General

Mitigating the Risks of Lower Extremity Injuries in Soccer: A Comprehensive Analysis of Lower Extremity Injury Rates in Soccer Between 2014 and 2023

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Objective

With events such as the Copa America 2024, the 2026 World Cup, and the arrival of European stars in Major League Soccer (MLS), the already observed and forecasted rise of soccer in the United States (US) seems to be an inevitable outcome. Although regular participation in soccer features several benefits, including increasing cardiovascular health, decreasing stress, and promoting interpersonal relationships, the risk of injury, as is the case in any sport, is ever present. Although many sports that are popular in America feature high rates of concussion, rotator cuff injuries, and general upper extremity injuries, soccer, being more strenuous on the lower-half of the body, features a disproportionate rate of lower extremity injuries. An analysis of the frequencies of these injuries, relative to factors such as year of injury, age, gender, location of injury, and diagnosis of injury, may help organizational bodies and soccer leagues implement new regulations regarding the usage of protective equipment and rules regarding gameplay. This study aims to illuminate these takeaways in an effort to better patient care outcomes in soccer-related injuries.

Method

This paper utilized the National Electronic Injury Surveillance System Database (NEISS) to compile data on lower extremity soccer-related injuries within the defined study period, 2014-2023. Inclusion criteria for the study involved all patients presenting to the emergency department (ED) within the study period and within the defined age range of 0 to 69 years old, with injuries sustained from or related to soccer. Using NEISS, trends were elucidated discriminating based on year of injury, sex, age group, location of injury, and diagnosis group of injury.

Results

Within the defined study period of 10 years, from 2014-2023, there were approximately 843,063 total soccer-related lower extremity injuries which presented to various EDs across the US. Regarding majorities, the most injuries were sustained in 2014 (12.84% of total injuries), most patients sustaining injuries were male (66.6% of all patients), and within the age range of 10-19 years old (63.24% of all patients), with the most instances occurring at age 15. Lower extremity injuries were most reported to be affecting the ankle with 306,797 incidences (36.39% of total injuries seen) and the most frequent diagnosis group was reported to be strains/sprains with 396,420 (47.02% of total injuries seen) total occurrences.

Conclusion

This study analyzes the incidents of lower extremity injuries while participating in soccer for the last 10 years, 2014-2023. The study provides new data regarding the frequency of injuries and their relative rate with respect to year of injury, age group, sex, location of injury, and diagnosis. The results of this study show injury majorities and trends which can be used to dictate changes in regulation regarding gameplay and the utilization of

protective equipment in order to mitigate injuries related to the lower extremities in soccer.

INTRODUCTION

Soccer is the most popular sport in the world, with a fan base consisting of over 250 million players and 3.5 billion watchers.[1,2] Even with this large pre-existing global fanbase, especially in the United States (US), as more soccer-related events are held and the general public becomes more exposed to the sport, the popularity of soccer is on the rise.[3]

This rise in popularity, could be seen as a public health positive, as soccer, akin to any sport, features a number of health benefits, including but not limited to: an increase in mental and physical durability, decreased rates of chronic cardiovascular disease diagnosis, the stimulation of muscle mass growth, and a rise in mental well-being, via a correlated decrease in stress.[4-7] The resulting decrease, and subsequent protection, that playing sports provides from mental health conditions is particularly important, as rates of stress and anxiety have been increasing year-after-year in teenagers and adolescents across the US.[8] Along with more definitive quantitative improvements, soccer, and sports in general, has also been shown to have a number of qualitative benefits, including promoting interpersonal relationships, improving coordination, and instilling a strong sense of community and belonging within the participants.[9,10]

Although superb, these benefits come with a fair share of potential detractors, primarily, as is the case in most sports, the ever-present risk of injury.[11] Although many of the most popular sports in the US feature higher rates of upper extremity injuries, including rotator cuff injuries, concussions, etc., soccer being more intensive on the lower-half of the body, features a disproportionate rate of lower extremity injuries.[12,13] Common injuries in soccer include: shin splints, patellar tendonitis, and achilles tendonitis. While these injuries are often viewed as relatively insignificant, more serious and detrimental injuries, including: cartilage tears and anterior cruciate ligament (ACL) tears may also occur.[14,15]

