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A Comparison of Post-Concussion Neurocognitive Test Results of Recently Concussed High School Athletes to their Neurocognitive Baseline Test Results Prior to Returning to Play

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Dedication

My DNP project is dedicated to my husband and daughters for your constant love and encouragement throughout this journey. Your unwavering support has been strength for me to complete this journey and I am so thankful. Lastly, I dedicate this project to my friends and pediatricians Dr. Sarah Hart & Dr. Casey Lewis. Thank you for your words of confidence and encouragement along this journey. Your support of me and this project is a blessing and I am forever grateful.

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Abstract

PURPOSE: In 2017, an estimated 2.5 million U.S. high school students reported having suffered at least one concussion while participating in sports or physical activity during the previous year. The purpose of this study is to evaluate the incidence of concussion among high school athletes and compare the athletes' post-injury neurocognitive function to their baseline test results prior to returning to play.

METHODS: A retrospective records review of neurocognitive test scores of high school athletes during the June 2017 – June 2018 sport season was conducted. The records of 696 high school athletes were reviewed, including 30 post-injury test scores. Data were analyzed to determine the incidence of concussion during the sport season and evaluate differences in neurocognitive test scores between students who experienced concussion and those who did not.

RESULTS: No differences were found between gender or age of high school athletes for incidence of concussion. Thirty students experienced concussion during the 2017-2018 sport season. The sports where concussions occurred included archery (2.1%), basketball (4.4%), bowling (3.7%), cheerleading (4.1%), football (13%), golf (16.7%), soccer (3.9%), swimming (8%), tennis (2.9%), volleyball (4.5%), and cross country (10%). There was no difference found between baseline and post-injury neurocognitive scores in athletes who suffered a concussion during the sport season.

CONCLUSION: Concussion among high school athletes is a growing problem in the U.S. Risk of concussion is present in most high school sports. It is important to ensure athletes are not returning too soon following concussion. The fact that no differences were found between baseline and post-injury neurocognitive scores is encouraging. Although concussion injuries

occur, this study verifies that current treatment protocols for concussion injuries instituted by the Kentucky High School Athletic Association are effectively ensuring cognitive healing prior to returning to play as evidenced by results found in this study.

A Comparison of Post-Concussion Neurocognitive Test Results of Recently Concussed High School Athletes to their Baseline Neurocognitive Test Results Prior to Returning to Play

Introduction

Sport-related concussions among high school athletes are in the rise on the United States (Doheny, 2014; Mitka, 2010). The risk of injury due to a sports-related concussion is at an increased level during childhood and adolescence due to on-going neurological development within the brain (Pfister, Pfister, Hagel, Ghali, & Ronksley, 2016). The American Academy of Pediatrics (AAP) recommends that coaches and athletic trainers be trained in concussion recognition and should remove any athlete from play suspected of concussive symptoms immediately, only allowing them to return to play after medical clearance has been granted by a licensed physician, pediatrician, or neurologist (American Academy of Pediatrics, 2017b). The Kentucky High School Athletic Association (KHSAA) has implemented guidelines mandating athletes suspected of suffering a concussion be removed from play immediately, be evaluated by a licensed provider, and upon return, the athlete must complete a stepwise protocol with provisions for delayed return to play based upon the return of any signs or symptoms (KHSAA handbook, 2015).

An objective tool utilized to aid with concussion management is computerized neurocognitive testing. According to Meehan, d'Hemecourt, Collins, Taylor, & Comstock (2012), when used in combination with a physical assessment, computerized neurocognitive testing has proven more valuable than just performing an assessment alone. However, this is not routinely performed in Kentucky.

Data from 1997 to 2007 found that over 23,000 teenagers ages 14-19 were seen in emergency rooms across the country as a result of sustaining concussions (Mitka, 2010). Without addressing this problem, the incidence of sports-related concussion will continue to rise among this vulnerable population.

In 2010, the KHSAA developed a protocol for concussion management titled "Sports medicine policy-protocol related to concussions and concussed student-athletes for all interscholastic athletics in the commonwealth of Kentucky" (KHSAA handbook, 2015). This protocol mandates an athlete who is suspected of suffering a concussion be removed from play immediately and be evaluated by a licensed provider (KHSAA handbook, 2015). Those who are approved to medically evaluate and authorize medical clearance include a MD, APRN, DO, or LAT (licensed athletic trainer) who have specialized training in concussion management (Tackett, 2013). Upon medical clearance to return to play, step-by-step provisions are followed before returning the athlete without restriction (Tackett, 2013). These steps progress from 1) no activity; 2) light aerobic exercise; 3) sport-specific exercise; 4) non-contact training drills; 5) full-contact/competition practice; and lastly 6) return to normal game play (Tackett, 2013). At any time during the stepwise process, if signs or symptoms return for the athlete, they are to resume cognitive rest and begin the step-by-step process again when ready (KHSAA handbook, 2015).

