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Research article

Boxing, wrestling, and martial arts related injuries treated in emergency departments in the United States, 2002-2005

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Abstract
The incidence of injury in combat sports has not been adequately reported although it is important to identify the nature and frequency of injuries prior to the implementation of prevention programs. This study compared injury rates treated in Hospital Emergency Departments between different combat sports of boxing, wrestling, and martial arts. A secondary objective described anatomic region and diagnosis of these injuries. Data were obtained on all boxing, wrestling, and martial arts-related injuries that were in the National Electronic Injury Surveillance System database and resulted in Emergency Department visits between 2002 and 2005. Pearson's chi-square statistics were calculated to compare injury rates for each activity accounting for complex sample design. Martial arts had lower injury rates compared to boxing and wrestling for all diagnoses ($p < 0.001$). Boxing had lower injury rates compared to wrestling for strains/sprains and dislocations. Boxing and wrestling had similar injury rates for concussions. Injury prevention efforts should consider the distribution of injuries and concentrate on preventing strains/sprains in wrestling, concussions in boxing and wrestling, and fractures for all three activities. The findings of the present study do not provide evidence that combat sports have alarmingly high rates of injuries resulting in emergency department visits.

Key words: Combat sports injuries, sports injuries, emergency department visits, complex sample design.

Introduction

Combat sports frequently involve striking, throwing, or immobilizing the opponent and therefore are commonly considered more dangerous compared to other athletic activities. Concerns about serious injuries in boxing have started a debate in the medical community about whether boxing should be banned (Lundberg 1983; Ioannou 1984). In an effort to decrease the number of serious injuries, the governing bodies of organized combat sports modified rules by decreasing the duration and number of rounds in boxing or by mandating the use of protective equipment as in the case of tae kwon do.

Despite of the popularity of combat sports, most studies on the incidence of injuries involve either a small sample size (Zazryn et al.,, 2006) or report injuries during tournaments (Arriaza and Leyes 2005). Additionally, there is disagreement in the literature about the incidence of injuries in combat sports; some studies suggest that combat sports are more dangerous for the participants compared to other sports (Oler et al., 1991; Jarrett et al.,, 1998) while others claim that the rate of injuries in combat sports is comparable or lower to that of other popular sports like football, basketball, and soccer (Birrer and Halbrook 1988; Porter and O'Brien 1996; Tenvergert et al., 1992). Defining the extent and type of injuries is a prerequisite to the development of successful injury prevention strategies in combat sports. To the author's knowledge, the present study is the first to use Hospital Emergency Department records to compare injury rates across different combat sports in the general population. A secondary objective is to describe the anatomic region and diagnosis of these injuries.

Methods

Maintained by the US Consumer Product Safety Commission, the National Electronic Injury Surveillance System (NEISS) receives data on all injury-related visits to emergency departments of 100 hospitals which are a stratified sample of all hospitals with emergency departments in the US and its territories. Each case collected has an associated statistical weight based on the inverse probability of being selected. For the purposes of the current study, information was extracted on all boxing, wrestling, and martial arts-related injuries that were in the NEISS database and resulted in emergency department visits between 1/1/2002 and 12/31/2005. Only injuries that identified boxing, wrestling, or martial arts as the primary activity responsible for the injury were included. The resulting sample consisted of 7290 cases.

In order to account for exposure, denominator data on the number of participants and average days of participation for each one of the three sports came from the American Sports Data, Inc. "Race, Ethnicity and Sports Participation in the US" study. This study is a large survey that provides national estimates on sports participation.

All statistical calculations were performed by using the Statistical Package for Social Sciences (SPSS) 13.0 Complex Samples software to account for the assigned weights. All injury rates presented in our study reflect annual national estimates of injuries per 100,000 player-days of participating in one of the three combat sports. The effect of sports activity (boxing/wrestling/martial arts) on injury rates was examined with the use of Pearson's chi-square test. The level of significance was set a priori to 0.006 to account for the multiple comparisons performed in the study. Injury rate estimates of less than 1,200, derived from less than 20 cases, or with coefficients of variation higher than 33% were considered un-

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stable and potentially unreliable (Birrer and Halbrook 1988).