Among the described injuries, shin splints, patellar tendonitis, and achilles tendonitis represent overuse injuries characterized by discomfort and slight pain in the shins, knees, and achilles respectively.[16-18] These injuries, and overuse injuries in general, are most readily treated by rest, painkillers, icing the affected area, and slight physical therapy if necessary.[17,18]

Overuse injuries, such as those mentioned above, do not facilitate the need for intensive intervention, however, the threat of mitigating more serious injury is what inspired this study. These injuries include, most prominently cartilage tears and ACL tears.[19]

ACL tears represent an extremely serious injury prompting regular and intensive medical intervention and a prolonged recovery time, and in some professional cases are perpetrators of retirements and career ends.[20] ACL tears occur when the knee is suddenly twisted, overextended, or hit.[21] They occur most frequently when an athlete suddenly changes directions, lands following a jump, or is hit, all of which represent common occurrences in soccer.[22] Treatment for ACL tears depends on grade of injury and can range from rest, ice, compression, and elevation (RICE) to surgical intervention.[23] If surgery is required recovery time for the injury can be upwards of one year.[24] In addition to the upfront pain and inconvenience caused by an ACL injury, the risk of reinjury greatly heightens after an initial tear with 15% of soccer players re-tearing their ACLs after an initial experience.[25]

Although the described lower extremity injuries are most common in soccer, they do not fully encompass all injuries sustained. Other injuries, including concussion, wrist fractures, and nose breakages also represent commonly suffered injuries.[26-28] However, in an effort to produce a specific analysis and highly-targeted intervention, this paper will focus on lower extremity injuries from 2014 to 2023 within the age group 0 years old to 69 years old, this age range being representative of individuals who participate in soccer most frequently.[29,30] This study will analyze discrepancies in injuries sustained in the lower extremities based on discrepancies in year of injury, gender, age range, location of injury, and specific diagnosis of injury. The elucidation of these trends can, hopefully, help educate governing bodies in formal soccer leagues and amateur soccer organizations and help mitigate the risk of injury via regulation adjustments and the possible implementation of protective equipment.

METHODS

STUDY DESIGN

The NEISS database, which is commonly used to gather data on consumer-product related injuries which occur in the United States, was the chosen database for this study This database often aids in supporting public-health investigations and educating policymakers on necessary interventions. The NEISS database was used in this study to culminate date to perform a retrospective contemplative study on the injuries which occur in the lower extremities of a soccer athlete.

STUDY POPULATIONS

Inclusion criteria for the study involved any patient presenting with a defined soccer-related injury, within the age range of 0 to 69 years old, within the study period, defined as 2014 to 2023.

The total study population was divided using a number of different criteria. It was primarily divided by age, separated into succinct age groups in an attempt to reveal specific trends in age of injury for soccer athletes. These age groups were each divided in ten-year subcategories and ranged from 0 to 69 years old, defined as: 0 to 9 years old, 10 to 19 years old, 20 to 29 years old, 30 to 39 years old, 40

to 49 years old, 50 to 59 years old, and 60 to 69 years old. Each of these age groups were compared relative to injury rate to reveal trends and frequencies regarding the relation between age and injury in soccer. In addition to age, gender was also considered as a discriminatory factor, as the relative rates of injury in soccer between males and females were compared to observe if a statistically significant difference was present. Year of injury was another discriminatory factor, as trends were modeled to reveal changes in injury frequency over time. Lastly, the type of injury was analyzed, categorized by region in the lower extremities along with diagnosis type. Location subcategories were defined as the knee, the lower leg, the upper leg, the ankle, feet, and toes. Location of injury was denoted with correlating NEISS database diagnosis codes. The codes were identified as follows: knee(35), lower leg(36), ankle(37), upper leg(81), foot (83), and toe (93). Additionally, specific diagnoses were shown including contusions, dislocations, fractures, hematomas, lacerations, strains/sprains, avulsions, and other non-specified injuries. Location and type of injury were analyzed to observe trends in injury type to see if specific intervention regarding regulation changes or the utilization of specific pieces of protective equipment could be useful in mitigating overall injury rates.

