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ORIGINAL ARTICLE

Injury profile of Longsword fencing in Historical European Martial Arts: a retrospective questionnaire study

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Summary

Introduction. Historical European Martial Arts (HEMA) are a mix of historical martial systems. It has been growing in popularity and research on HEMA–related injuries is lacking. Reliable data is necessary. The aim is to give insight in the most prevalent injuries of HEMA, determine whether or not fencing in full protective gear generates risk compensation behavior and which types of protective equipment are failing.

Material and methods. A retrospective questionnaire study in the Belgian – Dutch HEMA population, with questions about the obtainment of injuries, protective equipment modification and fencing intensities. Level of significance was chosen at 0,05%

Results. In terms of injury rate (IR), 60 participants (22,3%) obtained head injuries. 36,5% sprains, 28,3% strains, 10,4% fractures and 5,6% dislocations. 40,6% subungual hematomas (swordsman's thumbs/fingers). Total amount of upper body injuries and lower body injuries were significantly different as were fighting intensity with minimal (5,56/10) and full equipment (8,00/10) ($p<0,001$). Most acute injuries are located at the hand, wrist and fingers, while chronic injuries occur at shoulders, elbows, knees and back. The most prevalent issues on protective equipment were at the heavy duty gloves (29,9%) and fencing mask (12%).

Conclusions. HEMA has a specific injury profile other than other martial arts. Some of the current used protective equipment is lacking in safety. Frequencies of injuries can be reduced by proper mask fitting and more mobile hand protection is necessary. Full equipment fencing might be a victim of risk compensating behavior. More research is required.

Introduction

Historical European Martial Arts (HEMA) are a mix of historical martial systems in Europe [1]. Similar as eastern martial arts, they consist of a variety of armed/unarmed and armored/unarmored combat techniques with a variety of weapons like two handed longsword, one handed sword (with or without shield/buckler), rapier, dagger, long knife and pole weapons, whether or not armored. All can be combined with close-combat grappling techniques. These techniques are written down in historical manuscripts [1,2,3,4]. This martial art has been growing in the last few years and numbers of participants keep rising. It is the European counterpart of armed and unarmed eastern martial arts like kendo/kenjitsu, and judo/ju jitsu [5,6]. Martial arts can be divided in armed or unarmed sports. and striking, grappling or hybrid forms [7]. Depending on impact forces, combat sports can be further divided in light, medium or full contact [7]. HEMA is a hybrid martial art with medium to full contact. HEMA is closer related to Kendo (Japanese fencing) than Olympic Fencing since it is a full contact sport and the large impact forces [8]. Grappling techniques are comparable to those of judo and sumo [6].

HEMA tournaments are fought in 3-minute bouts where the opponents try to hit each other without getting hit, using skill, technique and distance management. Rules differ in organizations. Generally, Head and torso hits are the most valuable targets with 2 or 3 points and arms and legs 1 or 2 points. Fights and sparring sessions are quite intensive.

In this paper, we focus on unarmored longsword fencing or "blöss fechten", which is based upon the principle that none of the competitors would wear protective clothing or armor in real historical battle situation [1,2,5]. Armored combat consists of other techniques [1,2]. For the sake of safety HEMA fighters do wear protective clothing during sparring and tournaments. Currently used equipment are a fencing mask (as in classical fencing [3,4]), a “feder schwert” or lightweight sword, heavy duty fencing gloves (comparable to kendo gloves [8]), a padded gambeson/jacket and elbow, knee/shin, throat and groin protector (Fig. 1). Although current brands have developed good protective products, there still are some points of concerns as we will try to highlight.

Recently there has been a developing trend towards “blöss fechten” with minimal protective equipment, only wearing head and hand protection (Fig. 2). It is believed that here is less risk of injury due to a lower fighting intensity and less risk compensating behavior. Every sport is prone to this risk compensating behavior [9,10] which is a learning process that influences, alters or changes the way or intensity of sporting and can nullify preventive measures [9,10].

Prevention is a necessary first line of defense in sport related injuries. Good preventive strategies can reduce working day loss medical costs, prevent physiological and psychological stress and pressure in the victim and significant others [9,10]. Martial arts also have health benefits, such as improvement of strength, endurance, balance, flexibility, agility, body fat and body composition, hypertention, stress, relaxation, socialization, and internal diseases like coronary artery disease and diabetes mellitus [11,12].

