Journal of the Neurological Sciences 383 (2017) 101–104

Contents lists available at ScienceDirect

Journal of the Neurological Sciences

journal homepage: www.elsevier.com/locate/jns

Risk factors associated with baseline King-Devick performance

R. Moran[a,*], T. Covassin[b]

[a] Athletic Training Research Lab, Department of Health Science, The University of Alabama, Tuscaloosa, AL, United States
[b] Sports Injury Research Lab, Department of Kinesiology, Michigan State University, East Lansing, MI, United States

ARTICLE INFO

Keywords:
Concussion
Sports
Youth
Sex
Age

ABSTRACT

Objective: This study examined the effect of baseline risk factors on the King-Devick (K-D) test in youth athletes, including of age, sex, and history of concussion.
Methods: A total of 422 youth football and soccer athletes between the ages of 8 and 14 completed a baseline K-D test prior to the start of their respective seasons. Participant age, sex, and history of concussion were analyzed for K-D performance (i.e., errors and baseline time). A series of Mann-Whitney *U* tests were conducted to determine the effects of risk factors on performance. Correlations and regression analyses were conducted to assess the relationship between risk factors and K-D time and errors.
Results: Differences in age ($p < 0.001$) and sex ($p < 0.001$) were reported on K-D time and errors. A history of concussion did not have an effect on K-D time ($p = 0.15$) or errors (p range = 0.15–0.17). Overall, weak to moderate correlations were observed between risk factors and K-D performance (r range = −0.43–0.23). Baseline K-D time and total errors improved with increasing participant age ($p < 0.001$). Sex was also able to predict K-D time and errors ($p < 0.001$). History of concussion was not able to predict K-D time ($p = 0.18$) or errors ($p > 0.05$).
Conclusions: This study demonstrates the influence of risk factors such as sex and age on baseline K-D assessment. Associated risk factors at baseline further emphasize the need for individualized, multifaceted assessment for sport-related concussion diagnosis and management.

1. Introduction

The awareness of sport-related concussion in youth and adolescents has increased considerably over the last few years ([3,4]). A major stride towards better diagnosis, prognosis, and management of sport-related concussion has been the implementation of baseline testing [3]. Baseline assessment has become pivotal in providing subjective and objective clinical outcomes data and represents a standard of best practice by many professional associations and consensus statements [3,13]. A multifaceted assessment approach has been recommended at baseline to include symptom reporting, as well as neurocognitive, balance, vestibular, and ocular assessments, especially with youth populations due to developmental and maturation changes that occur.

Recently, the King-Devick (K-D) test has gained popularity as a concussion-screening tool [9,10]. Previous research at baseline has helped to produce normative reference values across multiple populations, however these studies have been primarily conducted in high school and adult aged males ([1]; Vartiainen et al. [17]). Researchers investigating the K-D test at baseline have also reported age differences in performance, with better scores as age increases in high school, collegiate, and professional athletes ([1,10]; Vartiainen et al. [17]). More specifically, Alsalaheen et al. [1] reported that high school football players aged 16 to 18 had faster total times on the K-D test than those aged 13 to 15 years, demonstrating better performance. Valovich and McLeod [16] also reported age differences in baseline Sport Concussion Assessment Tool 2 (SCAT-2) performance in high school athletes. Specifically, 9th graders scored worse than 11th and 12th graders on SCAT-2 total scores. In addition, 9th graders performed worse on memory, concentration, and delayed recall tasks of the Standardized Assessment of Concussion (SAC), which further supports the idea that age may have an effect on baseline concussion assessment measures. Glaviano et al. [11] also reported that middle school athletes performed worse on concentration scores than high school athletes.

Sex has also been identified as a risk factor for poor performance on baseline concussion assessment [3,7]. Female collegiate athletes have been reported to have lower verbal memory scores at baseline than male collegiate athletes [7]. In addition, collegiate females have faster reaction time at baseline compared to males [6]. Brooks et al. [4] discovered that adolescent athletes, ages 13–18 years, displayed sex differences on baseline concussion assessment. Females reported more

* Corresponding author at: 481 Russell Hall, Box 870311, Tuscaloosa, AL 35487-0311, United States.
E-mail address: rnmoran@ches.ua.edu (R. Moran).

http://dx.doi.org/10.1016/j.jns.2017.10.039
Received 23 July 2017; Received in revised form 24 October 2017; Accepted 25 October 2017
Available online 05 November 2017
0022-510X/

cognitive-sensory and sleep arousal symptoms than males at baseline. To date, the only study to examine the effect of sex on K-D performance, found that male and female patients between the ages of 10 and 77 years, did not differ on scores post-concussion [2]. However, the K-D has yet to be investigated for baseline sex differences in a youth population.

Considering that by the start of high school, 54% of student athletes report a history of concussion, further attention to youth sport athletes and the risk of a history of concussion is warranted [8]. Valovich and McLeod [16] reported that high school athletes with a history of sport-related concussion performed worse on the SCAT-2 at baseline. In addition, high school athletes with a history of concussion were more likely to report at least one baseline symptom. However, on the K-D test, a history of concussion has been previously reported to have no effect on baseline scores in American high school football players [1]. Very little is known regarding whether the risk factor of a history of concussion has an effect on concussion screening tool outcome measures at the youth level, below high school aged athletes. Therefore, the purpose of this study was to examine the effects of risk factors, including age, sex, and a history of concussion, as well as their relationship, on baseline K-D performance.