Data from certain categories were not taken into account during the analysis of this study as the NEISS database determined values under 1,200 insignificant and thus does not display them in data output or collection. Additionally, data collected from NEISS represent estimates calculated using all available data and may not be completely accurate to true values observed. To best mitigate this, in data representation, mostly via bar graphs, standards of error were calculated and shown.

STATISTICAL ANALYSIS

In this study, statistics on year of injury, age groups, sex, injury location, and diagnoses were utilized in analysis. These statistics could be found under the "sports and recreation equipment" tab in the NEISS database, further distinguished by the label "soccer." Statistical analysis for the results presented in this study were performed independently.

The purpose of this study is to identify trends related to year of injury, sex, age group, injury location, and specific diagnoses in injuries sustained while participating in soccer and to recommend actions which can help organizational bodies mitigate the risk and overall rate of injury.

RESULTS

In the defined study period, 2014 to 2023, there were a total of 843,063 reported lower extremity injuries while participating in soccer which presented to the ED, resulting in an annual mean of 84,306 injuries per year. Comparing this value to the overall number of lower extremity injuries treated in the ED, a total of 11,261,777 sport-related cases, a value compiled from the "sports and recreation equipment" tab in the NEISS datatables, were treated. Accordingly, soccer-related injuries represent 13.4% of all sport-related lower extremity injuries treated in the ED, reflecting the need for intervention to mitigate this relatively high rate.

Out of these injuries, 561,520 (66.60%) were male, 281,538 (33.40%) were females, and 5 individuals' gender was unlisted. Proportions regarding gender of the injured individuals are presented in Figure 1.

Furthermore, age groups played a notable role in discerning, and predicting, injury. Regarding children and young adults, in the 0-9 years old subgroup, 61,362 injuries occurred (7.28% of total) and in the 10-19 years old subgroup there was a tremendous 533,161 injuries reported (63.24% of total), representing the highest value observed regarding age group. The 20-29 years old subgroup had 140,923 injuries (16.72% of total), from 30-39 years old there were 66,085 reported injuries (7.84% of total), and from 40-49 years old there were 30,099 occurrences of injury (3.57% of total). Injury numbers did eventually drop significantly in the 50-59 year-old subgroup to 8,451 (1.01% of total), and finally in the age group defined as 60-69 there were only 2,141 injuries in the lower extremities (0.25% of total), representing the lowest value in the total trend. Trends regarding age-group frequency in soccer-related lower extremity injuries are presented in Figures 2 and 3.

Concerning location of injury over the study period, the most injuries were sustained to the ankle with 306,794 total injuries (35.8%), followed by the knee with 255,147 injuries (29.8%), then feet with 104,159 injuries (12.2%), then toes with 52,986 injuries (6.2%), and, finally, the upper leg with only 24,346 injuries (2.8%). Trends and relative frequencies regarding location of injury are represented in Figures 4 and 5.

Additionally, the diagnosis of each injury is significant in determining what actions must be taken to prevent specific injury types and to prioritize the mitigation of more serious injuries. From least to most prevalent, the following diagnoses regarding the injuries were made: avulsions (2,091, 0.2% of total injuries), hematomas (6730, 0.8% of total injuries), lacerations (13,383, 1.6% of total injuries), dislocations (22,583, 2.6% of total injuries), contusions (110,480, 12.9% of total injuries), fractures (124,194, 14.5% of total injuries), other undefined injuries (181,108, 21.1% of total injuries), and strains/sprains (396,230, 46.2% of total injuries). Trends and relative frequencies regarding diagnosis of injury are represented in Figures 6 and 7.

