

EPIDEMIOLOGY OF INJURY IN OLYMPIC SPORTS

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Dear Prof. Harmer:

Your request that the chapter on fencing that you published in Vol. XVI, Epidemiology of Injury in Olympic Sports, in The Encyclopaedia of Sports Medicine series, be included as a link to the web site of the International Fencing Federation has been forwarded to me.

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It is our pleasure to assist you in this fashion.

Yours sincerely,

Lars Engebretsen

Head of Scientific Activities, Medical and Scientific Department, IOC

Chapter 10

Fencing

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Introduction

Fencing is one of only four sports to have been included in every Olympiad of the modern era. Olympic competition has basically consisted of events for men in the standard three weapons since its inception (individual foil and sabre from 1896, individual epee from 1900; team epee and sabre from 1906; team foil from 1920) (Fencing 2008). The first event for women (individual foil) was introduced in 1924, with a team foil event being added in 1960. Individual and team épée for women were included in the Olympic program for the first time in 1996 with women's saber added in 2004. The martial origins of fencing and the use of weaponry in individual combat impart the impression of high risk to modern competitive fencing. The purpose of this chapter is to examine the veracity of this belief by evaluating the extant literature on fencing-related injury. The focus was on data-based studies, although case reports and case series were included for a fuller understanding of clinical outcomes, particularly for catastrophic and complicated injuries. Overall, the paucity of well-designed, data-driven studies was evident.

Who Is Affected by Injury?

A summary of studies reporting injury rates in fencing is presented in Table 10.1. Although the

percentage of fencers recorded as injured in specific competitions (20–27.5%; Majorano & Cesario 1991; Naghavi 2000) or self-reported as sustaining an injury in their fencing careers (59–77.8%; Nye 1967; Carter et al. 1993) appears high, exposure-based injury rates, especially for time-loss injuries (i.e., those significant enough to necessitate an athlete withdrawing from competition) indicate that the majority of fencing injuries are minor. For example, in a review of 15 years of sports-insurance data in Germany, Raschka et al. (1999) estimated an injury rate of 0.12 per 1,000 persons/yr for fencing, which was the lowest, with aikido, of eight combat sports analyzed. Studies in Table 10.1 indicate consistent findings of a time-loss rate of 0.0 to 0.3 per 1,000 athlete exposures (AE) across a wide variety of competition and training settings. By comparison, soccer and basketball have been found to have ~50 times and 31 times higher rates of time loss from competition because of injury, respectively, than fencing (Harmer 2008a).

Where Does Injury Occur?

Anatomical Location

The percent distribution of injury by anatomical location is presented in Table 10.2. Although several studies have found that the highest proportion of injuries involved the wrist, hand, and fingers (range, 54.6–61.3%), the majority of research has shown the lower extremities to be the most common site of injury (mean = 59%; range, 42.9–77.3%), specifically

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Table 10.1 Comparison of fencing injury rates.

Study	Design	Data Collection	Data Source (Duration of Study)	Location	No. of Participants	No. of Injuries	Injury Rate		
							Overall per 1,000 AE ^a	Time-loss per 1,000 AE ^b	Other
Weightman & Browne (1975)	P	Q	Community fencing clubs (1 yr)	England	Clubs = 18	25	—	—	0.42 ^{a,c}
Graham & Bruce (1977)	P	Q	University fencing teams (1 yr)	USA	F = 64	0	—	0	0.0 ^{b,d}
Roi & Fasci (1986)	P	DM	Regional youth competitions (1 yr)	Italy	n = 358	11	—	0	3.1 ^{a,d}
Roi & Fasci (1988)	P	DM	Regional competitions (1 yr)	Italy	n = 1365	58	—	0.22	0.2 ^{b,d}
Lanese et al. (1990)	P	DM/I	University fencing team (1 yr)	USA	M = 18 F = 6	5 3	—	—	1.0 ^{b,c} 1.8 ^{b,c}
Majorano & Cesario (1991)	P	DM	National competition (1 competition)	Italy	n = 801	100	—	—	0.25 ^{b,d}
Gambaretti et al. (1992)	P	Q	Milan-area fencers (1 yr)	Italy	n = 178	49 (competition only)	—	—	27.5 ^{b,e}
Naghavi (2000)	P	DM	International Junior competition (1 competition)	Iran	M = 155	31	—	0.0	20.0 ^{b,d}
Harmer (2007)	P	DM	Veterans World Championships (5 yr)	International	n = 1398 M = 892 F = 506	2 2 0	—	0.2 0.33 0.0	0.1 ^{b,d} 0.2 ^{b,d} 0.0 ^{b,d}
Harmer (2008a)	P	DM	National competitions (5 yr)	United States	n = 78,223 M = 47,483 F = 30,740	184 98 86	—	0.3 0.27 0.36	0.2 ^{b,d} 0.2 ^{b,d} 0.3 ^{b,d}

AE = athlete exposure; P = prospective; Q = questionnaire; DM = direct monitor; I = interview; M = male; F = female

^a Any injury for which medical assistance was sought.

