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The characteristic of injuries among combat sport athletes in particular disciplines

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ABSTRACT

Background. The frequency of related injuries is growing. Traumas affect people of all ages, both professionals and amateurs. However, they vary and their characteristics differ significantly depending on the discipline.

Aim. The objective of the present study was to elucidate the variability in injury patterns across different combat sports to improve athletes' safety and contributing to the mitigation of injury risk in combat sports,

Material and methods. We analyzed over 40 scientific articles contained in the PubMed database. We related the collected data to parameters such as specific discipline, gender, age, injury mechanism, location, and, in some cases, required treatment and presented the results in the form of paragraphs.

Results. In Taekwon-do and Judo injuries mostly occurred in lower limbs. mainly in knees. In karate mostly refer to foot and ankle. Hands were mostly injured in Boxing. MMA competitors mostly experienced wrists and hands traumas. Head injuries occurred most often in Boxing, Kickboxing, Karate, MMA. Many of those traumas were connected with neck injuries. In TKD there were mainly joint sprains or dislocations. Soft tissue contusion was the most common in boxing. Most common in kickboxing were lacerations and fractures. In Karate mostly occurred

contusions and lacerations. MMA injuries were mostly: lacerations/abrasions, fractures, nerve injuries.

Conclusions. Injuries in combat sports are a very broad and diverse issue. Particulars disciplines show many similarities in this regard, but also differ significantly in terms of specific parameters. The characteristics of injuries in combat sports should be carefully analyzed based on a division into disciplines which may increase the safety of athletes.

Keywords: injuries, martial arts, combat sports, traumas, taekwon-do, boxing, kickboxing, karate, mixed martial arts, judo, protective gear

1. Introduction

Combat sports are becoming an increasingly popular form of sport. Younger and younger people begin their adventure with these disciplines. Despite having one common name, martial arts encompass many different disciplines. They differ in terms of fighting rules, protective gear used, and training specifics, which may be associated with different risks of injury. This article is the review of studies aimed at describing the differences and similarities in the epidemiology of injuries in combat sports depending on the discipline. We focused on: Taekwon-do, Boxing, Kickboxing, Karate, Mixed Martial Arts.

2. Research materials and methods

We analyzed over 40 scientific articles contained in the PubMed database. We took into account data from both meta-analyses and original studies on injuries in combat sports. We then related the collected data to parameters such as specific discipline, gender, age, injury mechanism, location, and, in some cases, required treatment. We presented the results in the form of paragraphs referring to specific disciplines so that they would be clear and easy to analyze.

3. Results

3.1 Taekwon-do

Taekwon-do (TKD) is a famous combat sport known as one of the most popular martial art. This is an Olympic discipline. TKD athletes are well trained in high kicks, which makes this sport an unique form of fighting. There are 2 main types of Taekwon-do: World Taekwon-do Federation (WTF), International Taekwon-do Federation (ITF) [1,2]. Those types differ in rules and used equipment. Most often described in literature is WTF, but in this article we analyzed data about injuries among athletes in those both TKD types. In literature most often described location of injuries among TKD athletes was lower limb. Zdaniewicz et al. collected data about 119 athletes from Covid-19 pandemic and described that most often injuries referred to knee (n=10), ankle (n=8), foot (n=8) and thigh (n=6). Less frequently injuries occurred in upper limb: shoulder (n.=6), wrist (n.=3), the upper arm (n.=2), a finger (n=2), and the rarest location: the forearm (n=1). Most often reported type of injury was joint sprain or dislocation (N.=18), then muscle strain or tear (N.=12) [3]. Similar observations had Noh et al. who noted that knee injuries constitute more than a half of TKD injuries. They noted the main injury type as contusion (71%) or fracture (68%) [4]. Jeong et al. collected data from 3 World TKD Championships and also observed that most affected areas were knee (2.33 per 1000 min exposures in 2017, 0.76 in 2019, 1.78 in 2022), thigh (1.27 per 1000 min exposures in 2017, 0.76 in 2019, 1.07 in 2022), and ankle (1.27 per 1000 min exposures in 2017, 0.51 in 2019, 0.53 in 2022) [5].