Results

The vast majority of the 7290 injuries that were treated in emergency department during the study period did not require hospitalization; only 1.6% of the injured athletes were admitted. Of the injuries that required hospitalization, 10.3% were boxing-related, 59.8% were wrestling-related, and 29.9% were martial arts-related. Boxing injuries peaked in the 14-30 year old age group; 9.2% of the injuries involved children 13 years old or younger, 50.2% involved 14-22 year old athletes, 24% involved 23-30 year old athletes, and 17.4% involved 31 year old or older athletes. Males comprised 88.2% of all boxing-related injuries. In wrestling, athletes in the younger than 13 year old age group accounted for 24.5% of the injuries, in the 14-22 year old age group for 69.3%, in the 23-30 year old age group for 3.5%, and in the over 31 year old age group for 2.7%. Males comprised 95.3% of wrestling-related injuries. In martial arts, the younger than 13 year old age group accounted for 22.7% of injuries, the 14-22 age group for 25.1% of injuries, the 23-30 age group for 18.6%, and the older than 31 year old age group for 33.6%. Males comprised 67.8% of martial arts-related injuries.

Table 1 presents the distribution of the anatomic regions of the body injured by percentage of total injuries. From the descriptive analysis it is evident that upper extremities and head/face injuries constitute the most vulnerable regions for those participating in boxing (87%). The upper and lower extremities accounted for most injuries in boxing and martial arts.

Table 1. Distribution of injuries per anatomic region for boxing, wrestling, and martial arts.

Anatomic region	Boxing	Wrestling	Martial Arts
Upper extremities	63.7%	44.3%	32.%
Lower extremities	4.5%	20.5%	41.6%
Trunk	8.2%	17.9%	14.0%
Head/face	23.3%	16.9%	11.1%
Other	0.3%	0.3%	0.5%

The diagnostic distribution of injuries for each one of the three combat sports category are presented in Table 2. Contusions/abrasions, fractures, and strains/sprains were the three most frequent diagnoses for all three sports.

The overall injury rate per 100,000 player-days was lower in martial arts compared to the other two sports ($p < 0.001$). Boxing had a lower injury rate compared to wrestling ($p = 0.003$). Injury rates as well as group comparisons for the most common diagnoses are presented in Table 3. None of the injury rate estimates were unstable.

Discussion

The findings of the present study suggest that injury rates vary significantly between combat sports. Wrestling had the highest rate of injuries followed by boxing. Martial arts had the lowest injury rate compared to those of the other two activities. No other studies have compared the incidence of injury between boxing, wrestling, and martial arts. However, a recent study (Zazryn et al., 2006) calculated the injury rate in boxing and contrasted it with previously published data on karate suggesting that boxing had a 50%-300% higher injury rate. In the present study all martial arts were grouped together which may explain that boxing had a five-fold higher injury rate than martial arts. However, when mixed martial arts competitions which is one of the most violent forms of martial arts that combines a free style combination of striking and grappling arts was compared to boxing in a recent study (Bledsoe et al., 2006), mixed martial arts had 65% more injuries than boxing.

The higher injury rate in wrestling compared to boxing is likely due to more strains/sprains and dislocations. Unlike boxing, wrestling involves grappling and maneuvering the opponent which frequently results in extreme positions for the joints. The forces and positions encountered in wrestling may frequently result in elongation of the muscles and ligaments beyond their physiologic range. Strains/sprains and dislocations represented 42.3% of all injuries in wrestling which is consistent with other reports on wrestling injuries (Jarrett et al., 1998; Pasque and Hewett 2000) pointing to high percentage of strains/sprains and dislocations.

In agreement with a recent systematic review (Koh et al., 2003), the incidence of boxing-related concussions was higher than the incidence of martial arts-related concussions. The problem of concussions and their serious consequences in boxing has received a lot of attention (Lundberg 1983; Ioannou 1984). However, little attention has been given on the incidence of concussions in wrestling. Pasque et al (Pasque and Hewett 2000) reported that concussions accounted for 1.4% of all wrestling injuries.