Prevention has many biopsychosocial input factors with multiple biopsychosocial output factors or benefits [9,10]. Van Mechelen et al presented a 4-step model for injury prevention (sequence of prevention) in 1992 [13]. This model was modified by Van Tiggelen et al in 2008 [9] to a 7-step model. The first step is establishing the extent of the injury problem. The second is to find the etiology and mechanisms of the injury. Then preventive measurements can be formed (step 3), tested on efficacy (step 4), efficiency (step 5) and compliance and risk compensation behavior (step 6). In the final 7th step effectiveness is assessed by repeating step 1 [9]. Whether an injury occurs or not (injury risk) is the outcome of the attitude/risk compensation behavior, sportive and technical skills, training and training effects, coaching, environment and used equipment, knowledge of the athlete and the attitude, behavior, skills, training and knowledge of the opponent [9,10].

This study fits in the first and second step of the model of Van Tiggelen et al [9] and the multi-layered model described by McIngtosh [10]. The aims are 1) to investigate the profile of HEMA-related injuries considering longsword fencing, 2) the presence of risk compensation behavior 3) which types of protective equipment lack safety.

Material and methods

Recrutation

Belgian and Dutch HEMA federations were contacted and contact data of registered HEMA clubs were collected. For the homogeneity of the study only clubs that train in longsword fencing were included. Clubs and trainers were contacted personally, visited and flyers with the link to the online questionnaire were distributed. To help remember social media was used at regular base.

Questionnaire

The questionnaire consisted of several sections. General information about the athlete and his club (part 1), questions about head injuries (part 2), fractures on several body parts (part 3), sprains and dislocations (part 4), strains (part 5), specific injuries (part 6), “blöss fechten” (part 7) and tournament fighting (part 8). Control questions for double and non-HEMA responses were integrated. A combination of closed and open questions were used to gain as much relevant information as possible. A paper version was available.

The study was approved by the ethical committee of the University of Ghent, Belgium.

Statistics

Statistical analyses were done using the IBM SPSS Statistics 20 program.

Normality was tested using Kolmogorov-Smirnov and Shapiro-Wilk test. Then parametric or nonparametric tests were chosen. Basic statistics, frequency- and cross tables were used for the examination of injury frequencies. Whether an injury was related to the failure of protective material crosstabs and Chi² were used. Fighting intensity with full and minimal equipment was questioned by plotting experienced intensity on a 1-10 scale with 1 equaling minimal and 10 maximal intensity. For this analysis repeated measures were used. To analyze the severity of injuries obtained by “blöss fechten”, a modified Likert scale was used. Zero was identified as “Injuries are/were equally severe to full equipment fighting”. 1,2,3,4 were identified as “Injuries in full gear fighting are/were more severe” and -1, -2, -3, and -4 as “Injuries in fighting with a minimal gear are/were more severe”. Higher absolute score equaled higher severity.

Results

We had 279 responses or 75% of the active Belgian-Dutch longsword training HEMA population. Two were excluded for being less than 17 years old and another seven because the participants reported medical conditions that might give them more chances for injuries (e.g. chronic rheumatic diseases). Analyses were done on 268 responses. None of the variables showed a significant difference between males and females ($0{,}150<p<0{,}989$).

Basic sample characteristics

Basic sample characteristics are shown in Tab. 1 and 2.

Global injury characteristics

In terms of injury rate (IR) 60 participants (22,3%) obtained at least one head injury. 98 (36,5%) got at least one sprain, 76 (28,3%) muscle strains, 28 (10,4%) fractures and

Tab. 1. Sample characteristics

Variable	Subcategory	N
Sex	Male	218
	Female	53
Hand dominance	Right	245
	Left	23
Blöss fighting		153
Tournament fighting		102
Other M.A.		137

Tab. 2. basic descriptive statistics, age, height, weight, and BMI

Variable	Mean	SD
Age	29	8,33
Height (cm)	180,31	9,38
Weight (kg)	80,04	15,25
BMI	24,57	4,07

15 (5,6%) a dislocation. Small and big bruises and contusions were present in respectively 157 (58,6%) and 77 (28,7%) persons. 109 (40,6%) participants reported subungual hematomas of thumbs and fingers (swordsman's thumbs/fingers). All injuries are listed in Tab. 3 and 4. In total 177 sprains, 116 fractures, 114 strains, 22 dislocations and 90 chronic injuries were recorded. Often more than one injury type was present within the same victim.

Anatomical location

Total upper body injuries (2,5 per person (SD= 2,4)) were significant higher than lower body injuries (0,5 p.p (SD= 0,8) p<0,001). 39 (14%) participants reported no injury. Trunk injuries were rare (<5%).