Mark McPherson et al. found knee injuries as main reason of trauma in martial arts (referred to 41% of athletes) [6]. Son et al. noted also highest injury incidence in lower limb but he observed more often injuries of ankles (20,8%) and feet (21,4%) than knees (15%). They describe 3 main trauma mechanisms: ligament sprain (27%), contusion (24,7%), fracture/stress fracture (21%) [7]. Similar results had Lee et al.. They observed that ankle was most frequent body location of injuries (20.4%), next were foot (17%), finger (11%) and hand (11%). Most common mechanisms of injuries were contusion (40%), sprain (38%), strain (11%), laceration (4%) [8]. Blanco et al. analyzed many studies and also found that lower limb injuries were the most frequent (51-80% in various studies), followed by upper limb (10-25%) and finally head and trunk (10%). The most common injury types were sprains and strains (35- 60%). Contusions accounted for 15-30% of cases [9]. In contrast to other authors Ziaee et al. observed the highest frequency of upper limbs injuries. They highlighted that 43% of all injuries involved the upper limb, which was opposed to the lower limb (42%) [10].

Most dangerous type of injury is the head trauma. Among TKD athletes it is rare, which was proved in many researchers. One of them conducted Kazemi et al. who noted that head injuries constituted 3.6% of all injuries in TKD [11]. TKD requires from athletes highly advanced flexibility. This discipline is spectacular but also demanding in terms of both technical difficulties and the risk of injury.

3.2 Boxing

Boxing is connected with high-intensity fighting and a significant number of blows taken. Mao et al. analyzed injuries among boxers noted in articles through years in 21st century. They described injuries among professional and also amateur boxers. They reviewed more than 8000 records and qualified to final analysis 14 studies. They noted significantly lower incidence rate of injuries per 1000 competition exposures among amateurs (233.3 was identified (95% CI, 161.3-305.2, $P < .001$) than professionals (379.8; 95% CI, 254.0-505.5; $P < .001$). They separated 6 types of injuries: concussion, laceration/abrasion/skin lesion, soft tissue contusion/hematoma/bruise, sprain/ muscle/ligament injury, fracture, and dislocation/subluxation. Mean concussion frequency was 12.3% (95% CI, 8.7%-15.9%) and they didn't describe significant difference between the amateur and professional boxing. Soft tissue contusion was the most common injury which constituted 30.2% (95% CI, 22.1-38.2) of injuries in both groups: amateur or professional boxing. Moreover soft tissue contusion was even more frequent among female boxers (67%-90%). Musculoskeletal Injury constituted: 15.3% (95% CI, 7.7%-21.9%) of all boxing injuries in case of sprain/rupture of the muscle or ligament, synthesized frequency was 11.4% (95% CI, 2.7%-20.1%) in case of fractures, dislocation/subluxation and nerve injuries occurred with the frequencies of only 3.4% and 3.2%. The other injuries like meniscal or cartilage injury, aponeurosis injury, impingement occurred with 5.2% frequency (95% CI, 2.9%-7.6%) [12]. Lemme et al. also described injuries among boxing athletes. In their article they highlighted that hand fractures were most common types of injuries, mean 132 per 100,000 person-years (95% CI 130-135) [13]. Siewe et al. also noted that most common boxing injuries referred to upper limbs and moreover head. Most common types of injuries were soft tissue lacerations and contusions. Neurological symptoms connected with head injuries occurred with 4.2% frequency. The injury rate was 12.8 injuries per 1 000 h of training. More than 3 bouts per year were connected with higher risk of injuries ($p=0.0075$). The injury rate wasn't connected with athletes' age [14]. Moeller et al. focused only on craniofacial injuries. They described the boxing injuries treated on emergency department

between 2010-2019 years. They noted most frequently: facial fractures n=4996, (45.1%), concussion n=4292 (38.7%), facial laceration n=1796 (16.2%). Moreover they highlighted that most often facial injuries occurred between 15 and 20 years old (n=5292, 47.7%), which was the evidence that there should have been better facial protection for adolescents [15]. Alevras et. al described only amateur boxing. They described head and neck injuries as most common ones (median: 72 %; range: 46 % to 100 %). Further injuries referred to upper limb (median: 49 %; range: 40 % to 53 %). Most common mechanisms were contusions (median: 35 %; range: 5 % to 100 %) and lacerations and abrasions (median: 20 %; range: 0 % to 69 %) in the competition setting, and sprains and strains (median: 60 %; range: 50 % to 81 %) in the training setting [16].

Based on previous articles we noted that boxing injuries mainly refer to head, neck and upper limbs. It is connected with the fighting rules in this particular discipline. Those results highlighted the value of well fitted protective equipment to prevent severe injuries especially among adolescents. Head traumas could have a significant impact on a young person's development.

