

Hawai'i Concussion Awareness & Management Program (HCAMP): Impact

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Abstract

Concussion, also referred to as mild traumatic brain injury (mTBI), is caused by a direct or indirect blow to the head or body causing the brain to move rapidly within the skull, resulting in immediate, but temporary, brain dysfunction. Developing awareness and promoting concussion education can reduce the number of short and long-term injuries associated with sports and non-sports related concussions in Hawai'i. The purpose of this study was two-fold: (1) to describe the number of concussions in 67 Hawai'i high school athletic programs using the ImPACT database; and (2) to describe which contact and collision sports had the highest rate of concussions in 67 Hawai'i high schools. This was a retrospective study that described the number of concussions generated across school years 2010-2016, concussion data across 14 contact sports, and athletic exposure rating for the 14 contact sports. Data were analyzed and aggregated from a data-bank associated with the Hawai'i Concussion Awareness and Management program. Findings suggest that for Hawai'i high school student athletes' concussions increased from 2010-2013 with a gradual decrease from 2014-2016, specific sports had higher number of concussions (eg, football), and when evaluating concussion rate per 1000 exposures, girls' judo was the highest. These findings stress the need for continued data collection, monitoring, education/awareness and research that will reduce the number of concussions among student athletes.

Abbreviations

AE - Athlete Exposure
AHCTP - Athletic Health Care Trainers Program
AT - Certified Athletic Trainer
CMP - Concussion Management Program
HCAMP - Hawai'i Concussion Awareness and Management Program
HIDOE - Hawai'i Department of Education
ImPACT - Immediate Post-Concussion Assessment and Cognitive Test
KRS - Department of Kinesiology and Rehabilitation Science, College of Education, University of Hawai'i at Manoa
mTBI - mild traumatic brain injury
SY - School Year

Introduction

Concussion, also referred to as mild traumatic brain injury (mTBI), is caused by a direct or indirect blow to the head causing the brain to move rapidly within the skull, resulting in immediate, but temporary, brain dysfunction. This damage to the brain can result in a variety of physical, neurocognitive, and behavioral symptoms such as alteration of consciousness, headache, blurry or double vision, irritability, slowed reaction times, and insomnia.¹ Repeated concussions without proper intervention tend to result in further damage and long-term brain dysfunction. For example, second impact syndrome, can lead to increased cerebral swelling and intracranial pressure, which may be fatal.² In the United States, it is estimated that there are 3.8 million sports-related concussions annually.³ Despite the potential threat that concussions pose, many go unreported.

Studies have shown that student-athletes have a negative bias and attitude toward reporting injuries out of fear of being taken out of play.⁴ Other studies suggest that student-athletes are unaware of signs and symptoms indicative of a concussion and therefore do not report.⁵

Background

Hawai'i has one public school system for the entire state with at least one Certified Athletic Trainer (AT) assigned to each public high school. The Hawai'i Department of Education (HIDOE) has been tracking injuries for student athletes since the inception of the athletic health care trainer program in 1993. Since the 2007-2008 school year (SY 2008), HIDOE started monitoring and tracking concussions from high school student athletes statewide. Tracking included concussion management protocols and assessment tools like Grading Systems,^{6,7} Standard Assessment of Concussion,⁸ and Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT).⁹

In SY 2010, after the publications of the 2004 National Athletic Trainers Association (NATA) position statement, 2004 and 2008 Concussion Consensus Statements, and with the myriad of concussion protocols and assessment tools utilized by Hawai'i high schools, a standardized concussion management program (CMP) was established through the collaboration of the Department of Health's Neurotrauma Supports, University of Hawai'i, College of Education, Kinesiology & Rehabilitation Science Department and HIDOE Athletic Health Care Trainers Program. This collaboration resulted in the Hawai'i Concussion Awareness & Management Program (HCAMP) which was established in SY 2011 with the mission of providing Hawai'i high school athletic programs, physically active community and medical community with evidence-based research education, support and resources to manage concussions, and to standardize concussion management in Hawai'i high schools. The goals for HCAMP include: (1) utilize ImPACT for baseline and post injury neurocognitive testing, (2) provide a neuropsychologist to review all post injury tests, (3) coordinate the management of the CMP, and (4) provide concussion education and awareness to athletic trainers, coaches, health care professionals, parents, school personnel and students.

