Neuropsychological Test Performance of Hawai'i High School Athletes: Updated Hawai'i Immediate Post-Concussion Assessment and Cognitive Testing Data

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Abstract

The present study reviewed the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) baseline test scores of 247 high school athletes ages 13 to 18 from a private school in Hawai'i. The aim of the research was to update a prior exploratory investigation conducted in 2008 that compared the test scores of Hawai'i public high school athletes with the normative data provided by the ImPACT publishers. The results of this study provide assurance that the present ImPACT scores of the Hawai'i high school athletes are similar to the general ImPACT norms. The present study is a rare effort to compare the ImPACT scores of high school athletes from an ethnically diverse region with the ImPACT norms. The findings offer further support for the use of the ImPACT norms when evaluating high school athletes from Hawai'i. Future research in varied regions of the United States and with other sociocultural backgrounds is encouraged.

Keywords

neuropsychological test, concussion, ImPACT, high school athletes

Introduction

Recently medical research and media coverage have increasingly focused on sports-related concussion, or mild traumatic brain injury. While concussions in professional sports and college have captured public attention, epidemiologic studies indicate that most concussions in organized sports occur in high school, probably because of the sheer quantity of athletes participating at this level.[1] A study of emergency services found that 3 in 1000 children ages 14 to 19 had an emergency department visit for concussion sustained in organized team sports, demonstrating an increase of more than 200% between 1997 and 2007.[2]

Neurodiagnostic methods for head injuries, such as X-ray, CT scan and MRI, remain the standard for accurate diagnoses and management of sport concussion. In addition, the use of neuropsychological testing plays a significant role in the evaluation of the concussed athlete.[3] Traditional paper-and-pencil neuropsychological tests have been applied for head injury assessments, but more recently computer-based neuropsychological test batteries, such as the Immediate Post-Concussion Assessment and Cognitive Testing(ImPACT) and Cog Sport, have gained widespread acceptance.[4,5] Currently, ImPACT is used in over 400 high schools and is one of the most utilized neuropsychological test instrument, according to its website, *http://impacttest.com*.

To assess the head-injured athlete, ImPACT score interpretation compares the athlete's post-injury test performance with preseason baseline levels. The ImPACT creators suggest baseline testing every two years. When baseline test scores have not been obtained, however, the post-injury scores can be compared to normative data provided by the publishers of this test battery.[4] Normative data are provided for 4 of the 6 composite scores generated by the ImPACT test and are based on a sample of 75,000 athletes.[4] Potential diagnostic problems could occur when assessing test scores of ethnic minority athletes based on the norms of the mainstream population, as longstanding research has established that minority individuals, eg, African Americans and Hispanic Americans, tend to obtain relatively lower scores on standard psychological tests.[6] In view of the possible influence of sociocultural factors on psychometric tests, there are concerns that ImPACT norms developed in the continental United States may not be an appropriate reference base for the unique multi-ethnic population residing in Hawai'i.[7,8]

There is, to date, practically no study that examines the influence of sociocultural or regional factors on the test scores of ImPACT, which is widely employed across the United States. In 2008, ImPACT research on 751 Hawai'i high school athletes was reported in the Hawai'i Medical Journal.[9] The ImPACT test scores of the Hawai'i student athletes were similar to the continental United States norms, but with a trend toward slightly lower scores among the Hawai'i athletes. This difference suggests that the normative percentiles in Hawai'i may be different from the larger population of ImPACT exam takers. The Hawai'i study, however, did not account for those whose primary language was not English, and did not provide details about the different ethnic groups in the research. In addition, the investigation did not exclude invalid ImPACT profiles (ie, those with Impulse Control scores > 30, suggestive of suboptimal test effort).[10]

The purpose of the present study was two-fold: (1) to update the ImPACT normative data with baseline testing and improved inclusion/exclusion criteria on a large population of male athletes at a Hawai'i private high school, and (2) compare the findings with the available normative data from ImPACT. Based on the 2008 ImPACT study in Hawai'i, the hypothesis was that the current Hawai'i high school ImPACT data would be similar to those obtained in high schools on the continental United States.

Methods

The study was reviewed by the Hawai'i Pacific Health Research Institute and was determined to be exempt from Institutional Review Board review.

Test Instrument

The ImPACT is a 20-30 minute computerized neuropsychological test battery administered by certified athletic trainers trained in the standardized administration of the examination. ImPACT

consists of 6 individual test modules that measure different neurocognitive abilities. ImPACT yields five composite scores, including Verbal Memory, Visual Memory, Processing Speed (Visual Motor), Reaction Time, and Impulse Control. The test also provides a Total Symptom Score. A partial list of biopsychosocial data collected with ImPACT includes age, gender, years of education, primary spoken language, ethnicity, sport played, position played, years of experience, prior concussion, history of seizures, psychiatric illness, learning disability, attention deficit disorder, and headache treatment by a physician. The ImPACT test provides standard racial/ethnic categories in a drop down list for participants to choose from. Participants were allowed to choose more than one race/ethnic group.

