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Feasibility Assessment of the Reebok CHECKLIGHT™ and King-Devick Tests as Screening Tools in Youth Football

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ABSTRACT

Background: Concussions are one of the foremost issues in sport, with football having one of the highest incidence rates of injury. Moreover, there is a need to monitor sub-concussive head impacts because they may not initiate further assessment which may increase an athlete's risk of suffering a brain injury. The purpose of this article is to discuss the viability of use for the Reebok CHECKLIGHT™ system and its correlation to the results of screening concussive events screening in two levels of football: youth recreation league football (ages 11-13) and high school football (ages 13-18). **Results:** The Reebok CHECKLIGHT™ system activation did not correlate with the King-Devick score (r=-0.08, p=0.7). There was no difference between the two levels of football in the number of times the lights came on, 1.77 ± 2.05 vs. 1.42 ± 0.79, p=0.57. **Limitation:** The viability of CHECKLIGHT™ system was limited by threshold issues with the light alert system, light usefulness, set-up, and implementation. **Conclusion:** The Reebok CHECKLIGHT™ system may be beneficial to individual athletes below the high school level; however, it appears to have limited usefulness for entire teams and/or high school athletes.

INTRODUCTION

Concussions are a foremost issue in contact sports. Conservative data estimates that approximately 300,000 sport-related concussions (SRC) occur each year.[1] Recent data suggest that the incidence could be as high as 1.6-3.8 million per year accounting for 5-9% of all sports-related injuries.[2-4] In all youth sports, football is documented as having the highest rate of concussion for males.[5-7] Since there are an estimated 3.5 million youth football players in the United States, considerable research must be committed to the identification of individuals at risk for SRC in this population.[8,9]

There are many different SRC assessments that may be utilized on the field by trained healthcare professionals. There remains the need for objective, validated and rapid sideline tests to definitively support remove-from-play decisions.[8,10-12] Among the various tools, the King-Devick (K-D) has been emerging in the literature as a valid screening for individuals that may have been exposed to concussive forces.[10,11,13]

The K-D test has been shown to be easily administered as a sideline screening tool and is very user friendly.[14] In order to better utilize the K-D, new technology has been created to identify which athletes are exposed to impacts that often lead to SRCs. One such new technology is the Reebok CHECKLIGHT™ device that is marketed to help identify further testing for SRC. The device is comprised of a skull cap with a sensory array worn underneath the helmet. It has a green, yellow or red light alerting system to indicate forces which may be significant enough to identify head impact resulting in concussive and/or sub-concussive event(s). [See Figure 1] Sub-concussive forces often do not result in concussive symptoms, therefore the SRC protocol is never initiated.[15] Being able to use a head impact device, like the Reebok CHECKLIGHT™ device, may allow the health care provider to monitor the health status of these sub-concussive, non-symptomatic, impacts.

Figure 1 – Reebok CHECKLIGHT ™ accessible via: http://www.reebok.com/us/checklight/Z85846.html

The purpose of this article is to discuss the viability of use for the Reebok CHECKLIGHT™ system, and its correlation to concussive events assessed by the K-D test in two levels of football: youth recreation league football (ages 11-13) and high school football (ages 13-18). Specifically, we want to determine if the combination of the CHECKLIGHT™ system and the K-D test can be reasonably streamlined into youth football. Until there is an improvement in the identification of concussive events in athletes that are involved in contact sports, there will likely continue to be adverse events and outcomes for the athletes.

METHODS

This study was approved by the Radford University Institutional Review Board, and informed consent was obtained from each participant.

Participants

A total of twenty-five subjects completed the study. Thirteen subjects were recruited from local High School junior varsity (JV) and varsity football teams (12 male, 1 female) and were compared to twelve male subjects from a local Parks and Recreation youth league football team (mean age 14.4 ± 1.0 yrs. and 12.3 ± 0.8 yrs, respectively, $P < 0.0001$). In order to be included in the study, all participants completed documentation indicating they did not have any preexisting conditions placing them at risk for injury. Parental consent was also required for all of the subjects.

Instrumentation

Each subject was fitted with a Reebok CHECKLIGHT™ system (Figure 1) which was provided free of charge (retail price of $150 at time of the study). The system consists of two components: a soft skull cap made of lightweight fabric and a removable sensor which fit into a pocket in the skull cap. According to the manufacturer the product is designed to measure both impact force and acceleration to the head, with higher forces triggering a red light, and lesser forces triggering a yellow light. The sensor uses a gyroscope to measure rotational forces and a tri-axial accelerometer to measure linear acceleration in order to measure changes in linear and rotational acceleration. Triggering the light system does not provide the actual forces measured and it does not mean that an SRC has occurred; instead, the alert indicates that the device has received an amount of force that has exceeded the threshold, thus serving as a warning system and a potential need for further assessment of the athlete.