In order for HCAMP to fulfill its goal of coordinating a CMP, the ImPACT database for tracking the number of baseline and post injury 1 tests administered by each high school was implemented. With ImPACT being used as one part of the CMP, HCAMP utilized the Balance Error Score System (BESS) to assess postural stability, the Sideline Assessment of

Concussion (SAC) for field/court mental status assessments, and a stepwise gradual return to play plan. A standardized protocol was established for baseline, follow up assessments and the stepwise return to play. Annual concussion monitoring is important to quantify the number of student athletes with a concussion each year and to identify sports with a highest rate of concussions. When sports with the highest concussion rate are identified, administrators, officials, and other stakeholders can use the information to support competition rule changes and practice guidelines directed at lowering the rate of concussions. The purpose of this study was: (1) To describe the number of concussions in 67 Hawai'i high school athletic programs using the ImPACT database; and (2) to describe which contact and collision sports had the highest rate of concussions in 67 Hawai'i high schools.

Methods

To conduct this study, approval from the University of Hawai'i at Manoa Institutional Review Board and the HIDEOE Data Governance and Analysis branch was obtained. Signed assent and consent forms were distributed and obtained prior to the student athletes starting their season.

This retrospective study described the number of concussions by sport and concussion injury rate per 1000 athlete exposures for school years from 2010 to 2016 in 14 contact/collision sports. ImPACT (ImPACT Applications, Inc., San Diego, CA., Version 2.0 to 3.2) is a computerized testing battery tool that provides healthcare professionals with objective measures of neuro-cognitive function that are useful in assessing and managing concussions in individuals 12-59 years.¹⁰⁻¹² ImPACT baseline assessments were administered prior to the start of each of the 14 collision and contact sports (boys baseball, girls softball, boys basketball, girls basketball, boys judo, girls judo, boys soccer, girls soccer, boys volleyball, girls volleyball, boys wrestling, girls wrestling, co-ed cheerleading, and co-ed football) for ninth and eleventh grade student athletes. A proprietary formula using data from the battery of tests produces four composite scores that measure visual design memory, word memory, processing speed and reaction time. When an individual is diagnosed with a concussion, the composite scores are compared to preseason baseline or norms established by ImPACT.

When a student athlete was suspected of a concussion, the athletic trainer would conduct a series of tests on the sideline and in the clinic/training room. When the diagnosis of a concussion was made by the athletic trainer, the concussed student athlete was referred to a licensed health care provider for follow up care. Within a recommended timeframe of 0-72 hours an ImPACT post-test 1 was administered to the concussed student athlete by an athletic trainer and the results were interpreted by a neuropsychologist. If applicable, further testing and treatments were administered throughout recovery. For the purpose of this study, HCAMP identified the number of concussed student athletes when the individual was administered an ImPACT post-test 1.

To measure concussion injury rate, athlete exposure (AE) was calculated by multiplying the number of players participating by the estimated number of practice days and number of games played for each sport.¹³ One AE is equal to one student athlete participating in a practice or game. Player participation data were obtained from HIDEOE player eligibility database. Number of practices and games was estimated using the Hawai'i High School Athletic Association start date calendar and high school leagues games schedules. Concussion injury rate is defined as the total concussions per sport divided by total athlete exposure for the season multiplied by 1000.¹⁴ Concussion totals were obtained using the ImPACT database with an administered post-test 1 counted as one concussion. Moreover, the percent difference in concussion injury rate across selected years was also reported. This percent difference in concussion injury provided insight into the how much the injury rate varied between and across years.