^b Any injury that resulted in withdrawal from competition, inability to practice after the competition, or both.

^c Per 1,000 hours of participation.

^d Per 100 participants.

^e Per 100 participants/yr.

Table 10.2 Percent comparison of injury location in fencing.

	Roi & Fasci (1986)	Majorano & Cesario (1991)	Müller-Strum & Bierner (1991)	Gambaretti et al. (1992)	Naghavi (2000)	Wild et al. (2001)	Kelm et al. (2003)	Jäger (2003)	Harmer (2008a)
				(n = 164)	(n = 49)			(n = 732)	(n = 481)
Head/spine/trunk	(0.0)	(1.0)	(2.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(4.4)
Head/skull	—	—	2.0	—	—	—	—	—	2.2
Neck/throat	—	1.0	—	—	3.2	—	—	—	2.2
Trunk/back	—	—	23.0	15.2	6.5	24.1	9.8	22.6	9.1
Upper extremity	(63.7)	(67.0)	(20.0)	(6.6)	(77.4)	(9.9)	(26.9)	(21.3)	(19.5)
Shoulder	—	3.0	(inc. in trunk)	3.0	—	6.6	4.9	—	7.7
Arm	9.1	(inc. in shoulder)	8.0	—	—	—	4.9	—	3.8
Elbow	—	4.0	—	1.8	16.1	3.3	—	2.3	1.6
Forearm	—	(inc. in elbow)	—	—	—	—	9.8	(inc. in elbow)	2.7
Wrist	—	60.0	—	—	3.2	—	—	19.0	11.4
Hand/fingers	54.6	(inc. in wrist)	12.0	1.8	58.1	—	7.3	(inc. in wrist)	(inc. in wrist)
Lower extremity	(27.3)	(23.0)	(55.0)	(68.4)	(12.8)	(66.0)	(63.3)	(42.1)	(63.6)
Pelvis/hips	—	4.0	—	12.2	—	3.3	—	16.3	3.8
Thigh	—	2.0	18.0	—	3.2	7.9	29.2	(inc. in hip)	15.2
Knee	—	4.0	10.0	9.2	3.2	20.3	17.1	6.8	19.6
Leg	9.1	2.0	6.0	—	3.2	8.7	2.4	—	8.7
Ankle	18.2	11.0	21.0	23.2	3.2	25.8	14.6	29.0	13.0
Foot/toes	—	(inc. in ankle)	(inc. in ankle)	23.8	—	—	—	(inc. in ankle)	3.3
Other	9.1	9.0	—	9.8	—	—	—	4.0	5.9

the ankle and knee (Figure 10.1). In addition to prospective studies with this outcome, in the largest retrospective self-report study to date (1,603 respondents), Carter et al. (1993) reported that the knee (17–19%) and ankle (14–14.5%) were cited as the locations of both the worst injury suffered in the previous year and the worst injury suffered in a fencing career.

In the largest prospective, exposure-based study of fencing injury (78,223 participants), Harmer (2008a) noted that while the knee was the most commonly injured region (19.6%), a wide variety of pathologies were involved. Of particular concern were injuries to the anterior cruciate ligament (ACL). Mountcastle et al. (2007) reported that in a 10-year study of sports-related injury at the U.S. Military Academy at West Point, fencing ranked the second lowest of six club sports for which an incidence rate for males was recorded (0.06 per 1,000 AE). No ACL ruptures occurred in females during the study period. Majewski et al. (2006) examined the cause of knee injuries in a 10-year study of patients at an orthopedic clinic in Switzerland and found a rate of 1.5 per 1,000 participants per 10 years for fencing.

Environmental Location

Few studies have examined the distribution of injury between competition and practice. However, Gambaretti et al. (1992), in a 1-year study of 178 fencers (youth through elite level), found

that 77% of recorded injuries occurred in practice and 23% in competition. It is not clear from these data, however, whether the rate of injury (i.e., relative to exposure units) would be greater in practice than competition.

When Does Injury Occur?