Computerized neurocognitive testing assesses cognitive function through activities of reaction time, memory, and concentration and when used in combination with a physical assessment, has shown to be more valuable than just the physical assessment alone (Meehan, d'Hemecourt, Collins, Taylor, & Comstock, 2012). Despite the current research regarding factors that contribute to concussions acquired during contact sports, there is a paucity of data regarding the effect of administering cognitive testing at baseline and again at post-injury should a concussion occur.

Purpose

Neurocognitive testing is an objective assessment tool that, when used in conjunction with a physical assessment, can assist the health care provider in determining the time needed to ensure proper healing of the concussed adolescent brain. This testing aids the provider to identify athletes who are not functioning at their baseline level post-injury, thus delaying their return to play. Providing a longer cognitive rest may be necessary to reduce risk of permanent brain damage. The long-term goal of this study is to ensure that concussed athletes have full cognitive healing prior to returning to play, reducing the risk of subsequent concussions. Worsening concussion symptoms could result in further cognitive damage that could permanently affect the athlete's life, post high school. The purpose of this study is to evaluate the incidence of concussion, particularly subsequent concussions among high school athletes during a school year sport season and determine if changes in neurocognitive testing scores develop.

Objectives

Objective 1: Assess prevalence of concussions during the sports season from June 2017 to June 2018 and examine this prevalence by demographic variables [age, gender, and sport].

Objective 2: Assess for differences between athletes who had experienced concussion and athletes who had not experienced concussion to determine if any differences in baseline neurocognitive exam results existed.

Objective 3: Assess for differences in post-concussion neurocognitive exam results among athletes who had experienced one concussion and those who experienced two or more concussions.

This study is important for reducing the risk of further damage to the concussed brain of a high school athlete.

Rationale

Concussion is defined by both the Centers for Disease Control and Prevention (CDC) and the American Academy of Pediatrics (AAP) as the disruption of normal brain function as the result of an injury to the brain (The American Academy of Pediatrics, 2018; Centers for Disease Control and Prevention, 2016). Children are especially vulnerable to the effects of a concussion due to the progression of neurological development within the brain that continues into adulthood (Pfister, Pfister, Hagel, Ghali, & Ronksley, 2016). In 2012, more than 160,000 young athletes presented to emergency departments across the United States for sports-related concussion; 75% were 12-19 years of age (National Athletic Trainers Association, 2014). There were twice as many children hospitalized with sports-related concussion than any other sports injury (National Athletic Trainers Association, 2014). It is important to address this on-going health problem. High school athletes who have sustained a concussion are at risk for subsequent concussions. This increases the risk of worsening symptoms and the possibility of increasingly devastating outcomes (Centers for Disease Control and Prevention, 2016).

Computerized neurocognitive testing assesses cognitive function through activities of reaction time, memory, and concentration and when used in combination with a physical assessment, have proven more valuable than just the assessment alone (Meehan, d'Hemecourt, Collins, Taylor, & Comstock, 2012). Despite current research findings supporting the use of neurocognitive testing to assess cognitive function, there is a paucity of data regarding the effect of baseline testing and post-injury neurocognitive testing should a concussion occur. When used in this manner, these results could be used for comparison to provide objective data and assist the provider in determining an appropriate treatment plan for the athlete.

Neurocognitive testing has been used in athletes, however there is a lack of evidence evaluating the use of neurocognitive testing in a baseline & post-injury comparison format. Instead, individual post-injury results are compared to normative values based on age, sex, and education level of the athlete (Covassin, Elbin, Stiller-Ostrowski, & Kontos, 2009). It is reported that some athletes will deny concussive symptoms when assessed by a provider in order to obtain the medical clearance they desire, yet may not be cognitively ready to return to play (Lovell & Solomon, 2013). Broglio, Macciocchi, & Ferrara (2007) found 35% of young adult athletes (m=19.8 years, ± 1.25) studied were asymptomatic yet had not returned to their baseline cognitive function. These are two examples that demonstrate the importance of neurocognitive testing, so the athlete does not return to play too soon.