3.3 Kickboxing

Kickboxing athletes during a fight can not only box but also kick, which may involve a potentially higher risk of lower limb injuries. This discipline is connected with heavy knockouts because of high athletes performance and their diverse abilities. Lystad analyzed in descriptive epidemiology study the profile of injuries among kickboxing athletes. They described data came from 481 athletes. Most common body region touched by injuries was a head (n=115, 57.8%), second most common region was lower limb (n=52, 26.1%). Most common types on injuries were lacerations (n=96, 70.6%) and fractures (n=28, 20.6%). In compare to amateurs, professional athletes had 2.5 times higher risk of injuries, moreover defeated athletes experienced injuries 3.5 times more often than winners [17]. Romaine et al. had similar observations. They noted the highest injuries rate of back, knee and ankle injuries. Most common mechanisms of injuries were strains, sprains, tendinitis [18]. Because of high incidence of head injuries among kickboxing athletes Biagi et al. focused on traumatic dental injuries. They noted that main types of dental injuries in kickboxing were 55% crown fracture (67% males and 45% females), 28% tooth avulsion (22% males and 33% females), and 17% tooth luxation (11% males and 22% females) [19]. Pater et al. also collected data about maxillofacial trauma in kickboxing. They analyzed questionnaires from 92 athletes. 71.7% of

athletes had experienced at least one maxillofacial injury. Most common part of face affected by injuries was the lip (26.1%; $p < 0.05$). Protective equipment played significant role in decrease in injuries incident: headgears (2.1 Injury rates per participant) , mouthguards (2.6 Injury rates per participant), in compare to no protection (4.7 Injury rates per participant) [20]. Authors highlighted the value of a mouthguard to reduce the number of sever dental and facial injuries in combat sports which was mentioned before in this article. As in boxing, kickboxing should be taken into consideration as highly risky discipline, especially in case of head traumas. This is significant among adolescents.

3.4 Karate

There are many Karate styles but in this review we analyzed all karate injuries as one group. This is very efficient form of fighting. Karate athletes can resist many blows. This condition is connected with high injury risk. Lystad et al. conducted a meta-analysis of Olympic-Karate injuries. Most common injured region of the body was head and neck with median frequency 57,9%. As most frequent types of injuries were reported contusion (median: 68.3%) and laceration (median: 18.6%). Moreover authors observed that karate athletes experienced injuries on average 1 time /11 exposures [21]. Aziz et al. collected data from 119 karate athletes. They noted that 64,3 % of injuries occurred during training sessions. They highlighted that 87,6 % of all injuries were mild. Most common trauma referred to head and neck (24%) which was in the line with other authors. Less frequent were injuries of the ankle (10.1%) and foot (10.9%). Sprain/strain were found as most frequent mechanism of injury (42.6%). Moreover most injuries occurred during striking of the opponent (48,1%) [22]. Garcia-Isidoro et al. conducted descriptive epidemiology study. They collected data from martial arts athletes included karate. Among karate competitors they noted that most frequent injuries occurred in lower parts of lower limbs (9,95%), especially in mechanisms of sprains and joint injuries (4.98%) [23]. Pérez-Martín et al. focused only on knee injuries in karate. They surveyed 293 athletes. 24.2% of them had ever had serious knee injury mostly in the mechanism of pivoting or dodging [24]. Čierna et al. described injury incidence among younger karate athletes. Most common occurred face injuries (69.6%), especially minor ones, with the following mechanisms: light abrasions 24.5%, epistaxis 24.1%, contusion 16.7% [25]. Ziaee et al. analyzed data only from karate training and found that the most common injury locations were: head and neck area (61%), trunk (24%), lower limb (12%) and upper limb (9%). Most prevalent injury types were: contusion, redness, bruise, superficial scratch (64%) [26]. In older researchers authors had

similar conclusions as currently. Destombe et al. noted that most often occurred lower limb injuries (35%) and with high frequency also head injuries (26.5%). Nevertheless they noted high frequency of the upper limb injuries (28.9%), which was contradictory to current new researches [27].