Tasks

Each light sensor was numbered and assigned to a specific athlete. Skull caps were appropriated sized (S, M or L) and issued to each athlete (Figure 1). The devices were worn under their helmets during all contact practices and games including scrimmages and the devices were monitored by trained medical personnel.

Procedures

Each athlete was assessed preseason with the following baseline measures: Visual assessment (eye tracking using an "H" test) and the K-D (Figure 2). An electronic K-D was utilized via an *iPad Air™* device. The iPad was not able to monitor any events associated with the athlete's system being triggered, it was only utilized in order to administer the K-D. When the athlete's system triggered a red or yellow light, the athlete was immediately assessed (prior to the next play) for SRC risks by trained personnel using the "H" test and three of the Maddock's cognitive questions. If they failed this initial screen, then they were administered the K-D. If the athlete failed the K-D test, defined as anything above the athletes baseline K-D score, and/or demonstrated multiple SRC signs and symptoms, then the athlete was referred for additional medical evaluation by appropriate sideline personnel who used a modified Sports Concussion Assessment Tool (SCAT) for further screening. The diagnosis of concussion, or the need for further medical care, was determined by the certified athletic trainer and this decision was based on their clinical judgement. The K-D test results were recorded and stored on a password-protected, secure website maintained by the K-D company.

Statistical Analysis

Statistics reported in the results section were analyzed using SPSS version 19.0 (IBM, Chicago, IL). Simple linear regressions were performed to analyze if the number of triggered sensors and K-D scores predicted the number of concussions. Light sensor activations were compared according to team participation using independent t-tests. Pearson correlations were conducted to compare the K-D scores with the occurrence of any light color or just the threshold intensities corresponding to yellow or red. Athletic exposure (AE) was defined as one athlete participating in one practice or competition situation and used in calculation of incidence rate (IR) of SRC per 10,000 AE. Statistical significance was accepted at $p<0.05$.

RESULTS

The number of Athletic Exposures (AEs) experienced and the incidents of triggered lights per AE are presented in Tables 1-3. In the present population, the incidence rate of SRC was 20.16 in 10,000 AE. The total exposure time was tracked based on the observation of practices and games/scrimmages as researchers were present at these events in order to monitor any potential concussive events.