Results

The number of concussions per year in 14 contact and collision sports were reported for 67 Hawai'i high schools in Figure 1. During 2010-2011 there were 424 concussions and the number of concussions increased in 2011-2012 through 2013-2014 to reach a total of 1262. A decrease in number of concussions was noted during 2014-2015 (947) and 2015-2016 (911). The average number of concussions across all 14 contact and collision sports during the 2010-2016 is reported in Figure 2. Football continues to be the sport with the highest number of concussions, followed by girls' soccer, boys' wrestling, girls' basketball, and cheerleading. Further analysis of contact and collision sports across sex was also reported (Table 1). A closer examination of concussion data by sex found increases in number of concussions across both sex and sports in all 14 sports during the 2010-2011, 2011-2012 and 2012-2013 school years. A decreasing trend in number of concussions is noted starting in 2013-2014. Athlete exposure (AE) per sport can be found in Table 2. Data show a range of AE from 20,430 (Girls Judo) to 243,052 (Football). These exposure rates provide an indication to the number of AEs as experienced from student athletes across selected sports. The concussion injury rate per 1,000 AE across the same 14 sports from 2010-2016 was analyzed in Figure 3. The purpose of reporting this data was to normalize the number of concussions by sport and to identify the sports with the greatest rate of sustaining a concussion. Specifically, highlighted was girls' judo (2.18/1000AE) as having the highest concussion rate followed by football (1.67/1000AE). Perhaps even more interesting was the decrease in concussion rate reported between 2013-2014 in all sports, except for volleyball (Table 3). More specifically, Table 4 demonstrated the percent difference in concussion injury rate in which a decrease was noted during the 2013-2016 in 13 out of 14 reported sports.

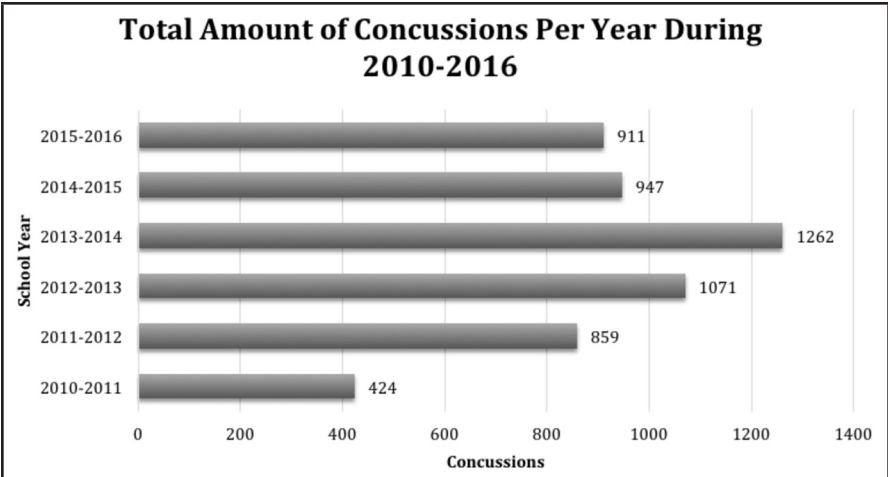


Figure 1. Total Number of Concussions Reported by 67 Hawai'i High School Athletic Programs from SY 2010 to 2016.