Participants

The participants were 247 male athletes, ages 13 to 18 years old, in a private high school in Hawai'i during the 2011-2012 and 2012-2013 school years. All athletes underwent baseline testing individually with the computerized ImPACT battery prior to their sport seasons. For the fewer than 10 students in the sample who had multiple baseline scores, repeat baseline scores were removed and only the first baseline score was used in the analysis.

Participants were included if they were male, 13-18 years old, and spoke English as their primary language. Five student-athletes whose first language was not English were excluded from the study. The excluded students spoke Japanese (2), Korean (1), Hakka-Taiwanese (1) and Tongan (1). No athlete was excluded because of invalid profiles, i.e., Impulse Control score >30, because there were no invalid Impulse Control scores.

Consistent with the ImPACT normative categories, participants were divided into two age categories, 13 to 15 year olds and 16 to 18 year olds.

All statistical analysis was done using STATA/IC 11.2 for Windows (StataCorp LB, College Station, TX). Descriptive statistics were calculated for all variables. Percentile tables were created for the 4 ImPACT scores with corresponding normative values for the two age groups.

Results

The mean age of the student-athletes was 15.2 years (SD = 1.3). Participants included 144 in the 13 to 15 year-old age range and 103 in the 16 to 18 year-old age range. The self-identified racial/ethnic backgrounds of the participants were categorized into the following groups: Native Hawaiians or other Pacific Islanders (34.0%), Asians (11.7%), Caucasians (5.0%), Hispanics (2.1%), African Americans (1.3%), Native Americans or Alaskan Natives (0.4%), and mixed racial backgrounds (43.3%). Participants who listed more than one race were placed in the mixed race category only. Participants were allowed to choose more than one racial/ethnic category from a drop down list of standard categories. Nine students did not list a race/ethnicity.

Seven students (2.83%) reported a history of learning disability, which was lower than reported in a previous study of high school athletes(8%) and in the general population, perhaps because of the academic selectivity of the private school the participants attended.[11,12]

The number of athletes participating in each sport varied. Students selected only their primary sport. The sports chosen were football (74.1%), basketball (7.7%), baseball (6.9%), wrestling (4.5%), soccer (6.1%), cheerleading (0.4%), and paddling (0.4%). Fifty-one (20.6%) athletes reported having a previous concussion; 37 (15.0%) had one concussion, 11 (4.5%) had 2 concussions, and 3 (1.2%) had 3, 4, and 5 concussions respectively.

The means and standard deviations (in parentheses) for each of the five ImPACT composite scores and the Total Symptom Score of the 247 high school athletes are presented in Table 1 as a whole and by age group. Two sample t-tests were performed to test for statistically significant differences in scores between the two age groups (13-15 years and 16-18 years). Significantly different scores between age groups were found for Visual Motor Score (P-value < 0.0001) and Impulse Control Score (P-value = 0.0005). The classification ranges of the composite scores (not including Impulse Score and Total Symptom Score) of the two age groups of this study are shown in Table 2. ImPACT provides normative data for the 4 listed composite scores. The Hawai'i scores were similar to the classification ranges in the ImPACT normative sample for the 13 to 15 and 16 to 18 year-old age ranges.

Table 1. Means, standard deviations, and standard errors of measurement of the participants by age group

	All (n=247)			Age 13-15 (n=144)			Age 16-18 (n=103)		
	Mean	SD	SE	Mean	SD	SE	Mean	SD	SE
Verbal Memory	82.85	10.11	0.64	82.46	10.15	0.85	83.39	10.08	0.99
Visual Memory	74.01	12.60	0.80	73.84	12.56	1.05	74.24	12.71	1.25
Visual Motor Score	36.40	6.60	0.42	34.88	6.19	0.55	38.53	6.60	0.65
Reaction Time	0.60	0.08	0.01	0.61	0.07	0.01	0.60	0.09	0.01
Impulse Control	7.40	5.48	0.35	8.42	5.87	0.49	5.98	4.53	0.45
Total Symptom Score	7.84	11.70	0.74	8.74	12.85	1.07	6.57	9.80	0.97