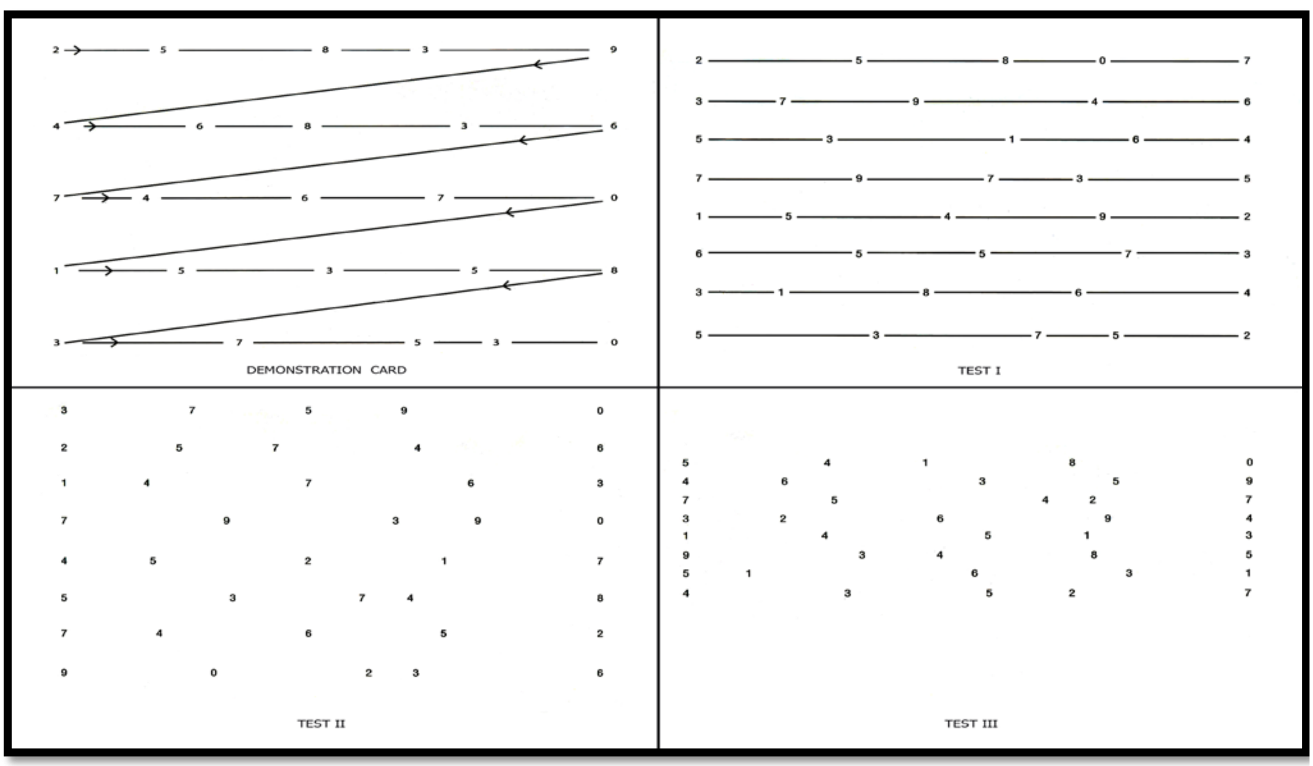

Figure 2 - K-D test Image of King-Devick cards reproduced with permission by King-Devick. Copyright 2015.

(r=-0.30, p=0.19). The same no correlation was displayed between K-D scores and yellow light (r=-0.14, p=0.53) or red light activation (r=-0.29, p=0.20). An increase in the number of concussions was not related to the increase in number of triggered lights, R^2=0.006, p=0.70. Similarly, the number of concussions were not predicted by the increase in baseline K-D scores, R^2=0.03, p=0.40. There was no difference between the groups in the number of times the lights came on, 1.77 ± 2.05 vs. 1.42 ± 0.79, p=0.57. When the intensity of threshold was analyzed, the yellow lights did not come more often in one group compared to the other, 1.08 ± 1.25 vs. 1.33 ± 0.78, p=0.55. Similarly, the red lights did not get triggered differently between groups, 0.69 ± 1.25 vs. 0.08 ± 0.29, p=0.11. It should be noted that specific threshold data for the red or yellow triggered lights is not available as this is proprietary information for the Reebok company.

Athletic Exposures	Recreation League	High School
Total	24	16
Practices	16	12
Games/ Scrimmages	8	4
Lights Triggered	Recreation League	High School
Total	22	32
Red	2	9
Yellow	20	23

Table 1. Athletic Exposures and Lights Triggered

Athletic Exposures	Recreation League	High School
Total	24	16
Athletes	13	16
Total	312	256
Number of Confirmed SRCs	0	1

Table 2. Athletic Exposures and Number of Confirmed SRCs

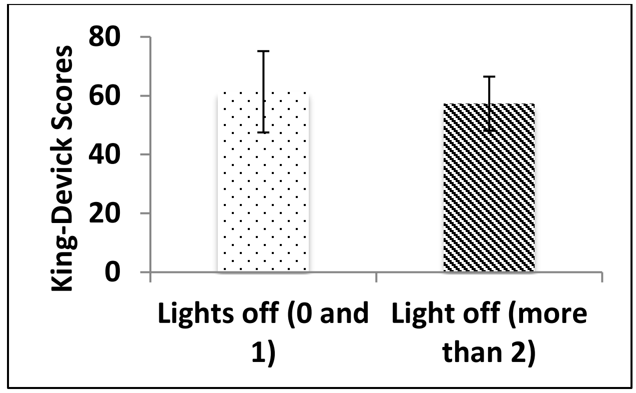

Table 3. Correlation of King-Devick scores and triggered lights.

DISCUSSION

One major challenge for clinicians and health care providers is to monitor events that may have the potential for causing an SRC. The overall (practices and games) incidence rate (IR) associated with youth football (ages 8-12 years old) is 11.76 SRCs per 10,000 AEs.[16] Other studies with high school football players have found the IR to be 4.7-6.4 SRCs per 10,000 AEs.[5,8,17] Analyzed separately, the rate of an SRC in games compared to practices has been shown to be approximately 7.39 times greater in the high school football population.[5,8] For the high school subjects in this study, there was one diagnosed SRC within a total of 208 AEs. This creates a rate of 48.07 SRCs per 10,000 AEs, which is 6-8 times higher than the previously reported levels. For the recreational league, there were no SRCs over a total of 288 AEs.

We were unable to access Reebok's threshold data; however, Reebok indicated their thresholds were determined utilizing laboratory and sports team data. The four parameters internally monitored by their device are: linear and rotational acceleration, duration of impact, and location of impact. These factors are then calculated resulting in a yellow light ("moderate") or a red light ("severe"). The device was activated 23 times during the JV/Varsity season (14 yellow, 9 red) and one player (yellow light) suffered an SRC, as diagnosed by a physician. Each of the other triggered hits was negative on our sideline screening assessment. None of the 17 lights triggered for the recreation league group (1 red) yielded a failure of the sideline screening.