Injury Onset

To date, only two prospective studies have presented data on injury onset in fencing. From a 1988–1990 study of fencers in the United States, Moyer & Konin (1992) found that 55.2% of the reported injuries were acute and 44.8% were overuse or chronic. Similarly, in a 5-year study of 293 fencers at the German Olympic Training Center in Tauberbischofsheim, Jäger (2003) classified 60.3% of the injuries as acute and 39.7% as overuse. A retrospective study conducted by Carter et al. (1993) in the United States found that of the self-reported cases of “worst injury in the previous year,” 67% were acute and 33% overuse or of gradual onset.

Chronometry

No research on the chronometry of injuries in fencing, such as the distribution of injuries over a competitive season or the relative rate of injury during different phases of a fencing tournament, was located.



Figure 10.1 Rapid change of direction and strong lunging place the knee and ankle at risk for injury. Photo by Serge Timacheff. Reprinted with permission.

What Is the Outcome?

Injury Type

The distribution of injury types in fencing derived from the extant literature is detailed in Table 10.3. Three general patterns are evident: (a) studies in which abrasions/blisters and contusions predominate, (b) those in which sprains and strains are most common, and (c) the low proportion of puncture injuries. Taken together, the data indicate that fencing injuries tend to be minor, whether surface trauma (abrasions, contusions) or musculoskeletal derangement (sprains, strains) common to any activity with rapid change of direction activity. For example, in addition to the data in Table 10.3, in an early ecological study of fencing clubs in England, Weightman & Browne (1975) noted that 28% of reported injuries were sprains and strains, while Moyer & Konin (1992) found that 33% of 323 acute injuries were sprains and 24% were strains in a 2-year study in the United States. The consistently low proportion of puncture wounds underscores the fact that this type of “fencing-specific” injury is not common and studies that reported a high percentage of lacerations (e.g., Naghavi 2000) indicated that these were principally minor cuts to the hand, readily treated with standard wound care such as a bandaid.

Time Loss

In the earliest fencing injury study found in the literature, Nye (1967) classified 32.7% of injuries (17 of 52) as severe (resulted in x-ray examination, medical treatment, or time lost from work; no further breakdown), but indicated that 48% of all injuries required no treatment. In their 1-year study of clubs in northern England, Weightman & Browne (1975) noted that 68% involved no time lost from participation but did not provide any data on time loss for injuries that involved some time loss. Lanese et al. (1990), the only study to date to quantify time loss, reported that eight time-loss injuries in a university fencing team resulted in 21.5 disability days for men (4.3 per 1,000 hours of participation) and 3.5 disability days for women (2.1 per 1,000 hours of participation). Fencing had the lowest rate of time loss of the eight sports studied. Müller-Strum

& Bierner (1991) surveyed 105 male and female fencers from Germany and Switzerland and noted that 148 reported injuries resulted in 64 days in the hospital and 203 days missed from work or fencing. Carter et al. (1993) found that 22% of injuries sustained in the previous year did not result in any time loss, but 15% were reported as having an extreme impact on participation. However, no other details were provided. Finally, Naghavi (2000), who reported the highest overall injury rate of any study in this review, emphasized that there were no time-loss injuries and that all injuries were treated with standard first aid.

Clinical Outcome

Catastrophic Injury

Despite the impression of high risk for significant injury from the powerful use of the various weapons in fencing, there have been few fatalities recorded in the literature. Since 1937, only ten deaths worldwide have resulted from penetrating wounds in fencing: all have been in men; 3 in foil, 6 in épée, 1 in saber; 6 occurred in competition, 3 in practice, 1 unknown; 7 resulted from a broken blade, 2 from an intact blade, 1 unknown; 7 penetrations were in the chest, 1 through the neck, 1 in the face, 1 unknown) (Parfitt 1964; Safra 1982; Crawford 1984, 1991; “Fencing match” 1990; “Fencer’s tragic” 1994; “Ukrainian fencer” 2004; “Fencer dies” 2005; “Smierc szermierza 2009”).

Although mortal injuries are very rare, non-fatal penetrating injuries are more frequent but still uncommon. For example, Carter et al. (1993) found that approximately 5% of 1,246 fencers surveyed reported a puncture wound (variously to face, neck, chest, abdomen, arms, and legs) as their worst injury during their fencing career but Harmer (2008a) indicated that only 0.006% of participants in national-level competitions in the United States over a 5-year period suffered a puncture or penetrating wound that resulted in time loss. Wild et al. (2001) noted only one pneumothorax and two lacerations from broken blades in a 15-year study in Germany. Harmer et al. (1996) detailed a distant-entry pneumothorax from a broken épée in an elite fencer, and a pneumohemothorax was reported

Table 10.3 Percent comparison of injury types in fencing.