Most prevalent head injuries were (mesh) impact injuries due to improper fitting of the helmet (N= 33; 50 % of total head injuries; 12% of participants) or high head impact forces (N= 32; 50%; 12%). Chi² and crosstabs analysis showed a link between the presence of a head injury and the failure of the fencing helmet (helmet shifting or no proper force damping (Pearson Chi², 116,03; Nominal Phi 0,658; p<0,001)). No dental, eye or ear injuries were recorded. One skull fracture and three cases of tinnitus were mentioned without specification.

Injury type

Sprains were the most prevalent injuries (IR= 36,5%). Most frequent sprained joints were the ankle (N=40; 22,6% of total sprains; 14,9% of participants) and fingers (N=39; 22%; 14,5%) followed by shoulder (N= 19; 10,7%; 7,1%), wrist sprains (N=16; 9,0%; 5,9%) and knee sprains (N=15; 8,8%; 5,5%). All other injuries are listed in Tab. 3. 22 dislocations in 15 persons (IR= 5,6%) were reported, with the shoulder joint being the most frequent (N= 10; 45%; 8,1%).

Strains (IR= 28,3%) were also highly prevalent with most frequent sites being the shoulder muscles (N=22; 19,2% of total strains; 8,1% of participants), muscles of the forearm (N= 15; 13,1 %, 5,6%) and posterior chain muscles like the hamstrings (N= 13; 11,2%; 4,8%). All other are listed in Tab. 3.

Fractures were less prevalent (IR= 10,4%). Finger fractures were the most prevalent (N=35, 30,2% of total fractures; 13,1% of participants) followed by fractures of the hand (N=13; 11%; 4,8%), shoulder (N= 13; 11%; 5%).All other are shown in Tab. 3. Frequent reported chronic injuries are aspecific knee pain (N= 28; 10,5% of participants) recurrent shoulder tendinopathy (N=17; 6,3%), elbow tendinopathy (N=14; 5,2%), Achilles tendinopathy (N=7; 2,6%) and sore back (N=16; 6%).

Other injuries

Specific injuries are listed in Tab.4. Although mild bruises were the least severe or threatening of all reported injuries, they were by far the most prevalent of all (N=157; 58,7% of participants). Subungual hematomas (Swordsman's thumbs/ fingers) had a high prevalence (N=109; 40%). Chy² tests showed that subungual hematomas are significantly linked with failure of heavy duty sparring gloves (Pearson Chi² value= 44,1; p<0,001; Nominal Phi value 0,406; p<0,001). Puncture injuries were rare (N=4; 1,5%).

Material failor

In total 120 material failures were recorded. The most prevalent issues were with the heavy duty gloves (N=80; 66,6% of failures; 29,9% of participants) and helmet (N=33; 27,5%; 12%). Others were recorded gambeson or knee protection failures (N= 7; 5,8%; 2,6%). Most injuries due to equipment failure are finger injuries and swordsman's thumbs. In one case a blade penetrated a heavy glove. 165 (61,3%) persons declared that current heavy gloves are not mobile enough and executing technique properly can be difficult.

Materials that are the modified are heavy duty gloves (N= 60; 22% of participants), jackets (N= 27; 10,1%) and helmets (N=21; 7,8%). There is a trend towards significance when helmet problems are compared to helmet modifications. (Pearson Chi² value 2,78; p= 0,095; Nominal Phi 0,102; p=0,095).

Tab. 3. Injury Frequencies, N= number of cases ;injury%, percentage injury location / injury type; % IR = global injury rate.

Fracture	**N**	**Injury%**	**IR%**
Head region	1	0,8	0,4
Neck region	1	0,8	0,4
Upper/lower back	1	0,8	0,4
Ribs	7	6	2,6
Hip	1	0,8	0,4
Femur	3	2,6	1,1
Knee	2	1,7	0,7
Tibia/Fibula	1	0,4	0,4
Ankle	4	3,5	1,5
Foot	3	2,6	1,1
Shoulder	13	11,2	4,9
Humerus	8	7	2,9
Elbow	4	3,5	1,5
Underarm	9	7,7	3,4
Wrist	10	8,6	3,7
Hand	13	11,2	4,9
Fingers	35	30,2	13
Sprain - dislocation	**N**	**Injury%**	**IR%**
Head region	0	0	0
Neck region	1	0,5	0,4
Upper/lower back	4	2,2	1,5
Ribs	13	7,4	4,9
Hip	0		
Knee	15 - 5	8,5	5,6 – 1,9
Ankle	40 - 1	22,6	14,9 – 0,4
Foot	12	6,8	4,5
Shoulder	19 – 10	10,7	7,1 – 3,7
Elbow	4	2,2	1,5
Wrist	16 - 2	9,0	6 – 0,7
Hand	14	7,9	5,2
Fingers	39 – 4	22,0	14 – 1,5
Strain	**N**	**Injury%**	**IR%**
Head region	0	0	0
Neck region	11	6,2	4,1
Upper/lower back	12	6,7	4,4
Intercostal	1	<1	<1
Hipmuscles	3	1,7	1,1
Hamstrings	13	7,3	4,8
Quadriceps	5	2,8	1,8
Triceps Surae	12	6,7	4,4
Anterolateral lowerleg muscles	0	0	0
Foot	1	<1	<1
Shoulder	22	12,4	8,2
Pectorais	1	<1	<1
Biceps	10	5,6	3,7
Ticeps	4	2,3	1,52
Forearm	15	8,4	5,6
Fingers	2	1,1	<1