In the literature, 7-8-year-old football players experience linear acceleration median forces of 16±2 g and rotational accelerations of 686±169 rad/s^2.[2,4,18] Head impact data for 9-12 year olds resulted in median linear acceleration forces of 18±2 g and rotational accelerations of 856±135 rad/s^2, with linear acceleration of 43±7 g and rotational accelerations of 2034±361 rad/s^2 comprised the 95th percentile, with only 0.3% sustaining impacts greater than 80 g. Linear acceleration of head impact data on 12 to 14 years of age has been reported as 26±18 g, while rotational accelerations were measured at 1082±846 rad/s^2.[2,19,20] The literature does not identify a specific head impact force threshold indicative of those likely to suffer a SRC. However, head impact force, typically derived from HIT™ football helmet telemetry, have published cut scores or force exposure thresholds of linear accelerations greater than 96 g and rotational accelerations forces greater than 5,500 rad/s^2 for collegiate or professional American football players, placing the athlete at higher risk of SRC.[17,19,21,22]

The findings of these studies provide specific data regarding the amount of forces sustained by these youth athletes. Based on that fact, having a device that can measure these forces is paramount in identifying those who may sustain such forces, weather high or low impacts from one or multiple events. The CHECKLIGHT™ device may be one of the devices beneficial in monitoring cumulative sub-concussive impacts. During a regular season of American football, there is an average of 240 head impacts between the ages of 9-12 years of age and 565 head impacts for high school-aged players.[19] This is important because cumulative sub-concussive impacts, which do not result in the standard concussion signs and symptoms, can alter brain function.[23] This age is a time of brain neurodevelopment maturation. Athletes younger than 12 presented with greater deficits in cognitive function, memory recall, and verbal ability than those older than 12, suggesting that athletes who suffer a concussion may appear fully recovered but do not demonstrate the standard sequela of a concussion.[24] Repetitive sub-concussive impacts may cause both short- and long-term neurological deficits, which may progress to more chronic neurodegenerative syndromes.[15] Even subjects with no concussion diagnosis and who were asymptomatic have been found to have deleterious effects from cumulative sub-concussive impacts.[25]

Reebok advertises this device for use in players 10 years and older. It is possible that in an effort to cover the average players from 10 and up, that Reebok chose a trigger threshold that was relatively low. Our observations suggest that the CHECKLIGHT™ thresholds may be set considerably lower than those average linear and rotational forces experienced by high school players, thus resulting in false positive results.

In order to evaluate the validity of the CHECKLIGHT™ devices, athletes with triggered lights were administered the K-D test on the field. The K-D demonstrates excellent intra-rater reliability (0.90-0.96) for assessments pre-and post-SRC, producing reliable scores regardless of environment (lighting, ambient noise, etc.), and is not affected by post-exercise fatigue.[16-18] As a standardized SRC screening assessment, research has validated that a 5 second increase in K-D performance indicates an athlete may have sustained forces consistent with a concussion and indicates further assessment is required.[10,11,13,14,26-28] However, the screening utility of the K-D test may be optimized when combined with other metrics, including symptom score, balance, and cognition. Since our results showed there was no relationship between the number of triggered lights and the K-D test, we could not support the use of the CHECKLIGHT device to observe the concussive activity among young players.

There was a considerable management issue with monitoring the devices. The LED lights could not be visualized adequately in direct sunlight, or under the lights of the playing field during night games. As a result, those players whose lights were triggered could not be screened at the time of the head impact, but rather, when the athlete left the field of play for the sideline. Other types of head sensor technology may allow for more optimal monitoring.

The limitations of the study include the small sample size of convenience with an age range of 13-18 year-olds. Data collectors were not blinded to participants in the study and one data collector was present for sideline assessment of trigger lights.
Based on our findings and limitations, future studies with larger sample sizes are required to correlate potential SRC with screening assessments. Considering the difficulties that we had with the practicality and monitoring, it will also be important to address the feasibility issues associated with on field devices.

CONCLUSIONS

The Reebok CHECKLIGHT™ system is an instrument designed to help sideline personnel detect forces that might predict SRC, but our data showed no significant correlation between CHECKLIGHT™ activation and concussive event. The lights' design does not allow for sideline review until after the athlete exits the field, which places limitations on its efficacy for preventing play following a concussive force. While there are other methods to determine a concussive event, the combination of the CHECKLIGHT™ system with the K-D test requires further assessment. Concussion light systems, such as the CHECKLIGHT™ system may be beneficial to individual athletes below the high school level; however, it seemed to have limited usefulness for entire teams and/or high school athletes. Due to the low force threshold of these devices causing many triggered lights, utilization may be impractical for sideline health care professionals managing athletes and, at this time, a definitive recommendation cannot be made for the use of these devices to Athletic Trainers, athletes, and their parents/guardians.

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