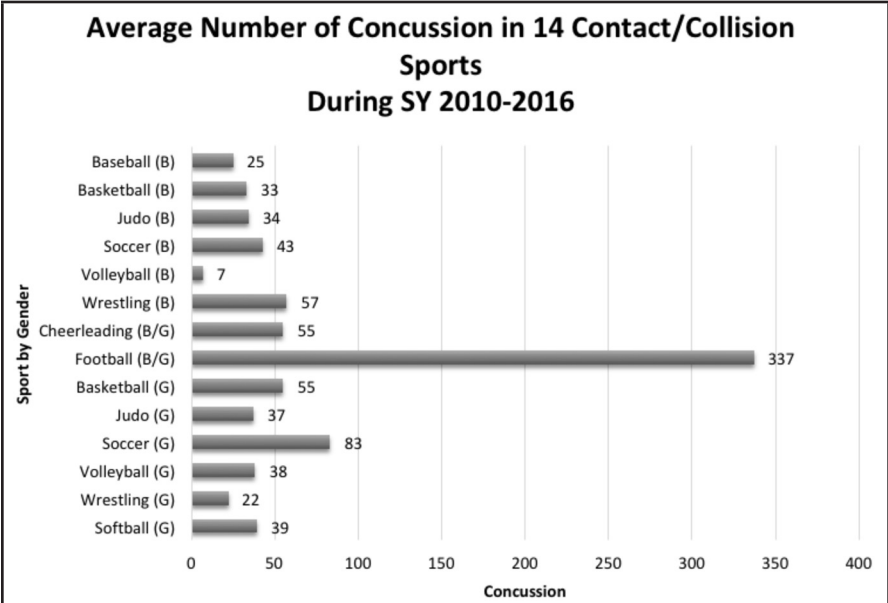
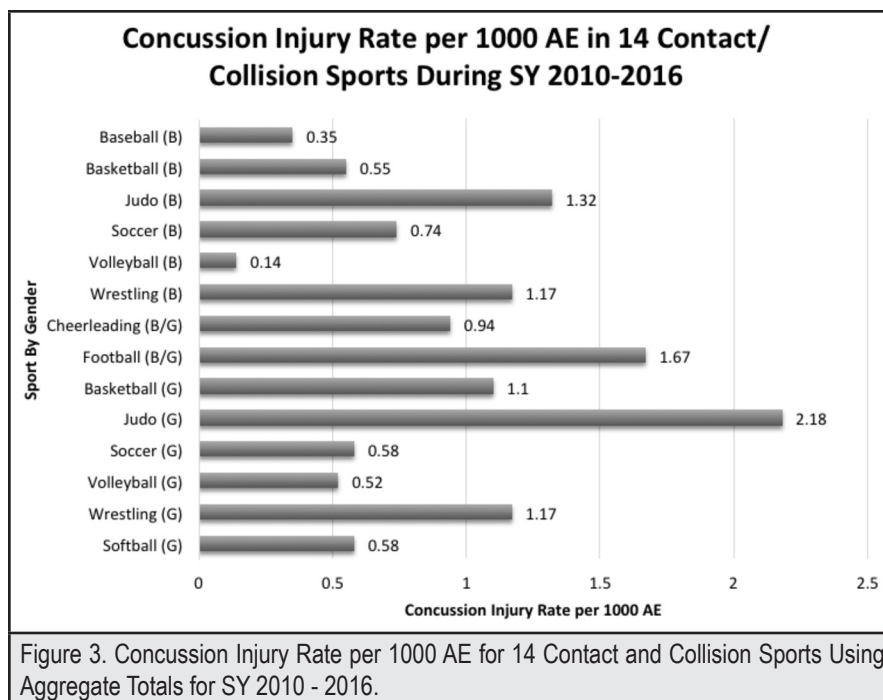


Figure 2. Average Number of Concussions for Hawai'i High School Students per Sport by Sex from SY 2010 – 2016.

Table 1. Number of Concussions per Year by Sport among Hawai'i High School Students During SY 2010 – 2016						
	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
Baseball (B)	4	10	38	37	31	32
Basketball (B)	9	10	39	72	44	26
Judo (B)	9	21	38	48	49	40
Soccer (B)	19	24	50	59	53	55
Volleyball (B)	1	1	8	6	11	13
Wrestling (B)	33	33	78	79	56	65
Cheerleading (B/G)	27	45	66	86	53	50
Football (B/G)	198	282	441	436	357	309
Basketball (G)	22	24	58	100	54	70
Judo (G)	17	28	40	57	39	40
Soccer (G)	50	42	106	130	78	89
Volleyball (G)	16	14	44	56	51	45
Wrestling (G)	9	11	23	33	17	36
Softball (G)	14	17	42	63	54	41