3.5 Mixed Martial Arts

Mixed Martial Arts (MMA) are one of the most brutal and bloody combat sports. Risk of injuries among those athletes is significantly high. They use every technique coming from disciplines mentioned above. Usually fights end before the final round because of the heavy knockouts. MMA fighters often require medical support after every fight. Thomas et al. conducted the review and found that incidence rate ranged from 101.9 to 246.4/ 1000 Athletic Encounters (AE). Injuries occurred most often in professionals (135.5/1000AE) than in amateurs (71.0/1000AE) [28]. Lystad et al. analyzed data from many studies and described the features of MMA injuries. Most common body region affected by injuries was the head (66.8% - 78.0%), followed by wrist and hand (6.0% to 12.0%). The types of injuries were as follows, according to their frequency of occurrence: laceration/abrasion (36.7% - 59.4%), fracture (7.4% - 43.3%), nerve injury (included concussion) ranging from 3.8% to 20.4%. Authors highlighted that injury incidence rate per 1000 athlete-exposures amounted to 110.4-473.5. Those numbers are significantly higher than in other combat sports [29]. Because of frequent head injuries among MMA athletes, Fares et al. focused only on craniofacial and traumatic brain injuries. Head injuries occurred in the frequency of 35 injuries per 100 athletic-exposures. Moreover most common types of injuries were traumatic brain injuries (16 per 100 athletes exposures). Fractures were characterized by significantly lower frequency. Injury rate depended on gender: males (injury rate of 37 per 100 athletes exposures), females' injury rate was 23 per 100 athletes exposures [30]. Similar results had Parekh et al. who noted that male athletes were 3.69 times more likely to get injured than female. Authors highlighted the role of proper protective gear. There should be taken into consideration long-term complications and negative results of head trauma especially among adolescents [31]. Jensen et al. described the diversity of techniques which can be used in MMA fight. Athletes who more often fought with opponents specialized in techniques from striking disciplines (boxing, karate, and Muay Thai) had high rates of head and facial injuries, but athletes who fought with opponents specialized in techniques submission disciplines (Brazilian jiu-jitsu, judo, and wrestling) had higher rates of joint injuries. Their results stood in the line with other authors because they described following frequency of

injuries connected with particular body region: the head/face (66.8%-78.0%), the wrist/hand (6.0%-12.0%). The most frequent injury type were skin lacerations (36.7% - 59.4%), fractures (7.4% - 43.4%) and concussions (3.8% - 20.4%) [32]. Fares et al. focused on second most common of MMA injuries region: upper limb. They noted that hand was the most commonly injured location (6.61 per 100 athletes-exposures). The rate of upper limb injuries was 9.9 per 100 athletic-exposures. Those authors highlighted the value of proper gloves in potential decreasing in hand injuries in future [33]. We mentioned above the risk of head traumas in Boxing and Kickboxing, but in those disciplines athletes use significantly bigger gloves than in MMA. In MMA fighters usually fight in light gloves with uncovered fingers. Their punches are faster and more dangerous than in other combat disciplines. They can not use helmets but only mouth guards, which is connected with many traumas.

3.6 Judo

Judo is very popular, Olympic sport, connected with very dynamic and strong fighting style. Those rules are connected with the risk of injuries. Mooren et al. conducted the research about injuries during Judo tournaments. They found that there were very wide range of injury incidence depended on particular study. Injuries which required medical treatment occurred with the incidence 2.5%-72.5%. Locations of traumas differed depended on study, but joint sprain was the most common mechanism of injuries. In their research injuries which caused time loss occurred with the incidence 4.2- 60/1000 athlete exposures [34]. Błach et al. assessed the frequency of Judo injuries during top-level competitions in Europe through 15 years. They noted that most common injury locations were knee (17.4%), shoulder (15.7%) and elbow (14.2%). Elbow injuries significantly more often occurred in female athletes. Most common types of injuries were sprain 42,2%, contusion 23,1%, luxation 8,8%. Moreover Unconsciousness occurred in 6,8% of all injuries [35]. Neck injuries are not as common as limbs injuries in judo, but can be very serious. Nakanishi et al. analyzed only neck injuries and noted that serious neck traumas accounted for only 2% to 4% of all neck injuries in Judo. They highlighted that the mechanism of neck injury could differ depends on used thrown technique [36]. Injuries in Judo also applied to high experienced athletes (30-65 y.o.). Carvalho et al. observed that most common injured regions were knee (19 %) and shoulder (18 %). They were also connected with the highest number of surgical treatment (knee, 6 % and shoulder 2 %, $p < .001$) [37]. To prevent Judo injuries valuable is the knowledge not only about injuries locations and mechanism but also about the crucial moment during the fight. Błach et al. found

that in the combined second half and last minute of combat occurred most of Judo injuries. In male athletes injuries were most common during the first and second halves, but females experienced a higher frequency of injuries during the last minute of match [38].

4.7 The value of protective gear

Injuries in combat sports are relatively common and varied, as we have shown in this article. Some injuries heal quickly, while others require long and difficult recovery, and sometimes even mean the end of a sports career or disability. Therefore, attention should be paid to ways of reducing the number and frequency of injuries in combat sports. In addition to adequate knowledge of physical preparation, warm-ups, and training methodology, it is extremely important to use protective gear regularly. Gotlieb et al. recommended the mandatory use of head and face protective gear among children in boxing. They highlighted that this attitude could possibly reduce the number of facial injuries among the youngest athletes [39]. Vidovic-Stesevic et al. have also mentioned the role of education about wearing protective gear in martial arts especially in karate [40]. Štyriak et al. in their research proved that protective gears and proper rules could significantly decrease the risk of injuries, but they also highlighted that there was the lack of studies and this issue have required further analysis and wider reviews [41]. Many athletes treat protective gear as an unnecessary equipment. It is highly valuable to know how risky are combat disciplines but with the effective preparation we can reduce a danger.