In recent years, a local pediatric practice in Bullitt County recognized an increased number of concussed athletes in the county. They approached the Bullitt County Board of Education and recommended neurocognitive testing be utilized as a tool to better understand the long-term impact of concussion on the adolescent athlete. At the initiation, these pediatricians funded the neurocognitive testing for the county high-school athletes. In 2017, the Bullitt County Board of Education mandated neurocognitive testing for all high-school athletes for baseline scores so better determination of neurocognitive readiness could be assessed prior to returning the athlete to play.

For the purposes of this study, the Bullitt County school district utilizes the ImPACT test, a computerized version of cognitive testing which assesses neurocognitive function and for the presence of concussion symptoms. ImPACT was developed in the 1990s and is a commonly used neurocognitive testing program today (Asken, Clugston, Snyder, & Bauer, 2017). ImPACT has a 90% sensitivity rating and a 70% specificity rating when evaluating cognitive function (Asken, Clugston, Snyder, & Bauer, 2017). To determine the level of neurocognitive function, ImPACT utilizes various methods to assess reaction time, recollection, attention span, and problem solving (Covassin, Elbin, Stiller-Ostrowski, & Kontos, 2009). ImPACT results five scores: verbal memory composite, visual memory composite, visual motor speed composite, reaction time composite, and impulse control composite (ImPACT, 2018). The impulse control composite score is used for measuring errors on the test and determining test validity (ImPACT, 2018). Baseline testing is performed early in the season, prior to competitive play. If the athlete suffers a concussion during the season, a post-injury test is taken after medical clearance is granted. Those results are then compared to the athlete's baseline to determine if the athlete's neurocognitive function has returned to their baseline level. In addition to a physical assessment, utilizing ImPACT provides objective information that assists the healthcare team to make a more informed decision to return the athlete to play or learning.

Methods

A retrospective records review of neurocognitive test scores was conducted to assess the occurrence of concussive injuries in high school athletics and determine if differences existed in baseline neurocognitive exam results between athletes who experience a concussion and those who do not. Differences in post-concussion neurocognitive exam results between athletes who experience a second concussion and those who did not were also explored. No athlete will be excluded from the study. Instead, data collection will consist of two elements: how many athletes suffered a concussion during the season; and of those athletes, had they any differences in their level of their baseline cognitive function when compared using their post-injury neurocognitive results. These are the athletes the study is intended to benefit and protect from an un-intended risk of subsequent concussion and further cognitive damage.

Setting

This evaluation project was completed via records from the Board of Education for the Bullitt County Public School system. The mission of the Bullitt County Board of Education is to provide the safest environment possible for athletes, as athletics is a vital part of the educational experience (Bullitt County Public Schools, 2017). The Bullitt County Public School system serves over 14,000 students from preschool to 12th grade (Kentucky Department of Education, 2019).

Sample

957 records were reviewed for inclusion and exclusion criteria. Inclusion criteria for this study consisted of all high-school athletes (grades 9-12) within the district. Exclusion criteria included students identifying as 7th or 8th grade level on demographic entry of the ImPACT baseline assessment. Students were not excluded based on gender or sport. The Bullitt County Public School system is comprised of three high schools, which is where computerized neurocognitive testing for all athletes took place under the administration of each school's athletic trainer. Post-injury neurocognitive testing was only administered if the athlete suffered a concussion during the sports season.

Procedures

A waiver of documentation of informed consent and an IRB exemption certificate was obtained prior to data collection. To protect the identity of the school and the student athletes, data was collected by the Administrative Assistant for Student Learning at the Bullitt County Board of Education in a de-identified format. This retrospective data included statistics from all high schools in the county for the sport season June 2017 to June 2018.

Data Analysis

Descriptive analysis of the data involved using frequencies and percentages to describe nominal and ordinal demographic variables. Frequency and percentages were also used to describe the proportion of athletes who experienced a concussion during the sports season. Chi-square analysis was used to examine demographic variable differences between those who experienced concussive symptoms and athletes who did not experience a concussion by gender, sport, and age. Independent sample t-test was used to examine differences in baseline neurocognitive test scores between those who experienced a concussion and those who did not experience a concussion. Among those who experienced a concussion, a paired samples t-test was used to examine differences in baseline neurocognitive test scores and post-concussion neurocognitive test scores.