Tab. 4. specific injuries

Injury type	N	% of sample
Swordsman's thumb	109	40
Mild bruises	157	58,6
Big bruises	77	28
Failure of gloves	49	18,3
Shoulder tendinopathy	41	15,3
Elbow tendinopathy	12	4,5
Achilles tendinopathy	5	1,9
Other	5	1,9
Penetration injuries	4	1,5

in the open questions some of the participants explicitly mentioned modifying their helmet after being injured (N= 5 for helmet; N=10 for gloves) so we tend towards the hypothesis that material is modified after injury. Reasons why material was modified were injuries (N=15) reparations (N=10), fitting (N=10) or financial reasons (N=3).

Blöss and tournament fighting

We compared the fighting intensity with minimal and full equipment fencing using a repeated measure t-test and the experienced severity of the injury with a one sample test in which the Test Value was "0" (no difference in severity). Mean fighting intensity was significantly lower in blöss fechten (5,56/10; SD=1,97) than in full equipment fencing (8,00/10; SD=1,42) with $p<0,001$. The mean injury severity was 0,67 (Test Value 0; $p<0,001$).

102 participants participate in tournaments. 17 of them (16,7 %) declared that tournaments are won with too much force and to little technique.

Discussion

The results of this study fit in prevention project in historical European martial arts focused on longsword fencing. The results have to be interpreted in that way.

Injuries

Most prevalent injuries were sprains, strains, contusions and subungual hematomas (swordsman's thumb/fingers). Less frequent were head injuries, fractures, dislocations and penetration wounds. Head injuries were often the result of inadequate fitting of the helmet. Penetrating injuries are rare due to the rounded tip of the sword giving it more surface area and less pressure that can cause penetration. Upper body injuries were significant more frequent than lower body injuries.

In general, our results are consistent with other studies regarding martial arts where contusions, sprains and strains are the most frequent injuries followed by fractures and dislocations [8,11,14-21]. In most martial arts that favor head or high hits, head injuries are frequent [14-20]. In our study however, as also seen in kendo [8] and classical fencing [3,4], severe head injuries are rare suggesting protective gear protects enough against severe injuries. Yet the current injuries could be prevented. Most of the head injuries are caused by improper helmet fitting and high impact forces. It is known that inadequate fitting of helmets can cause head injuries [22]. Added padding may help in distributing the head impact forces [23-26] and give better fitting [22]. Differences in injury profiles in different martial arts exists [14-20]. In general, most injuries in striking martial arts are at the lower body [14-20] and in grappling sports at the upper body [17,18]. In our study most injuries were done to the upper body. Geometrically one can hit his or her opponent from a larger, thus safer, distance when aiming for the upper body rather than the lower body (überlaufen). Thus most of the hits are at the upper body and head. So it is to be expected that there are more injuries to the upper body.

A high amount of ankle strains was recorded. Sports with high intensity and sudden movement changes have an increased risk of ankle strains. This is also the case in martial arts [3,4,14-21,30]. Incorporating stability training in (footwork) training might be beneficial [30]. Shoulder sprains-, strains and tendinopathies as well as elbow tendinopathies were also highly prevalent. High load during swift shoulder movements are one of the factors of obtaining chronic shoulder injuries [30,31]. Guards, blows, thrust and sword-on-sword impact might generate high loads of forces in the shoulder and elbow joint and might weaken the muscles due to micro traumata [10]. This decrease of load tolerance combined with high loads can evolve in an injury [10]. Preventive program focused on limiting the decrease of load tolerance can be beneficial [10,30]. Further core, hip and knee muscle function are associated with chronic knee pain [30,32]. A preventive program on core, hip and knee muscle function might help prevent the development of injuries [3,4,18,30,32].