Table 2. Athlete Exposure* by Year and Sport							
	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	Average/
Sport							
Baseball (B)	**	82745	87750	89440	84435	85995	86073
Basketball (B)	72345	73385	73255	75725	71435	69810	72659
Judo (B)	35580	33000	34020	26880	31320	29820	31770
Soccer (B)	67080	64545	66820	69940	69030	81055	69745
Volleyball (B)	42965	51610	50830	53170	61165	64285	54004
Wrestling (B)	65910	62465	59540	61360	58565	52260	60017
Cheerleading (B/G)	70920	80730	84780	73260	58860	51390	69990
Football (B/G)	247590	248150	245140	248150	235480	233800	243052
Basketball (G)	62855	60710	60385	62140	55315	59670	60179
Judo (G)	21300	20580	19980	19080	19500	22140	20430
Soccer (G)	87880	87165	91455	96590	86775	84175	89007
Volleyball (G)	85085	82355	89180	91780	81835	86320	86093
Wrestling (G)	26325	27170	25090	24765	26065	29250	26444
Softball (G)	80275	79625	83330	83330	74165	77480	79701
Average/Year	74316	75303	76540	76829	72425	73389	

*Athlete Exposure was calculated by player participation number multiplied by the estimated number of practice days and number of games played.¹³ Player participation data was obtained from HDOE player eligibility database. Number of practices and games were estimated using practice start dates, estimated practice days, game schedules, and playoff schedules for each sport. One AE is equal to one athlete participating in a practice or game. ** Total Participation not reported.



B=boys, G=girls, B/G=co-ed. Football (B/G) recorded 13 girl post test 1 during this period. Cheerleading (B/G) recorded 11 boys post test 1 during this period.

	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
Baseball (B)	*	0.18	0.43	0.41	0.37	0.37
Basketball (B)	0.12	0.42	0.53	0.95	0.62	0.37
Judo (B)	0.25	0.82	1.12	1.79	1.56	1.34
Soccer (B)	0.28	0.64	0.75	0.84	0.77	0.68
Volleyball (B)	0.02	0.17	0.16	0.11	0.62	0.20
Wrestling (B)	0.50	0.96	1.312	1.29	0.96	1.24
Cheerleading (B/G)	0.38	0.58	0.78	1.17	0.90	0.97
Football (B/G)	0.80	1.59	1.80	1.76	1.52	1.32
Basketball (G)	0.35	0.51	0.96	1.61	0.98	1.17
Judo (G)	0.80	2.04	2.00	2.99	2.00	1.81
Soccer (G)	0.57	0.93	1.16	1.35	0.90	1.06
Volleyball (G)	0.19	0.29	0.49	0.61	0.18	0.52
Wrestling (G)	0.34	0.99	0.92	1.33	0.65	1.23
Softball (G)	0.17	0.38	0.50	0.76	0.73	0.53

Concussion injury rate is defined as the total concussions per sport divided by total athlete exposure for the season multiplied by 1000. *Total number of participants not reported.

Table 4. Percent Difference in Concussion Injury Rate During SY 2013-2016.					
	Peak Year 2013-2014	2014-2015	Percent Change from 2013-2014	2015-2016	Percent Change from 2013-2014
Baseball (B)	0.41	0.37	-11%	0.37	-10%
Basketball (B)	0.95	0.62	-35%	0.37	-61%
Judo (B)	1.79	1.56	-12%	1.34	-25%
Soccer (B)	0.84	0.77	-9%	0.68	-20%
Volleyball (B)	0.11	0.62	452%	0.20	79%
Wrestling (B)	1.29	0.96	-26%	1.24	-3%
Cheerleading (B/G)	1.17	0.90	-23%	0.97	-17%
Football (B/G)	1.76	1.52	-14%	1.32	-25%
Basketball (G)	1.61	0.98	-39%	1.17	-27%
Judo (G)	2.99	2.00	-33%	1.81	-40%
Soccer (G)	1.35	0.90	-33%	1.06	-21%
Volleyball (G)	0.61	0.18	-71%	0.52	-15%
Wrestling (G)	1.33	0.65	-51%	1.23	-8%
Softball (G)	0.76	0.73	-4%	0.53	-30%
Average Concussion rate/year	1.21	0.91	-25%	0.92	-24%
Average Number of Concussion/year	1262	947	-25%	911	-28%