Study	No. of Injuries	Sprain	Strain	Contusion	Subluxation/Dislocation	Fracture	Laceration	Puncture	Rupture	Cramp/Spasm	Abrasion/Blister	Other/Unknown
Roi & Fasci (1986)	11	18.2	—	27.3	—	—	9.1	—	—	—	45.5	—
Roi & Fasci (1988)	58	8.6	—	48.3	—	—	—	—	—	6.9	10.3	25.9
Majorano & Cesario (1991)	100	22.0	6.0	18.0	—	1.0	—	—	—	—	46.0	7.0
Müller-Strum & Bierner (1991)	148	24.0	17.0	8.0	Inc. in Other	2.0	—	2.0	6.0	—	—	30.0
Gambaretti et al. (1992)	213	23.0	10.8	—	2.4	5.6	—	—	—	—	—	58.2
Carter et al. (1993) ^a	?	23.9	26.0	—	—	2.1	3.0	3.3	2.4	—	—	39.3
Azémar (1999)	132	26.0	—	44.0	—	—	11.0	—	—	—	10.0	9.0
Naghavi (2000)	31	6.5	3.2	25.8	—	—	38.7	—	—	—	19.3	6.5
Kelm et al. (2003) ^b	41	12.2	12.2	24.4	—	2.4	—	—	46.3	—	—	—
Harmer (2008a)	184	25.5	26.1	12.0	7.6	4.4	0.5	2.7	3.3	4.9	—	13.0

^a Self-reported worst injury in the previous year.

^b Self-reported worst injury in previous 5 years.

(also from a broken épée) in a practice session for the 2007 Pan American Games (“Brazilian fencer” 2007). In addition, penetrating injuries have been reported in various locations, including the neck (Harmer 2008c) and abdomen (Matloff 1985). However, the incidence of significant penetrating wounds has not been well researched. In the only study to document the incidence of penetrating wounds resulting in a time loss, Harmer (2008a) noted an overall rate of 0.008 per 1,000 AE (any penetrating injury resulting in time loss) and a rate of 0.0016 per 1,000 AE for penetration wounds to the trunk.

Other Outcomes

In addition to serious injuries, a variety of unique clinical presentations related to fencing have been introduced in the literature. Borelli et al. (1992) described an intravascular papillary endothelial hyperplasia, possibly an organized thrombus, in the hand of a female fencer, postulated to be related to “the continuous microtrauma to which the hand of a fencer is exposed.” Gray and Bassett (1990) detailed a case of osteochondritis dissecans in an 18-year-old elite épée fencer, which was surgically repaired without complications. Kelm et al. (2004) presented an instance of acute tibialis anterior rupture in an elite veteran fencer.

Economic Cost

No studies were located that examined the economic impact of fencing injuries on individual athletes, clubs, National Governing Bodies, or the Fédération Internationale d’Escrime (FIE).

What Are the Risk Factors?

Intrinsic Factors

Age

Jäger (2003) argued that poor strength and muscle imbalance in young athletes (≤ 16 years old) were responsible for injuries in this population, but no data were provided to support this contention. Harmer (2008b), in an analysis involving approximately 42,000 participants, found no significant difference in the rate of time-loss injury (per 1,000 AE) between youth (8–17 years old; 0.27; 95% confidence

interval [CI], 0.20–0.35), young adult (~18–30 years old; 0.31; 95% CI, 0.22–0.44), and veteran (≥ 50 years old; 0.21; 95% CI, 0.10–0.39) fencers.

Sex

In the first study to examine the influence of sex on injuries in fencing, Lanese et al. (1990) found no significant difference in the rate of disability days per 1,000 hours of participation for time-loss injuries between men and women ($P = 0.47$). Similarly, in a 10-year study of cadets at the U.S. Military Academy at West Point, Mountcastle et al. (2007) noted no significant difference in the rate of complete ACL ruptures between men and women (1 case in 16,964 AE vs. 0 in 12,148). However, in their 15-year study of 93 elite German fencers, Wild et al. (2001) concluded that women had a rate of ankle injury that was three times higher than that for men, but no statistical analysis was done. In the largest study of fencing injuries to date, Harmer (2008a) found that women had 35% higher risk for a time-loss injury in competition than men (relative risk, 1.35; 95% CI, 1.01–1.81).

