

# LOCOMOTOR INJURIES IN COMBAT SPORTS: SYSTEMATIC REVIEW

Mladen Živković<sup>1</sup>, Amel Mekić<sup>2</sup>, Slobodan Furunović<sup>1</sup>, Nikola Stojanović<sup>1</sup>, Nikola Milošević<sup>1</sup>,  
Anđela Došić<sup>1</sup> and Danijela Živković<sup>1</sup>

<sup>1</sup>Faculty of Sport and Physical Education, University of Niš, Serbia

<sup>2</sup>Faculty of Sport and Physical Education, University of Sarajevo, Bosnia and Herzegovina

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## SUMMARY

The aim of this research was to systematize the available literature on the types and frequency of locomotor injuries in combat sports. The sample consisted of martial arts athletes (judo, karate, wrestling, boxing and taekwondo) of both sexes, aged 11-49 years. Survey questionnaires and medical reports were used as measuring instruments for assessing injuries in the research. The found data, presented numerically and in percentages, were used for further analysis. The results of this research show that the characteristics of injuries of the locomotor system in martial arts usually do not depend on the sex of the respondents. There is a higher frequency of injuries in competitions and lower in training (except for under-18s). The most common locations of injuries (head and neck, extremities and joints), types of injuries (contusions, bruises and fractures), and severity of injuries (mild, moderate, or severe) depended on the characteristics of martial arts (sports techniques, tactics, physical and mental fitness, etc.). By applying additional methods, by improving physical preparation that is adequately dosed with the improvement of technical and tactical elements, injuries to athletes could be prevented.

**Key words:** training, competition, contusion, fractures, sprains

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### Corresponding author

Mladen Živković  
*profzile@gamil.com*

## INTRODUCTION

Combat sports are polystructural, complex, and acyclic activities, typically involving two athletes trying to overcome each other<sup>6</sup>. Following the sports structure of combat sports, there are falls, blocks (defense), throws, and strikes (attacks) during training or competitions. In these situations, various types of locomotor sports injuries can occur, with different causes of occurrence<sup>21</sup>. An injury is understood as any physical complaint experienced by an athlete that necessitates a temporary cessation of training<sup>20</sup>. The causes of injuries can result from the direct application of force that exceeds the elastic properties of tissues<sup>29</sup> or another person as the cause of injury<sup>18</sup>. In 80% of sports injuries, the causes of injury include inadequate warm-up, overtraining, poor technique, physical unpreparedness, insufficient flexibility, personal carelessness, and many others<sup>23</sup>. The frequency of injuries to specific parts of the locomotor system varies depending on the type of combat sports<sup>28</sup>; the location of the injury also varies. In judo and karate, injuries are more common during training than in competitions<sup>3,9</sup>, while boxing injuries are less frequent and severe during training than during competition<sup>30</sup>. There are also various classifications of types and forms of locomotor injuries, such as soft tissue injuries, joint injuries, injuries incurred while standing, injuries incurred on the ground, injuries during competitions, and injuries during training<sup>18</sup>; acute and chronic injuries; fractures, sprains, and contusions<sup>14</sup>.

Preventing sports injuries can be influenced by the team physician, conditioning programs (increasing cardiovascular endurance, strength, and flexibility), specific exercises for a particular sport, proper warm-up and muscle preparation before sports activities, and gradual cooling down and stretching at the end of sports activities. The most commonly applied methods in injury prevention include proprioceptive training, plyometrics, and balance development<sup>23</sup>. Balance training, combined with strength training and neuromuscular training, can reduce the incidence of foot, ankle, and knee injuries and is essential in preventing anterior cruciate ligament injuries in the knee<sup>10</sup>.