Results

696 athletic records were reviewed and enrolled into the study. Demographics obtained as part of the data included gender, age, education level, and sport. Ages ranged from 12 to 19 years old with an average age of 15.4 years old for females and 15.3 for males. Because of this range, educational level was used to identify high-school athletes and therefore used for this

study. Of the study's high-school athletes, 49.4% were female and 50.6% were male. Educational level included 25.1% of freshmen, 30% of sophomores, 27.2% juniors, and 17.7% seniors. Throughout the 2017 – 2018 sports season, only 30 post-injury scores were obtained, indicating 30 concussions suffered, or 4.3% of the total athletes. Dependent on the number of athletes playing each sport, the sports resulting in concussive injuries included archery (2.1%), basketball (4.4%), bowling (3.7%), cheerleading (4.1%), football (13%), golf (16.7%), soccer (3.9%), swimming (8%), tennis (2.9%), volleyball (4.5%), and cross country (10%). No statistical differences were found between gender and the incidence of concussion (p-value 0.218; sign. value 0.64) or educational level of high school athletes and the incidence of concussion (p-value 0.766; sign. value 0.857).

When interpreting differences between baseline and post-injury neurocognitive scores for the concussed athletes, ImPACT test scores are broken down into five composite scores: verbal memory composite, visual memory composite, visual motor speed composite, reaction time composite, and impulse control composite (ImPACT, 2018). The impulse control composite score is used for measuring errors on the test and determining test validity; therefore, this composite score was not used for the purposes of this study (ImPACT, 2018). Of the concussed athletes, 43.3% were female and 56.7% were male. Educational level of the concussed athletes included 26.7% freshmen, 33.3% sophomores, and 20% were both juniors and seniors. No statistical differences were found among genders between baseline and post-injury neurocognitive scores (p-value 0.513) or among different educational levels of high school athletes (p-value 0.569). After conducting data analysis using a paired samples T-test, no statistical difference was observed for the concussed athletes when comparing the four composite scores of the baseline and post-injury neurocognitive tests (visual memory: p-value 0.657; verbal memory: p-value = 0.144; visual motor: p-value = 0.605; and reaction time: p-value = 0.110).

Of the concussed athletes, only 2 were found to have suffered two concussions during the sports season, both were male, one identified as a junior and the other a senior. Due to this low sample size, the analysis of post-concussion neurocognitive exam results for those athletes who experienced two or more concussions did not occur.

Limitations

Limitations were identified during the study. Since this was a retrospective review study, these limitations were incapable to prepare for, but will be helpful to address for future study.

Several limitations were identified related to the ImPACT software. One such limitation included demographic information entered by the student athletes at the beginning of the ImPACT test. Several student athletes identified themselves as 7^{th} and 8^{th} graders. Perhaps the directions were misunderstood by the athlete when entering the last grade level completed or there were several junior high athletes in attendance. Depending on experience, junior high athletes are permitted to play high-school level sports, but for the purposes of this study, those identifying as 7^{th} and 8^{th} grade athletes were excluded from the study. Another computer software limitation was the inability for students to enter each sport in which the athlete participates. The ImPACT test gives the student the opportunity to enter only one sport. The option to enter multiple sports played by the athlete would help improve data collected and provide more accurate counts for each sport. It is well known that often student athletes play more than one sport throughout the year.

Another limitation is that only one school district was included in the study, which yielded a small sample size. While that is good for reported concussive injuries, it could relay a false sense of decreased injury. Thus, collecting and analyzing data from multiple districts would provide a greater indicator of potential risk to the athletic adolescent population.

Recommendations for Future Study

A few recommendations for future study were identified while conducting this study. Increased sample size would be beneficial to determine accuracy of the study. This can be accomplished by analyzing data from multiple school districts or adding middle school students to future study. Another recommendation includes conducting a longitudinal study to determine how concussion impacted the high-school athlete over their high-school career while assessing for changes in neurocognitive function.

Conclusion

The purpose of this study is to ensure proper cognitive healing of the high-school athlete prior to returning to play and risk suffering a subsequent concussion, resulting in further, and potentially life-long, cognitive damage. As the study shows, concussions are a physical threat to athletic adolescents and found not to impact just those athletes involved in high impact sports. It was also determined that length of time playing a certain sport does not lessen the risk of concussion to the athlete. With no differences observed between baseline and post-injury scores, it is reassuring that current treatment guidelines for concussion injury mandated by KHSAA and followed by school personnel are resulting in successful cognitive healing after a concussion. Although encouraging, neurocognitive testing is still important and necessary to ensure each athlete has returned to baseline prior to returning to play. The risk of permanent brain damage is too great to miss one athlete and jeopardize their future health.