Lastly, incidence of injury per year followed an interesting trend. The trend's high was represented in 2014 with 108,357 injuries (12.8% of total), then dipped in 2015 to 96,979 injuries (11.5% of total), then remained relatively constant in 2016 with 97,275 injuries (11.5% of total) and through 2017 with 97,137 injuries (11.5% of total injuries). Total injury incidences dipped further in 2018 with 83,995 reported injuries (10.0% of total injuries), remained relatively constant in 2019 with 86,087 reported injuries (10.2% of total injuries), then decreased significantly in 2020 to 37,494 injuries (4.4% of total injuries). Following the low observed in 2020, the trend increased relatively linearly with 62,930 cases seen in 2021 (7.5% of total injuries),

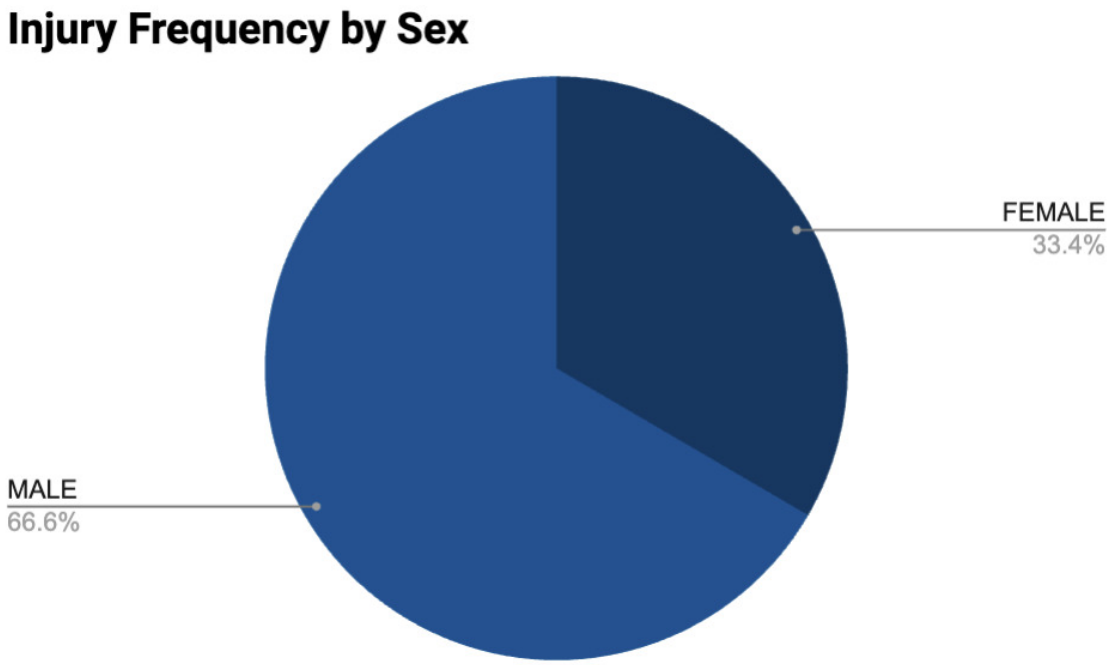

Figure 1. Pie chart comparing the proportions of soccer-related lower extremity injuries sustained by males and females.