Extrinsic Factors

The only extrinsic risk factor that has been reported is event (i.e., foil, épée, saber). Examining data from the 1991 Italian national competition, Majorano & Cesario (1991) noted that twice as many foil fencers (18.6%) sustained some injury as compared with either épée (8.9%) or saber (9.2%), but the significance of these differences was not tested. Harmer (2008a) found that although foil and épée were not significantly different in the rate of time-loss injuries, saber had a statistically significantly higher risk (62%) for time-loss injury as compared with foil and épée (relative risk, 1.62; 95% CI, 1.2–2.2), and this increased risk was evident for both men (relative risk, 1.61; 95% CI, 1.06–2.44) and women (relative risk, 1.63; 95% CI, 1.05–2.54).

What Are the Inciting Events?

Inciting events have not been extensively examined, but from the available information, three major factors emerge: (a) trauma directly from an opponent’s weapon, (b) poor technique (both the opponent’s and that of the injured athlete), and (c) injuries from the piste.

An injury resulting from direct impact of the opponents' blade is the most common inciting event: Carter et al. (1993) found 4.5% of self-reported worst injuries in a career were due to the opponent's weapon. Nye (1967) indicated that this mechanism was responsible for 10% of injuries. However, when injury is defined as any request for care, a significantly greater proportion of injuries are attributable to the blade. Roi & Fasci (1986) and Naghavi (2000) reported that 55% to 64.5% of injuries were caused by opponent's weapon (principally minor contusions and abrasions).

Gambaretti et al. (1992) ascribed 63% of ankle injuries to poor foot position, while Carter et al. (1993) cited an athlete's poor technique (12.2–14.7% of injuries) and the opponent's dangerous actions (8.5–9.0%) as important inciting events. Jäger (2003) concluded that both acute and overuse injuries were a result of technical errors, but provided no data to support this claim.

Slipping, tripping, or stepping on the edge of the piste has been identified as responsible for between 9.6% (Carter et al. 1993) and 37% (Gambaretti et al. 1992) of injuries.

Injury Prevention

Although participant safety is presented as a high priority in fencing, no injury prevention studies have been instituted. To date, FIE-mandated changes to equipment and rules related to safety have been based on face validity. For example, the plastron was introduced as a consequence of a fatal penetrating injury in the 1951 World Championships, where it was determined that the fencer's jacket was of inadequate thickness (Parfitt 1964). However, no research has been conducted to determine the actual efficacy of this or any other change.

Similarly, numerous recommendations for decreasing injury have been presented in the literature (Carter et al. 1993; Zemper & Harmer 1996; Roi & Bianchedi 2008) based on descriptive studies, face validity or first principles, covering behavioral characteristics (e.g., improving conditioning and technical expertise), equipment and facilities (e.g., improved composition and construction of the piste, increased integrity of blades and clothing), and administration of fencing competitions

(e.g., enforcement of rules on dangerous fencing, enhanced medical coverage). None of these factors has been tested in any prevention intervention.

Further Research

Despite the long history, international scope, and perceived risk of modern competitive fencing, remarkably few well-designed injury studies have been conducted. However, the research that has been completed indicates that, contrary to popular belief, fencing is very safe. The rate of time-loss injuries has been shown to be significantly lower than that for more popular sports such as basketball and soccer, but the majority of fencing injuries are similar to these sports, principally involving sprains and strains in the lower extremities. Although "fencing-specific" injuries, including penetrating wounds, are rare, they remain a major concern.

Given the current dearth of comprehensive epidemiologic data, there are numerous options for future research. However, the first step in this process is to develop broadly implemented surveillance systems, which use a standard definition of a reportable injury, appropriate exposure metric(s), and qualified data recorders, such as medical personnel, and which are directed toward answering a coordinated set of research questions. Principal among these are confirming injury rates for various subpopulations (children, youth, veterans, women, wheelchair) across all three events, and expanding analyses to explore specific risk factors (sex, age, training/experience, etc). Most urgent is the need to explore the antecedents of significant penetrating injuries and fatalities and to institute, and test, meaningful prevention programs to reduce or eliminate rare but catastrophic injuries. With the plethora of local, regional, and international competitions available, an important database could be achieved in a short period and strengthened with the addition of longitudinal data. Information related to the rate and risk factors of practice/training-related injuries will require additional research design efforts to accurately capture rate-based data.

The continuing growth of fencing indicates its enduring appeal as an athletic endeavor and places on researchers and medical personnel the onus to uncover the intricacies of fencing injury to allow participants to enjoy their sport for life.

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