Table 2. Classification Ranges for Composite Scores								
	Verbal Memory		Visual Memory		Visual Motor Speed		Reaction Time	
	Hawai'i	ImPACT	Hawai'i	ImPACT	Hawai'i	ImPACT	Hawai'i	ImPACT
Males, Ages 13-15								
Impaired (<2%ile)	<55	<59	<44	<47	<21.81	<24.28	>0.77	>0.84
Borderline (2-9%ile)	56-67	60-69	45-56	48-56	21.82-27.61	24.28-27.97	0.76-0.71	0.84-0.73
Low Average (10-24%ile)	68-78	70-75	57-65	57-65	27.62-30.96	27.98-31.84	0.70-0.67	0.72-0.67
Average (25-75%ile)	79-90	76-89	66-82	66-83	30.97-38.42	31.85-40.29	0.66-0.56	0.66-0.55
High Average (76-90%ile)	91-95	90-94	83-91	84-89	38.43-43.48	40.30-44.46	0.55-0.51	0.54-0.51
Superior (91-97%ile)	96-97	95-97	92-93	90-94	43.49-47.60	44.47-47.92	0.50-0.48	0.50-0.47
Very Superior (>98%ile)	>98	>98	>94	>95	>47.61	>47.93	<0.47	<0.46
Males, Ages 16-18								
Impaired (<2%ile)	<63	<60	<45	<47	<24.86	<26.30	>0.86	>0.86
Borderline (2-9%ile)	63-68	61-70	46-53	48-58	24.87-29.30	26.30-30.74	0.85-0.72	0.86-0.71
Low Average (10-24%ile)	69-76	71-77	54-66	59-66	29.31-33.08	30.75-34.37	0.71-0.65	0.70-0.64
Average (25-75%ile)	77-90	78-91	67-83	67-83	33.08-43.45	34.38-45.12	0.64-0.54	0.63-0.53
High Average(76-90%ile)	91-97	92-96	84-91	84-89	43.46-47.99	45.13-49.14	0.53-0.50	0.52-0.49
Superior (91-97%ile)	98-99	97-99	92-97	90-94	48.00-50.74	49.15-51.71	0.49-0.48	0.48-0.46
Very Superior (>98%ile)	100	100	>98	>95	>50.75	>51.72	<0.47	<0.45

Discussion

The current study presents mean ImPACT composite scores and Total Symptom Score of the Hawai'i high school athletes, as shown in Table 1. The study also provides the classification ranges of the present ImPACT composite scores according to age groups, along with the classification ranges from the general ImPACT norms. As can be seen, the present research revealed data that are similar to the ImPACT normative data obtained on the continental United States. The present data support the continued use of percentile ranks based on norms obtained in the continental United States with Hawai'i high school athletes. The current results were consistent with those obtained in a previous normative study in Hawai'i five years ago when ImPACT scores were found to be similar but slightly lower compared to the mainland norms.[9]

Although the present results reveal similarities with the general norms for ImPACT, the recognition of normative data for a culturally unique population like Hawai'i is a step in the right direction, with increased awareness that diversity is a feature of our population that needs to be appreciated in the use of neuropsychological tests. A future study could examine ImPACT scores for the different subgroups of minorities in Hawai'i, such as Native Hawaiians, varied Polynesian and Asian groups, Africans, Hispanics, and Caucasians.

The significant role of age in the test findings was expected. In prior studies employing ImPACT and other neuropsychological test batteries, older student-athletes have performed better than younger student-athletes.[13]

In this research, none of the athletes obtained invalid profiles due to Impulse Control score >30. This finding suggests that the student-athletes in this study did not display suboptimal effort on the ImPACT test and provided valid data for research. This compares favorably with the 13% of high school football players who scored >30 on the ImPACT Impulse Control score in the literature.[14]

The limitations of the current research are worthy of note. Only male athletes were included in this study, mostly football players. ImPACT normative data are listed by gender and age group. Male scores by age group were used for this study. Nonetheless,the present results of only male athletes were similar to those obtained from the combined male and female study in Hawai'i in 2008.[9] Another limitation of this study was the exclusion of athletes who attend public high schools that are a significant segment (83%) of the high school population in Hawai'i; as a result, the findings may not apply to Hawai'i public school athletes. However, as mentioned above, the present data of private school athletes were similar to those obtained in the previous study of public high school athletes in Hawai'i.[12] Lastly, the research design excluded those whose first language was not English and, thus, may not be applicable when interpreting the scores of those whose primary language is not English.

The present study provides support for the use of ImPACT norms in regions of the country, like Hawai'i, where ethnic minority populations may be substantial. The present investigation is a rare effort to compare the ImPACT scores of high school athletes in an ethnically unique geographic region with the general ImPACT norms. Further research on the use of ImPACT with other ethnic and racial minority high school athletes is recommended.

Conclusion

The current study provided important findings for those who utilize the ImPACT test battery for the evaluation of athletes who sustain a concussion. The results revealed that ImPACT test scores of multi-racial high school athletes in Hawai'i are similar to the scores provided by the ImPACT normative sample. As such, the use of separate baseline ImPACT norms for Hawai'i high school athletes in neurocognitive concussion assessment is not warranted. The present comparison of local ImPACT test scores with the national ImPACT sample is a unique effort that can serve as a model for other users in the U.S. and other countries that employ this widely used neuropsychological test battery.

Conflict of Interest

The authors have no financial interest in or relationship with ImPACT Applications, Inc.

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