Discussion

HCAMP data suggest that over the span of six school years, the number of concussed student-athletes rose across all sports. A closer examination of data showed a dramatic increase in concussions during SY 2012, SY 2013 and SY 2014. Part of this increase may stem from improved reporting and increased awareness of the severity of concussion and its potential long-term negative effects. During this time period, the State of Hawai'i passed Act 197, which required annual concussion training for coaches, administrators, faculty, staff, sports officials, AT, parents, and athletes. This law provided the catalyst for long term concussion awareness, education, and training. Act 197 also required all Hawai'i high schools to implement a mandatory removal from participation if a concussion is suspected, and medical clearance from a licensed health care provider prior to return to participation. In 2016, Act 197 was amended to Act 262. The amendment included support for neurocognitive testing in high school athletics and also implemented concussion education and awareness programs for youth athletics.

Also of note, since 2010, HCAMP has provided concussion education and awareness training to high school coaches, youth sports groups, and community organizations. Post-attendance surveys indicated that attendees had a better understanding of concussions and could identify signs and symptoms of a concussion, knew what to do, and who to contact if someone sustained a concussion. Other methods of providing concussion education and awareness included concussion awareness videos, PowerPoint presentations, and literature specifically designed to address the needs of and management protocol for concussed high school student athletes in Hawai'i. These tools were used during faculty meetings as well as parent and team pre-season

meetings. Therefore, the advent of Act 197 and HCAMP's efforts to raise awareness through education programs, may have led to an increase in recognizing concussions.

As noted, concussions across all 14 sports increased since 2010, gradually leveling off in SY 2014. Concussion numbers decreased by 25% in SY 2015 and 38% in SY 2016. A potential explanation for this may be a change in concussion reporting behavior in student athletes. It has been reported that student athletes do not want to report concussions because of fear of losing participation time, receiving pressure to not report from parents, coaches, and fans, and not wanting to disappoint teammates.^{4,15,16} The student athlete's education and awareness curriculum is complex because there needs to be less emphasis placed on policy and more emphasis on the potential consequences of playing with a concussion and encouraging a supportive environment for players and teammates to report suspected concussions.¹⁷ HCAMP continues to educate coaches and parents on creating a safe reporting environment, asking student athletes to take care of themselves, to be aware of the ramifications of not reporting their concussion, and finally asking teammates to take care of each other and to report a teammate who may appear to have a concussion.

At HCAMP Concussion Education and Awareness Clinics a commonly asked question by parents is "which sport is the most dangerous for having concussions?" When investigating this question, HCAMP data demonstrated some unique results. A national study demonstrated that football had the highest rate of concussions.¹⁴ In Hawai'i high schools, girl's judo had the highest rate of concussion out of the 14 contact and collision sports that HCAMP reported. This is unique data in that Hawai'i is the only state where judo is a sanctioned interscholastic

sport. It also makes an argument that concussions are not just a football issue as the media portrays.

