnostic validity of the KD test in this cohort.
- Difficult to generalize study findings to general population of adaptive/Para athletes who represent a large span of underlying medical conditions, impairments, and other factors that may impact KD test results (e.g. challenges in using the KD test in adaptive/Para athletes with visual impairment, those who have variable visuospatial

discrimination issues or saccadic rhythms, or those with certain intellectual impairments).
- Methodology could be strengthened by enrolling athletes without disabilities from the parallel college basketball team for comparison of their results related to KD testing.

Take Home Messages
- This study on a small cohort of adult wheelchair basketball athletes demonstrated:
    - The KD test showed good reliability among wheelchair athletes with no clinically suspected concussion.
    - A learning effect was shown initially when completing the KD test, but plateaued on subsequent testing.
    - Wheelchair athletes with a clinically suspected concussion showed an immediate increase in KD test time compared with baseline, while other wheelchair athletes showed a decrease in KD test time throughout the season.
- Further research is needed to:
    - Assess the validity and predictive value of using the KD test in wheelchair athletes, including in other adaptive/Para athlete populations, and also in pediatric/youth adaptive/Para athletes.
    - Assess other potential clinical tools/tests to reliably diagnose concussion in adaptive/Para athletes and compare reliability, validity and predictive value, and feasibility of use compared to the KD test.