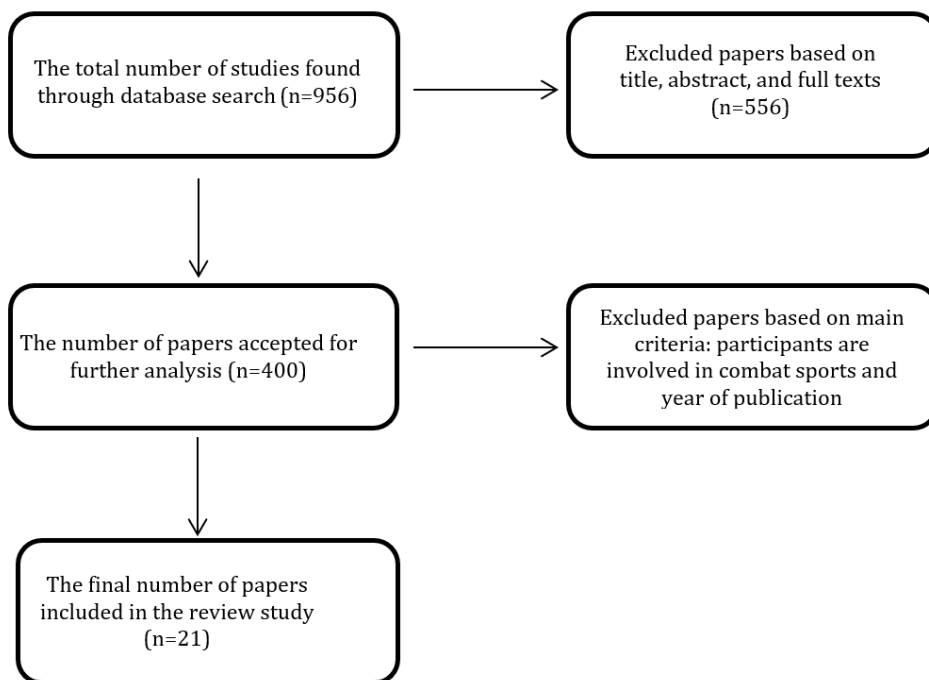
Based on all mentioned above, there is a need for an analysis of injuries in combat sports and finding the best prevention methods, all based on available literature. All studies addressing this topic were included in the search, regardless of whether they investigated injuries occurring in grappling-based combat sports (judo, wrestling) or striking-based combat sports (boxing, karate, taekwondo). Accordingly, the aim of this research was to systematize the available literature on the types and frequency of locomotor injuries in combat sports.

## METHODS

In order to gather relevant literature, the following databases were searched: Google Scholar, PubMed, SCIndeks and KoBSON. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines was used for searching and analyzing the studies<sup>19</sup>. The following keywords were used in the literature search: combat sports, health risks, injuries and frequency of injuries. The literature search

was conducted by four authors (M.Ž., A.M., S.F., and N.S.), after which the papers were either accepted or rejected for further analysis. Papers were included in further analysis based on their titles, abstracts, and full texts. To be included in the final analysis, all studies had to meet certain criteria. The first criterion was that the participants were involved in combat sports. Therefore, studies that analyzed injuries in other athletes were not included in the final analysis. The next criterion was that all studies were published in the last decade. Three authors (N.M., A.Đ., and D.Ž.) assessed the quality of the collected papers and whether they met the criteria for inclusion in the final analysis. Figure 1 illustrates the process of collecting, analyzing, and eliminating the found papers. All papers were presented based on the year of publication and analyzed according to a detailed description of the sample participants (number of participants, gender, age, and the combat sport they practice), the measurement instrument used for data collection, and the results obtained (activity during which the injury occurred, type of injury, location of injury, frequency and prevention).

**Figure 1. The procedure of collecting, analyzing, and eliminating the found papers**



## RESULTS

The papers were selected based on titles, abstracts, the research objective (injuries of the locomotor system in combat sports), participants (those involved in the training process) and year of publication. A total of 21 papers were included in

the final analysis, with the majority found using the Google Scholar database. The papers were analyzed and collected based on the previously mentioned criteria and are presented in Table 1. Each study is presented using the following parameters: reference (authors and year), participant sample (number of participants, gender, age, sport), measurement instrument, and research results.