During SY 2014 the highest concussion rate was reported and the subsequent years SY 2015 and SY 2016 the concussion injury rate decreased (Table 4). Thirteen out of 14 sports reported a decrease in concussion rates during the 2014-2016 period. The cause for the decrease in concussion rate remains unclear. One plausible explanation maybe the unwillingness for student athletes to report their concussion. A second explanation may be the implementation of contact limitation in practice and the introduction of game rule changes designed to reduce the risk of head injuries. For instance, decrease in football concussion injury rate may be due to the introduction of several game rule changes such as making it illegal to have a player's head the initial point of contact during a tackle. In 2014, football also introduced practice guidelines that limit the minutes of contact time to 30 minutes a practice and no more than 90 minutes per week.¹⁹ Another example of rule changes designed to reduce concussion rate was seen in the SY 2017 judo season. A rule change was implemented where the double knee throw maneuver was made illegal in matches. This maneuver is considered a high-risk maneuver potentially placing the participant's head as the initial point of contact with the mat. This rule change was initiated by school athletic directors, Judo coaches and ATs after viewing the concussion injury data. These specific rules and policy changes require more research to determine their effect on concussion rates.

This monitoring of concussions serves to enhance HCAMP's ability to provide the most effective and current information available to ATs, coaches, school administrators, educators, parents, and students. Moreover, HCAMP ATs, administrators and coaches need to continue to monitor concussion data to possibly incorporate methods to reduce the rate of concussions in sports. It is therefore imperative that HCAMP and related entities continue to pursue education, research and evidence-based practices in order to reduce and minimize the number of concussions received by student athletes.

Limitations

HCAMP has identified three limitations to this study. First is the possibility that concussions may be overestimated when using concussion post-test 1. When the ImPACT software was implemented, there were reported cases where student athletes with symptoms that resembled a concussion were administered the ImPACT test even if those symptoms may have been caused by another condition such as dehydration or heat illness. Similarly, some high schools were using ImPACT as a diagnostic tool when it is not. Consequently, with continuing education on the appropriate use of ImPACT and additional concussion assessment tools, the percent of cases where ImPACT was used as a differential diagnostic tool is minimum. The second limitation

is that with AE, player participation was estimated due to the unrealistic nature of obtaining daily attendance of practice and exact number of players participating during competition. More specifically, HCAMP does not know how many days a student athlete missed per sport. To obtain accurate AE, athletic teams could record daily practice attendance and player participation during games as part of a season report. The third limitation is the unwillingness or lack of intent of student athletes in reporting concussions, that may decrease the number of concussions being self-reported to AT. Because of the potential time loss from participation and pressure from coaches, parents, peers; an athlete may hide concussion symptoms from AT and health care professionals.

Conclusion

In 2003, the CDC reported to congress that mTBI is a public health problem.²⁰ In reaction to this statement every state in the United States has a concussion law. HCAMP education and awareness efforts and the advent of Hawai'i concussion law, Act 197, helped raise awareness of concussions, increase the number of concussions assessed, and helped shape a uniform concussion management protocol adopted in Hawai'i high schools. Moreover, a collaborative-partnership between HCAMP, AHCTP, HIDEOE, local hospitals, and stakeholders has helped address the health and safety of our student-athletes involved in interscholastic, community, and recreational sports.

Percent differences in concussion injury rates noted a decrease since SY 2013 to SY2016. Rule changes, less contact time during practice, and improved recognition of concussion signs and symptoms are possible reasons for the decrease in concussion injury rate. However, despite these promising data in concussion decreases, caution is necessary when interpreting the data.

Because of the nature of contact and collision sports, concussions cannot be entirely prevented in sports; however, the rate of concussions may be reduced through policy changes, education and awareness, as well as concussion monitoring. HCAMP concussion monitoring has identified sports with the highest number of concussions and the highest concussion rates. This is valuable information for the athletic community and stakeholders in making informed decisions on the safety of sports. Concussion rate information could also help in deciding and investigating possibilities in making a particular sport safer. Through public and athletic policy changes aimed at reducing concussion rates, education, and raising awareness in concussion, HCAMP has a role in continuing to providing evidence based information and resources to coaches, parents, school administrators, and educators.

Conflict of Interest

None of the authors identify a conflict of interest.

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