2. Participants and methods

A total of 422 youth athletes between the ages of 8 and 14 years from the mid-Michigan area completed a pre-season baseline K-D test prior to the start of their respective season. Inclusionary criteria consisted of individuals who were enrolled in either a participating youth football or soccer organization. Any athletes who were diagnosed with a concussion within 6 months prior to testing, had undergone brain surgery, or had a history of cranial pathologies as determined by a CT scan or MRI were excluded from this study. The Institutional Review Board (IRB) at the university approved this study. Informed parental consent and child assent were obtained from each participant, in addition to a Demographic And Medical History Questionnaire.

2.1. Demographic and Medical History Questionnaire

Participants' parents/guardians provided self-reported demographic data related to the child's age, sex, and sport (i.e., football or soccer). Pertinent medical history included a diagnosis of personal and family history of concussions. Data were not analyzed for a family history of concussion due to a low number of reported family history.

2.2. King-Devick (K-D) test

The K-D test is a rapid, number naming, sideline tool requiring saccadic eye movements and reaction time. The K-D test involves reading a series of single-digit test cards as quickly as possible. Participants are asked to read from left to right as if they were reading a book, without making any errors. The K-D test is scored as the cumulative time that it takes to read the three test cards. Participants complete the K-D test twice, with the faster of the two trials being recorded as the athlete's baseline time. For the purpose of this study, data were recorded for both trials and errors were counted to determine if individuals with a history of concussion made more errors at baseline. Data collection was conducted in a quiet location at the respective organizations facility.

2.3. Statistical analyses

Statistical analyses were performed using SPSS, version 24 software. General descriptives were utilized to provide means and standard deviations for demographic data and group K-D performance (i.e., baseline time, time per trial, errors). To determine the effects of a reported history of concussion, individuals with a history of concussion were match controlled, based on sex, age, height, and weight to individuals without a history of concussion. Match controls were utilized to match for physical and physiological development and maturation. A Mann-Whitney *U* test was used to determine if there were differences on K-D baseline scores and errors among youth athletes who had and did not have a history of concussion.

Age was separated into two groups of individuals aged 8–11 and 12–14, due to cognitive and developmental maturation. A Mann-Whitney *U* test was conducted to examine if there were difference in K-D scores and errors between youth athletes aged 8–11 years, and 12–14 years. Separate Mann-Whitney *U* tests were also used to examine differences between sex. Pearson correlations and regression models were used to assess the relationship of K-D time and errors between the risk factors of age, sex, and diagnosed medical history of concussion.

Table 1
Characteristics of the participant cohort, (n = 422).

Age	
8–11 years	246 (58%)
12–14 years	176 (42%)
Sex	
Male	278 (66%)
Female	144 (34%)
Sport	
Soccer	262 (62%)
Football	160 (38%)
K-D total time score	54.23 ± 11.51 s (range 30.01–85.3)
K-D errors total	1.26 ± 2.3 errors

3. Results

Participant characteristics and cohort data are summarized in Table 1. Among the 422 youth athletes (age = 11.04 ± 1.5 years), 38 reported a history of previous concussion, with 35 athletes reporting 1 previous concussion, 3 athletes reporting 2 previous concussions, and one athlete reporting 3 previous concussions.

3.1. Age, sex, and history of concussion and K-D baseline scores

The total time of the K-D test was utilized to examine the baseline effects of risk-factors including age, sex, and a history of concussion. Individuals aged 8–11 had a slower time than individuals aged 12–14 years ($U = 10{,}145.0$; $p < 0.001$) (Table 2). In addition, younger athletes, ages 8–11 years, also had more errors on Trial 1 ($U = 17{,}404.5$; $p < 0.001$) and Trial 2 ($U = 1861.0$; $p < 0.001$) than older youth athletes, ages 12–14.

There were also significant differences on baseline K-D test between sex ($U = 13{,}854.0$; $p < 0.001$) with males performing worse than females (Table 2). Sex differences were also found on total errors on Trial 1 ($U = 17{,}404.5$; $p < 0.001$) and Trial 2 ($U = 18{,}681.0$; $p < 0.001$).

Table 2
K-D performance by risk factor.

Risk factor	K-D time (sec.)	Errors	
		Trial 1	Trial 2
Age			
8–11	58.51 ± 11.2[a]	1.06 ± 1.4[a]	1.00 ± 1.4[a]
12–14	48.32 ± 10.5[a]	0.54 ± 1.0[a]	0.59 ± 1.0[a]
Sex			
Male	56.13 ± 11.3[a]	0.96 ± 1.3[a]	0.96 ± 1.3[a]
Female	50.54 ± 11.1[a]	0.60 ± 1.0[a]	0.58 ± 1.0[a]
Concussion Hx.			
History	52.11 ± 10.4	1.08 ± 1.5	0.71 ± 1.2
No History	48.88 ± 10.4	0.66 ± 1.1	0.66 ± 1.2

[a] Significant at the 0.05 level between risk factor (i.e., age, sex, etc.)