Hand injuries are frequent and multilayered problem in our study. There is the equipment failure, the fighting intensity and lack of technique, combined and the immobility of heavy duty fencing gloves. Subtle movements of hands and fingers are crucial for executing proper parry techniques [1,2,5,6]. When techniques are more difficult to execute, it is possible that fighters compensate by fighting more forcefully and with less technique. More than half of the test persons declared having mobility issues in the heavy gloves and preferring the more mobile yet less safe gloves. More mobile gloves might permit more technical and skilled fighting since skills and technique in martial arts are a big determining factor in the development of injuries [4,7-10,19]. Many sports have their specific injury mechanisms [21,32-34], either self or opponent inflicted. Like the boxers knuckle/fracture [30], "arm bar" injuries in grappling sports [21] , mallet finger in ball [35], jumpers knee in jumping sports [36]runners knee in running sports [37], throwing shoulder [38] in throwing sport. Each with its specific mechanism [35-38] and preventive measurements [9,10,35-38]. One specific injury in our study is the subungual hematoma or "swordsman's thumb/finger". This is an injury at the apex of the finger as an impact trauma. This injury is also known in Olympic classical fencing [3,4]. We like to recognize the swordsman's thump/finger as a sport specific fencing injury. Recognition of sport specific injury can lead to faster and proper intervention [9,10]. Hand and finger injuries with large impact forces are not to be underestimated in terms of severity and treatment [39]. but are often neglected in treatment, yet nails and fingertips play an important role in hand function [39,40].

Equipment and rules

Further our results state that fighting with less protective equipment seems less intensive and less dangers. risk compensation behavior is present in a lot of sports both martial and non- martial sports [9,10]. In case of tournaments and settings, a frequent respond was that tournaments are fought on a high intensity, forceful and sometimes technique lacking manner. With less intensive mindsets, fights may be less forceful and techniques may be executed better and safer. Comparable results were found by Arriaza et al in 2009 in karate [41]. When the rulesets that favor technique, more complex technique are used and injury rate decreases. But changes are to be made since changes can be either positive, non-effective or negative [9,10,42].

Training

Blöss fechten training can be integrated in regular training to develop this certain mindset. In karate, kendo and judo there are among others two distinctive ways of training. Kata [43-46,49] and kumite (sparring) in karate [43-46] or randori/geiko in judo [46-48] and kendo [48]. A "kata" is a theoretical/technical fight [43,45]. Most of the techniques used in HEMA are based upon techniques and plays that are written down in manuscripts [1,2,5]. These plays can be used in a similar way as a kata, kata tournaments or teaching tool. These are safe since only 4% of injuries occur during kata [19].

Blöss fechten and play-forms can be incorporated in skill training and intensity management training and tournaments for more technical fighting. It is believed intensity rather than contact hours alone are important in determining risk [14]. So managing intensity in tournaments and training by fighting with more conscious and/or rule sets that favors techniques above intensity can deliver more technical, tactical and safer fights in the future.

The place of hema as a martial art

In terms of sport and martial art HEMA is more comparable to kendo since kendo is more of a full contact sport and preformed with both hands [8,48,48] rather than Olympic fencing that only permits tip contact and one handed preformed with less variation in guards [1,3,4,27-29]. Research has shown that acute ankle and chronic non-specific shoulder and knee injuries are among the most prevalent injuries in both martial arts. Yet acute hand and acute shoulder injuries and are more common in HEMA then in Olympic fencing and kendo. A lot of Olympic fencing [3,4] and a kendo [8] injuries are unilateral. In our study we could not determinate weather like in classical fencing and kendo there is a side preference for some injuries. it makes a unique injury pattern.

Limitations

Firstly, this is a retrospective study. The amount of injuries thus is linked to years of experience and injuries might be remembered slightly different or been forgotten and more skilled fighters tend to have more injuries due to accumulation. This is one of the first studies in HEMA so there might be an urge of proof. Furthermore, little info was collected about injury mechanisms.

Conclusions

The injury profile is unique when compared to other martial and fencing arts.

1) The most prevalent acute injuries are contusions, strains, sprains. Ankle, hand, and shoulder are the most common site. Chronic injuries are mainly shoulder, elbow and to a lesser degree knee problems.
2) Protective material is often failing. Helmet fitting and gloves are the main problem.
3) Risk compensation behavior might be present in HEMA.
4) Tournaments need to be fought with more techniques. More research is necessary on all topics.

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