References

American Academy of Pediatrics. (2018). Concussions. Retrieved from https://www.healthychildren.org/English/health-issues/injuries-emergencies/sports-injuries/Pages/Concussions.aspx.

American academy of pediatrics (2017b). Concussion management: Return to play. Retrieved from https://www.aap.org/en-us/advocacy-and-policy/state-advocacy/Documents/Concussion.pdf.

Asken, B., Clugston, J., Snyder, A., & Bauer, R. (2017). Baseline neurocognitive performance and clearance for athletes to return to contact. *Journal of Athletic Training, 52(1)*, 51-57.

Broglio, S., Macciocchi, S., & Ferrara, M. (2007). Neurocognitive performance of concussed athletes when symptom free. *Journal of Athletic Training*, *42*(4), 504-508.

Bullitt County Public Schools. (2017). Athletic Handbook: Student-athletes, parents/guardians, coaches, and athletic directors guide. Retrieved from http://www.bullittschools.org/userfiles/4/my%20files/athletic%20handbook.pdf?id=569735.

Centers for Disease Control and Prevention. (2016). TBI: traumatic brain injury & concussion. Retrieved from https://www.cdc.gov/traumaticbraininjury/index.html.

Covassin, T., Elbin, R. J., III, Stiller-Ostrowski, J. L., & Kontos, A. P. (2009). Immediate post-concussion assessment and cognitive testing (ImPACT) practices of sports medicine professionals. *Journal of Athletic Training (National Athletic Trainers' Association), 44(6)*, 639-644. doi:10.4085/1062-6050-44.6.639.

DePadilla, L., Miller, G., Jones, S., Peterson, A., & Breiding, M. (2018). Self-Reported Concussions from Playing a Sport or Being Physically Active Among High School Students - United States, 2017. Centers for Disease Control: Morbidity and Mortality Weekly Report. *Weekly, 67(24),* 682-685.

Doheny, K. (2014). Concession rates double among high school athletes. Retrieved from http://www.webmd.com/brain/news/20140515/concussion-rates-double-among-high-school-athletes-report#1.

ImPACT: Administration and interpretation manual (2018). Retrieved from www.concussionmanagement.com.

Lovell, M. R., & Solomon, G. S. (2013). Neurocognitive test performance and symptom reporting in cheerleaders with concussions. *The Journal of Pediatrics, 163(4),* 1192-1195.

Kentucky Department of Education (2019). School Report Card: 2017-2018 School Year: Bullitt County, Kentucky. Retrieved from https://www.kyschoolreportcard.com/organization/5523/school_overview/students/end_of_year_enrollment.

KHSAA handbook (2015). Sports medicine policy-protocol related to concussions and concussed student-athletes for all interscholastic athletics in the commonwealth of Kentucky. Policies and procedures, p. 83. Retrieved from http://khsaa.org/Publications/Handbook/20152016/20152016fullhandbook.pdf.

Meehan, W. P., d' Hemecourt, P., Collins, C. L., Taylor, A. M., & Comstock, R. D. (2012). Computerized Neurocognitive Testing for the Management of Sport-Related Concussions. *Pediatrics, 129(1),* 38–44. http://doi.org/10.1542/peds.2011-1972.

Mitka, M. (2010). Reports of concussions from youth sports rise along with awareness of the problem. *JAMA, 304(16)*, 1775-1776. Retrieved from http://jamanetwork.com.ezproxy.uky.edu/journals/jama/fullarticle/186790.

National Athletic Trainers Association. (2014). Youth sports safety statistics: traumatic brain injuries and concussions. Retrieved from http://www.youthsportssafetyalliance.org/sites/default/files/Statistics.pdf.

Pfister, T., Pfister, K., Hagel, B., Ghali, W., & Ronksley, P. (2016). The incidence of concussion in youth sports: A systematic review and meta-analysis. *British Journal of Sports Medicine, 50(5)*, p. 292-297.

Tackett, J. (2013). KHSAA 2013-2014 Concussion requirements and protocol. Retrieved from https://www.khsaa.org/sportsmedicine/concussion/player.html.