4. Discussion

Injuries differ in body regions. Most often Injuries occurred in lower limbs among Taekwon-do athletes. It is caused by the fighting rules. This discipline is famous of highly efficient kicking technics. Mainly Taekwon-do injuries refer to knees. Similar observations had authors who analyzed injuries in Judo. In kickboxing knee injuries were second most common trauma among athletes. Lower limb was also the second most common injury region among Karate athletes. But in contrast to Taekwon-do and Judo, in karate injuries mostly refer to foot and ankle. Upper limbs were mostly injured in Boxing. They referred to hands. In MMA upper limb injuries were second most common. MMA competitors mostly experienced wrists and hands traumas. If upper limb was injured in Judo it was usually elbow or shoulder. The most dangerous type of sport trauma which can be potentially fatal, is head injury. Those types of combat-related injuries were occurred with high incidence rate in Boxing, Kickboxing, Karate MMA. Only in TKD and Judo it was rare. Many of those traumas were connected with neck

injuries. Range of head traumas types was very wide. From facial laceration, through facial fractures and dental traumas to traumatic brain injuries.

The diversity of injuries concerns not only their location but also the mechanism of their occurrence. In TKD there were mainly joint sprains or dislocations then muscle strains or tears. Moreover authors described contusions and fractures as common mechanisms of TKD trauma depends on study. Soft tissue contusion was the most common injury in boxing. Musculoskeletal Injuries constituted in case of sprain/rupture of the muscle or ligament were second most common. Most common types on injuries among kickboxing athletes were lacerations and fractures . Second most common mechanisms of injuries were strains, sprains, tendinitis. Karate athletes most common suffered from contusions and lacerations. Sprain/strain were also found as frequent mechanism of injuries. The types of MMA injuries were mostly: lacerations/abrasions, fractures, nerve injuries (included concussions). Because of Judo rules, joint sprain was the most common mechanism of injuries. Combat sports have many common injuries mechanisms but their severity and incidence rates differ significantly. The require protective gears should be clearly defined in fighting rules in every discipline. Because of diverse trauma mechanisms, protective gears have to be efficient and shouldn't make fighting more difficult. This condition is highly crucial in case of head traumas especially young athletes. Their development could be impaired because of fighting related traumas. Many authors focus only on particular discipline. We took into consideration many types of combat sports. This is valuable for further investigation a out the safety of all combat sports. The value of sport lies in the balance of health and recreation except additional risk. Every martial art is connected with traumas, but thanks to knowledge about their mechanisms coaches and athletes could implement solutions that will prevent further injuries and improve safety. Safety should be the basis of sport, especially among young athletes. Sport should be the main weekly habit among adolescents. It is one of the most effective prevention of obesity, cardiovascular diseases and diabetes [42,43].

5. Conclusions

Injuries in combat sports are very diverse, as we have shown in our article. They affect different parts of the body, require different treatments, and necessitate various therapies, from simple cooling to even life-saving surgery. For sport it is essential to minimize the risk of injury through the use of appropriate protective equipment and adapting the rules of combat and training to the skill level and age of the competitors. To achieve this, it is necessary to have

knowledge about the characteristics of injuries in a particular discipline, as described above. The issue of injuries in combat sports requires constant analysis, data collection, and reliable conclusions in order to properly care for the health of athletes, both amateur and professional. This knowledge could be valuable for coaches and athletes. Responsible attitude to sport is the clue of healthy lifestyle. Especially wide analysis is required for adolescents athletes who are highly at the risk of negative developmental consequences resulting from injuries.

Disclosure

Author's contribution

Conceptualization MZ and AO; methodology JA; software MM; check BC,AB and JJ; formal analysis, ZG; investigation PK; resources MZ; data curation ZG; writing - rough preparation MZ; writing - review and editing MZ; visualization BC; supervision JS; project administration MZ. All authors have read and agreed with the published version of the manuscript.

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Declaration on the Use of Artificial Intelligence

AI-assisted tools were used exclusively for linguistic refinement. The authors take full responsibility for the scientific content, interpretation of the data, and final version of the manuscript.

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