**Table 1. Analyzed Papers**

Authors and Year	Sample of Participants				Measurement Instrument	Results				
	Number	Gender	Age	Sport		Activity During Which the Injury Occurred	Type of Injury	Location of Injury	Frequency	Prevention
Sertić, Segedi & Trošt-Bobić (2011)	66	Male and Female	15 - 28 years old	Judo	Questionnaire	Training, Competition	Contusions, Fractures, Sprains	Shoulder, Extremities	Competition - 61%	Physical preparation
Akbarnejad & Sayyah (2012)	50	Male	18-25 years old	Wrestling	Medical Report	Competition	Minor, Moderate, Severe	Ear, Shoulder, Neck, Spine, Knee	Skin-62%, Muscle-22%, Bone - 9%, Joint - 7%	Physical and psychological preparation
Poecco, Ruedl, Stankovic, Sterkowicz, Del Vecchio, Gutiérrez-García, & Menz (2013)	380	Male and Female	18-25 years old	Judo	Medical Report	Competition	Contusions, Fractures, Sprains	Knee, Shoulder, Fingers	Competition - 88%	Physical and psychological

Authors and Year	Sample of Participants				Measurement Instrument	Results				
	Number	Gender	Age	Sport		Activity During Which the Injury Occurred	Type of Injury	Location of Injury	Frequency	Prevention
Kasum & Rajevac (2014)	20	Male	18-25 years old	Wrestling	Questionnaire	Training, Competition	Contusions, Fractures, Sprains	Ear, Shoulder, Knee, Ankle, Spine	Wrestler's ear - 50%, Shoulder - 20%, Other injuries	Physical preparation
Lenard (2015)	84	Male and Female	18-30 years old	Karate	Questionnaire	Training, Competition	Minor, Moderate, Severe	Ankle, Arm, Hand, Fingers	Competition - 58%	Physical preparation
Kim, Park, Lee & Kang (2015)	782	Male	18-25 years old	Judo	Questionnaire	Training, Competition	Contusions, Fractures, Sprains	Extremities, Trunk, Head and Neck	Lower body - 44%	Training load
Lystad (2015)	481	Male	15-48 years old	Kickboxing	Questionnaire	Training, Competition	Contusions, Fractures, Sprains	Extremities, Trunk, Head, Neck	Head - 57.8%, Leg - 26.1%	Good fitness

Authors and Year	Sample of Participants				Measurement Instrument	Results				
	Number	Gender	Age	Sport		Activity During Which the Injury Occurred	Type of Injury	Location of Injury	Frequency	Prevention
Ziaee, Shobbar, Lotfian & Ahmadinejad (2015)	620	Male	≤ 30 years old	Karate	Questionnaire	Training, Competition	Minor, Moderate, Severe	Head, Neck, Trunk, Feet	During kata performance - 4%	Training load
Šuljagić (2016)	30	Male and Female	15 - 30 years old	Karate	Questionnaire	Training, Competition	Minor, Moderate, Severe	Foot, Head, Neck, Wrist, Knee, Back	Competition - 50%	Training load and concentration
Akhmedov, Demirhan, Cicioglu, Canuzakov, Turkmen & Gunay (2016)	200	Male	21,15 ± 3,54 years old	Wrestling	Questionnaire	Training, Competition	Minor, Moderate, Severe	Knee, Arm, Back, Shoulder, Elbow	Freestyle - 14%, Greco-Roman - 39%	Technical preparation
Antekolović, Lenard & Wertheimer (2016)	84	Male and Female	18-25 years old	Karate	Questionnaire	Competition	Contusions, Fractures, Sprains	Head, Neck, Face	Ankle sprain - 11,41%	Technical and tactical preparation

Authors and Year	Sample of Participants				Measurement Instrument	Results				
	Number	Gender	Age	Sport		Activity During Which the Injury Occurred	Type of Injury	Location of Injury	Frequency	Prevention
Drury, Lehman, & Rayan (2017)	213	Male	15 - 30 years old	Combat Sports	Questionnaire	Competition	Contusions, Fractures, Sprains	Head, Trunk, Extremities	Finger and hand injuries - 34,7%	Training load and concentration
Aleksandra, Arkadiusz & Paulina (2017)	220	Male and Female	11 - 49 years old	Boxing, Judo, Karate	Medical Report	Competition	Contusions, Fractures, Sprains	Head, Extremities	Bruises - 50.6%, Foot - 18.8%, Hand - 15.4%	Physical preparation
Didace, André, Victoire, Justy & Alphonse (2017)	238	Male and Female	18-25 years old	Judo, Karate, Boxing, Taekwondo	Medical Report	Competition	Contusions, Fractures, Sprains	Extremities, Spine, Head, Neck	Contusions - 32%, Fractures - 26%	Physical preparation
Jevtić (2018)	250	Male	15 - 30 years old	Kickboxing	Questionnaire	Competition	Contusions, Fractures, Sprains	Extremities, Spine, Head, Neck	Foot - 29%, Shin - 26%	Physical preparation