Table 1. *Number of Baseline Neurocognitive Tests by Gender*

	Number	Percentage
Female	344	49.4%
Male	352	50.6%
Total	696	100.0%

Table 2. *Number of Baseline Neurocognitive Tests by Educational Level*

	Number	Percentage
Freshman	175	25.1%
Sophomore	209	30.0%
Junior	189	27.2%
Senior	123	17.7%
Total	696	100.0%

Table 3. *Number of Post-Injury Neurocognitive Tests by Gender*

	Number of athletes	Number of concussed athletes	% total
Female	344	13	
Male	352	17	
Total	696	30	4.3%

Table 4. *Number of Post-Injury Neurocognitive Tests by Educational Level*

	Number of athletes	Number of concussed athletes	% total
Freshman	175	8	
Sophomore	209	10	
Junior	189	6	
Senior	123	6	
Total	696	30	4.3%

Table 5. *Number of Post-Injury Neurocognitive Tests by Sport*

	Concussed athletes	Total athletes	% per sport
Archery	1	47	2.1%
Basketball	5	114	4.4%
Bowling	1	27	3.7%
Cheerleading	2	49	4.1%
Football	9	69	13.0%
Golf	2	12	16.7%
Soccer	3	77	3.9%
Swimming	2	25	8.0%
Tennis	1	35	2.9%
Volleyball	1	22	4.5%
X-Country	3	30	10.0%

Table 6. *Post-Injury Neurocognitive Tests by Gender*

	Number	Percentage
Female	13	43.3%
Male	17	56.7%
Total	30	100.0%

Table 7. *Post-Injury Neurocognitive Tests by Educational Level*

	Number	Percentage
Freshman	8	26.7%
Sophomore	10	33.3%
Junior	6	20.0%
Senior	6	20.0%
Total	30	100.0%

Figure 1. *Number of athletes per Sport*

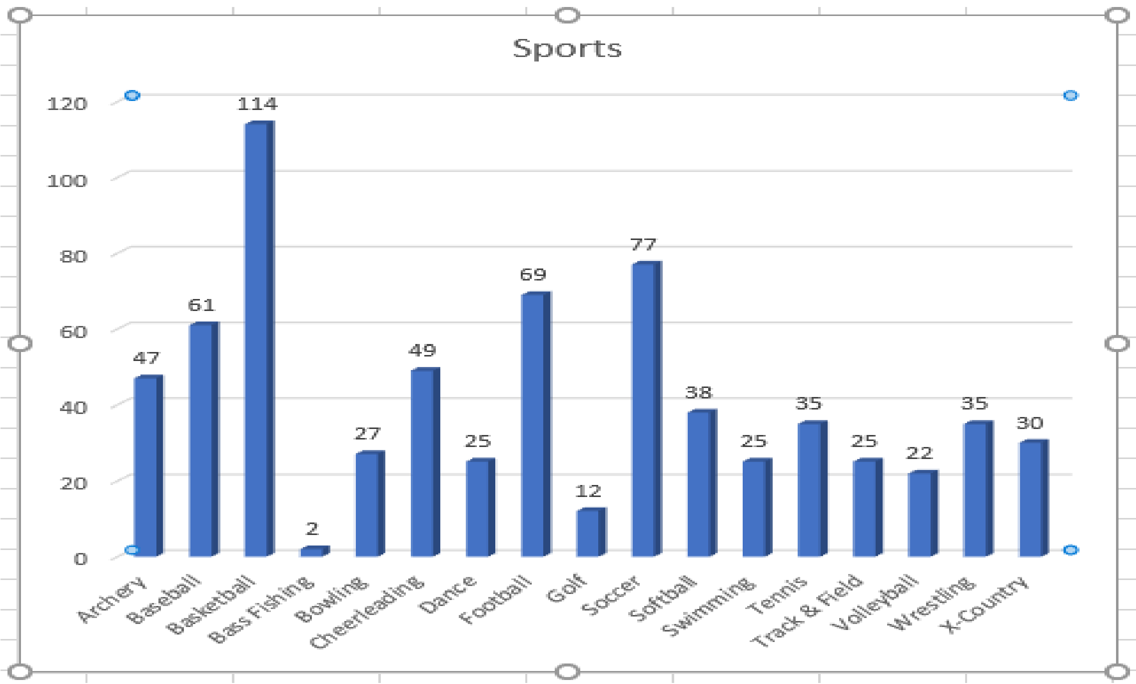

Figure 2. *Number of Post-Injury Neurocognitive Tests by Sport*