Table 2. Distribution of injuries per diagnosis for boxing, wrestling, and martial arts. * national estimates.

Injury	Boxing		Wrestling		Martial arts	
	Number of injuries*	% of total injuries	Number of injuries*	% of total injuries	Number of injuries*	% of total injuries
Concussions	1503	3.2	3840	3.0	1211	1.2
Contusions/abrasions	12817	27.2	20227	16.0	23333	23.2
Dislocations	1766	3.8	7514	5.9	4029	4.0
Fractures	12573	26.7	26941	21.3	24458	24.3
Lacerations	4057	8.6	7612	6.0	4552	4.5
Internal organ injuries	1339	2.8	3245	2.6	1996	2.0
Strains/sprains	9610	20.4	46092	36.4	31126	31.0
Not stated	2686	5.7	9367	7.4	8072	8.0
Total	47052	100	126610	100	100474	100

Table 3. Injury rates and pair-wise comparison chi square statistic for boxing, wrestling, and martial arts.

Injury	Injury rates per 100,000 player-days (95% Confidence Interval)			Pearson's chi square p-values		
	Boxing	Wrestling	Martial arts	Boxing vs. wrestling	Boxing vs. martial arts	Wrestling vs. martial arts
Concussions	.92 (.5-1.3)	1.20 (.8-1.5)	.07 (.03-.10)	.34	<.001*	<.001*
Contusions/ Abrasions	7.9 (6.4-9.3)	6.4 (4.8-7.9)	1.35 (1.0-1.6)	.16	<.001*	<.001*
Dislocations	1.1 (.7-1.4)	2.4 (1.7-2.9)	.23 (.1-0.3)	<.001*	<.001*	<.001*
Fractures	7.7 (6.4-8.9)	8.5 (6.5-10.4)	1.42 (1.0-1.7)	.45	<.001*	<.001*
Lacerations	2.5 (1.6-3.3)	2.4 (1.7-3.0)	.26 (.1-0.3)	.85	<.001*	<.001*
Internal organ injuries	.82 (.3-1.3)	1.02 (.6-1.3)	.11 (.07-.15)	.57	<.001*	<.001*
Strains/Sprains	5.91	14.52	1.81	<.001*	<.001*	<.001*
Total	29.0 (24.4-33.4)	39.9 (31.6-48.1)	5.8 (4.5-7.1)	.003*	<.001*	<.001*

* statistically significant difference between the two compared groups.

Zazryn et al. (2003) reported that 16% of injuries in professional boxers were concussions. The findings of this study suggest that the rate of wrestling- and boxing-related concussions resulting in emergency department visits is similar. Concussions occur much more frequently among professional than amateur boxers (Zazryn et al., 2006), which may explain the relatively low concussion injury rate due to boxing that was observed in the present study. Although information on the severity of concussions was not available, it is likely that athletes with more serious concussions (grade II and III) visit the emergency department. It is important to note that the incidence of concussions in non-combat related team sports such as ice hockey and football is higher than in combat sports (Koh et al., 2003). The present study has identified strains/sprains and dislocations as the injuries mainly accounting for the high injury rate in wrestling compared to boxing. Additionally, wrestling has similar incidence rates for concussions to boxing. Biomechanical and video analysis of wrestling injuries may identify the exact mechanism that results in strains/sprains, dislocations, and concussions and provide suggestions for rule changes that will decrease injury rates.

The findings of the present study suggest that the incidence of serious injury among combat sports practitioners is small. Only 1.6% of emergency department visits resulted in hospitalization which is comparable to the findings of Birrer et al (Birrer and Halbrook 1988) who reported that 1% of martial arts-related visits to emergency departments resulted in hospitalization. Although comparison of combat sports-related with non-combat sports-related emergency department visits is beyond the scope of this study, it is noteworthy that the emergency department injury rate for basketball which is the most popular team sport in the United States was 45 injuries/100,000 player days for the same time period 2002-2005. Therefore, it appears that basketball has a 10% higher injury rate than wrestling, 50% higher injury rate than boxing, and more than seven times higher injury rate than martial arts. Jarret et al. (1998) investigated injury rates in collegiate sports and reported that wrestling had higher injury rate than basketball. The discrepancy in the findings of the two studies may be related to the different populations studied and the type of injuries; the present study investigated only injuries that resulted in emergency department visits in the general population while the study on collegiate sports investigated all injuries that resulted in restriction of participation for one or more days. Further research should compare the injury rate between combat sports and non-combat sports.