Authors and Year	Sample of Participants				Measurement Instrument	Results				
	Number	Gender	Age	Sport		Activity During Which the Injury Occurred	Type of Injury	Location of Injury	Frequency	Prevention
Augustovičová, Lystad & Arriaza (2019)	3706	Male and Female	18-25 years old	Karate	Medical Report	Competition	Contusions, Fractures, Sprains	Acute limb injuries	Competition interruption - 1.4%	Training load
Cierna, Štefanovský, Matejová & Lystad (2019)	295	Male and Female	≥ 18 years old	Judo	Medical Report	Competition	Contusions, Fractures, Sprains	Extremities, Spine, Head, Neck	Head - 41%, Contusions - 33%	Physical preparation
Mohd Saleh, Abdul Hamid, Shahudin & Che Ismail (2019)	253	Male	≥ 18 years old	Taekwondo	Questionnaire	Competition	Minor, Moderate, Severe	Acute limb injuries	No gender difference	Technical and tactical preparation
Lystad, Augustovičová, Harris, Beskin & Arriaza (2020)	1000	Male and Female	15 - 30 years old	Karate	Medical Report	Competition	Minor, Moderate, Severe	Foot, Head, Neck, Hand, Knee, Back	Head and neck - 57.9%	Technical and tactical preparation



Authors and Year	Sample of Participants				Measurement Instrument	Results				
	Number	Gender	Age	Sport		Activity During Which the Injury Occurred	Type of Injury	Location of Injury	Frequency	Prevention
Polmann, Melo, Conti Réus, Domingos, De Souza, Padilha & De Luca Canto (2020)	1104	Male and Female	≥ 18 years old	Combat Sports	Questionnaire	Training, Competition	Minor, Moderate, Severe	Facial injuries	Judo has the lowest frequency of head injuries, while boxing has the highest	Training load
Pal, Yadav, Kalra & Sindhu (2020)	204	Male and Female	≥ 18 years old	Karate	Questionnaire	Training, Competition	Minor, Moderate, Severe	Foot, Knee	The risk is higher in males	Physical preparation

## DISCUSSION

The aim of this study was to systematize the available literature on the types and frequency of locomotor injuries in combat sports. Based on this defined aim and the established criteria, it can be noted that the majority of analyzed papers were published in 2016, 2017, 2019, and 2020 (three studies for each mentioned year). The number of participants varied depending on the studies. The smallest number of participants was 25, while the highest was 3706 participants. In addition to the number, the participant sample also differed based on gender composition. In 12 studies, both male and female participants were involved, while in 9 studies, only males participated. There were no studies that specifically examined locomotor injuries in females. The ages of the participants ranged from 11 to 49 years old. The majority of studies included participants aged above 18 years old. The smallest number of studies (two) focused on injuries in athletes older than 30. In terms of sport affiliation, the structure of studies was as follows: four studies involved judo, three involved wrestling, seven involved karate, two involved kickboxing, and one study involved taekwondo participants. There were four studies in which the participant sample consisted of athletes from multiple combat sports.

The most reliable data on injuries are obtained using official medical reports. However, it is important not to exclude the significance of local studies that determine the extent and types of injuries in sports clubs, which utilize questionnaires as a data collection method. Questionnaires can be completed by either coaches or athletes. The data on locomotor injuries in this study were derived from 14 studies that used questionnaires and seven studies that utilized data from medical reports.