Fractures were the second most frequent diagnosis for each activity representing more than 20% of the total injuries. The mechanism of injury that results in fractures varies between activities; in tae kwon do and boxing fractures occur during kicking or punching while in wrestling and judo they are more likely to occur during falling.

The distribution of wrestling injuries per anatomic region suggests that the upper extremities are injured more frequently followed by the lower extremities. This is consistent with the findings of Pasque et al (Pasque and Hewett 2000) and implies that prevention efforts in wrestling should concentrate on the extremities because trunk and head/face injuries are not injured as frequently. Similarly, the extremities were more frequently injured in martial arts but the lower extremities were more frequently injured than the upper extremities. Birrer and Halbrook (1988) also used the NEISS data and reported that the lower extremities were more frequently injured than the upper extremities in martial arts. However, there is a small decrease in lower extremities injuries between the two studies (from 46.9% to 41.6%) which may reflect the more widespread use of leg protective equipment in martial arts styles such as tae kwon do in the last 20 years.

In contrast to the low incidence of non-extremity injuries in wrestling and martial arts, head/face injuries in boxing represent 23.3% of the total injuries. The high incidence of head/face injuries in boxing as reported in the present study is consistent with other studies (Zazryn et al., 2006) and suggests that efforts should be made to develop better materials that limit the transfer of impact from the upper extremity to the face during a punch. A biomechanical study (Schwartz et al., 1986) showed that the effectiveness of box gloves in reducing acceleration of the target is limited.

Due to their competitive spirit, required discipline, and beneficial physiologic effects combat sports have been particularly popular among active youth. However, concerns about high incidence of injuries are common among parents and health care professionals. The present study provides evidence that martial arts have a relatively low incidence of injury while wrestling has a high incidence of injury. This finding may help create awareness among participants, coaches, parents, and heath care professionals about the relative safety of martial arts compared to other combat sports.

The high incidence of sprains/sprains and dislocations found among wrestlers is particularly concerning especially since joint trauma is associated with early degenerative changes (Roos et al., 1998; von Porat et al., 2004). Injury prevention efforts in wrestling should focus on decreasing strains, sprains, and dislocations by developing protective equipment and modifying rules in a way that promotes avoidance of extreme joint positions.

Limitations of the study

Although the findings of this study are an important first step toward characterization of combat sports injuries in the general population, its retrospective design carries with it several limitations. Injury and exposure data came from surveys that have an inherent error of measurement. Additionally, the injuries for all martial arts styles were grouped together. Martial arts consist of styles that are very different and may have different injury patterns. Tae kwon do promotes attacking the face and head with punches and kicks, judo involves grappling, and tai chi is non-contact. Previous investigators have shown that significant differences exist between the different martial arts styles in respect to incidence of injury; tae kwon had the highest incidence and tai chi had the lowest (Zetaruk et al., 2005).

Only injuries treated in Emergency Departments were included in this study. A more comprehensive assessment of combat sports injuries should include all injuries in order to provide more accurate descriptions of the injury rate within each activity.

Conclusion

This study provides evidence that there are significant differences between boxing-, wrestling-, and martial arts-related injury rates treated at emergency departments. Martial arts had the lowest injury rate from the three activities. Compared to boxing, wrestling had higher strains/sprains and dislocations. The overall injury rate for combat sports does not appear to be higher than in popular non-combat sports.

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Key points

- Martial arts have lower emergency department injury rates compared to boxing and wrestling.
- Wrestling has higher strains/sprains and dislocation injury rates compared to boxing.
- Combat sports do not appear to have higher injury rates compared to non-combat sports.

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