The research results encompass the activity during which the injury occurred, the type of injuries, the location of injuries, frequency, and prevention. The activities during which injuries occurred were either training or competitions. More studies focused on injuries during competitions (11 studies). Other studies analyzed injuries without a clear distinction of when the injuries occurred. In the studies, there are various classifications of sports injuries. Some used classifications based on diagnosis (wounds, contusions, concussions, muscle injuries, sprains, fractures), based on the type of tissue injured (bone injuries, soft tissue injuries, joint injuries), based on the location (injuries to upper and lower extremities, trunk), and based on the severity (severe, moderate, and mild injuries). The largest number of studies (12) examined various contusions, fractures, and sprains in different combat sports. The categorization into mild, moderate, or severe injuries was observed in 9 studies, where data were often obtained from medical reports during competitions. The most common location of injuries was in the head, neck, and face area, followed by lower and upper extremities, and injuries in the trunk region, though in slightly lower percentages. The most frequent injuries highlighted are contusions (blunt force injuries), followed by a lower percentage of sprains, concussions, fractures, tears and strains of muscles and ligaments, cuts, hematomas and wounds due to direct punches and kicks. Based on the reviewed studies, two main factors in injury prevention stand out: the team physician and the exercise program. The exercise program should encompass the improvement of technical elements, strength exercises, flexibility, and balance training. These exercises should be appropriately tailored regarding gender, age, and the competitive period.

Based on the obtained results, it can be concluded that in judo, young athletes of both genders are more often injured during training, while older athletes are more frequently injured during competitions (61% - 88%). Injuries include contusions (33%-41%), injuries to the extremities (44%), fractures, and joint sprains<sup>26</sup>. Karate is a sport where injuries are more common among men during training (acute head injuries, contusions, sprains, fractures of the extremities) than during competitions (58%). In karate competitions, there are fewer injuries to the shoulder, elbow, fingers, back, and knee, while slightly more injuries to the arms and head. The highest number of injuries occurred in the feet<sup>29</sup>. At elite competitions, the severity of injuries is higher for athletes weighing less than 70 kg and those with lower sports experience. Wrestling is a sport where athletes are more likely to get injured during competitions. Injuries commonly occur in the ear, shoulders, neck, spinal column, knees, and ankle<sup>12</sup>.

Freestyle wrestlers tend to suffer more knee, arm, and joint injuries compared to Greco-Roman wrestlers, who are more prone to rib, back, shoulder, and elbow injuries<sup>2</sup>. In kickboxing, injuries to the head and neck are typical (57.8%), including

cuts and contusions from direct blows to the head. Lower extremity injuries account for 26.1% of all injuries, with 26-29% of those being sprains. Injuries to the thigh muscles are most often caused by many microtraumas resulting from numerous strikes to the same region, while foot injuries occur due to individual, poorly targeted kicks. Injuries to the ribs and metacarpal bones of the hand occur less frequently than injuries to the head and lower extremities<sup>11</sup>. As preventive measures for injuries during competitions, better technical and tactical preparation is often recommended<sup>17, 25</sup>, and physical and psychological preparation of athletes<sup>1,21</sup>. To prevent injuries during training, one should consider load management<sup>5, 8,13,22</sup>, along with improving conditioning<sup>17</sup> and physical preparation.<sup>8, 11, 12, 15, 24, 25, 26, 27</sup>.

## CONCLUSION

Based on the found studies and the analysis of results, a systematization of knowledge and information has been obtained regarding whether the frequency and types of locomotor injuries are similar in different combat sports, whether injuries are more common during training or competitions, and so on. It is obvious that in judo athletes are more likely to get injured during training than in competition, and contusions and limb injuries dominate. Similarly, karate practitioners also sustain more injuries during training, with foot injuries being predominant. Wrestlers are more prone to injuries during competition, with head and joint injuries being characteristic. For kickboxers, typical injuries include head, neck, and lower limb injuries due to frequent strikes to the same region. The obtained results also provide valuable information that can significantly assist coaches in combat sports when determining models for preventing athlete injuries by applying more intensive preparation of the relevant musculoskeletal groups. In addition to everything mentioned, the presented results can be helpful for further research on locomotor injuries in combat sports.

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