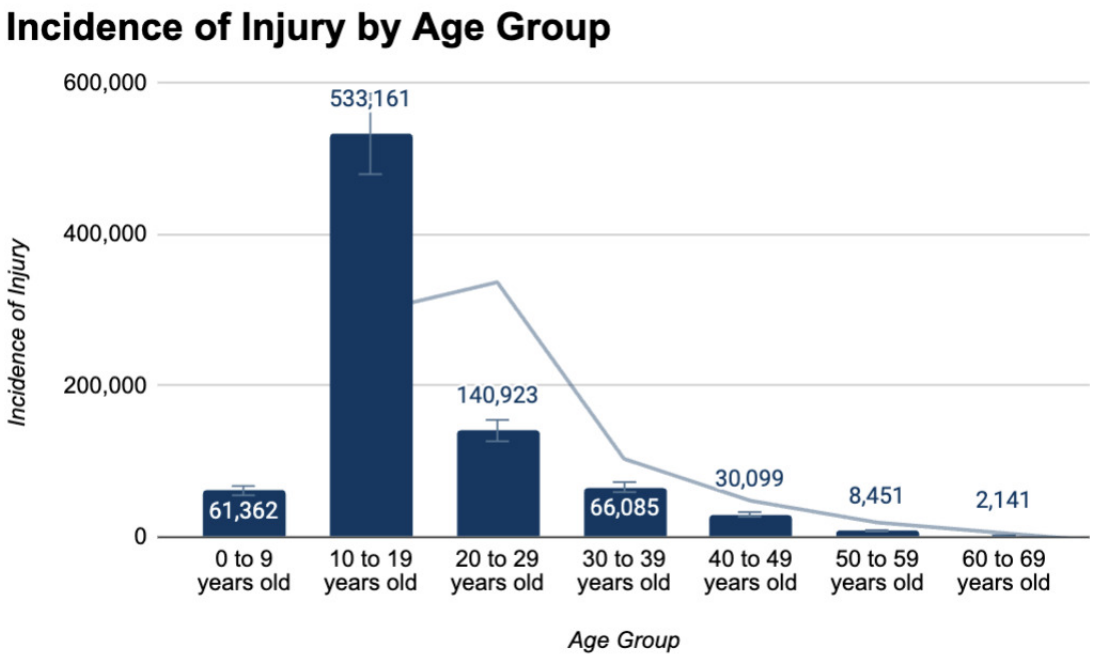

Figure 2. Bar graph, with error bars and trendlines, showing incidence of injury by age group pertaining to soccer-related lower extremity injuries

78,057 cases seen in 2022 (9.3% of total), and 94,852 cases seen in 2023 (11.3% of total injuries). Trends regarding year of injury are represented in Figures 8 and 9.

DISCUSSION

Reflecting the results, a significantly larger number of male soccer athletes were reported to have sustained lower extremity injuries when compared to female soccer athletes, with males more likely to sustain an injury by a factor of

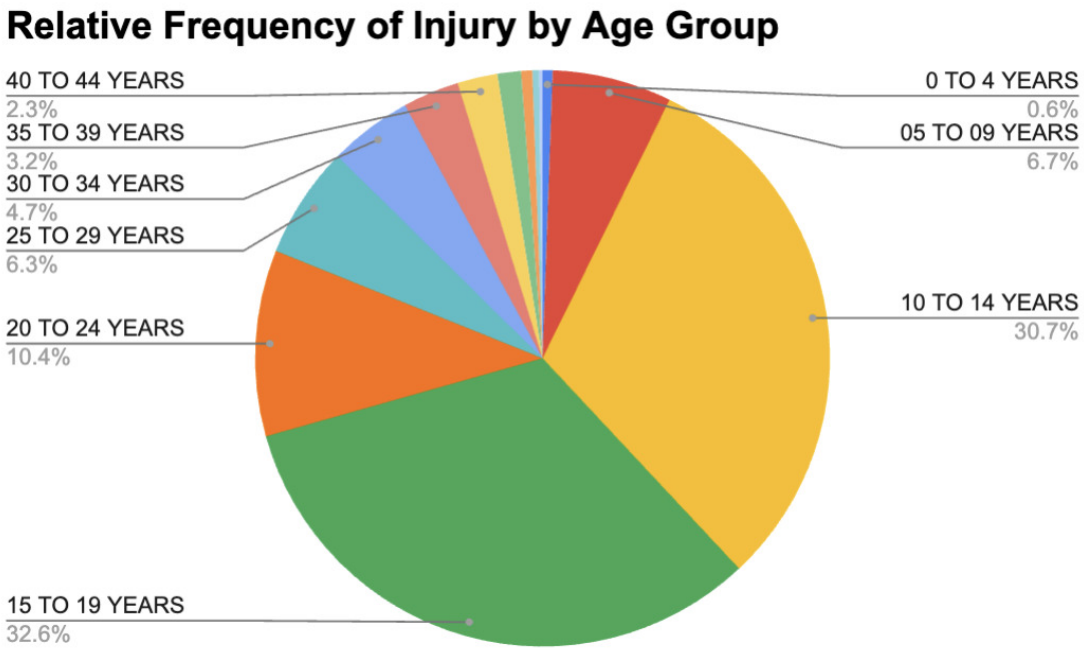

Figure 3. Pie chart showing relative frequencies of injury by age group subcategories pertaining to soccer-related lower extremity injuries

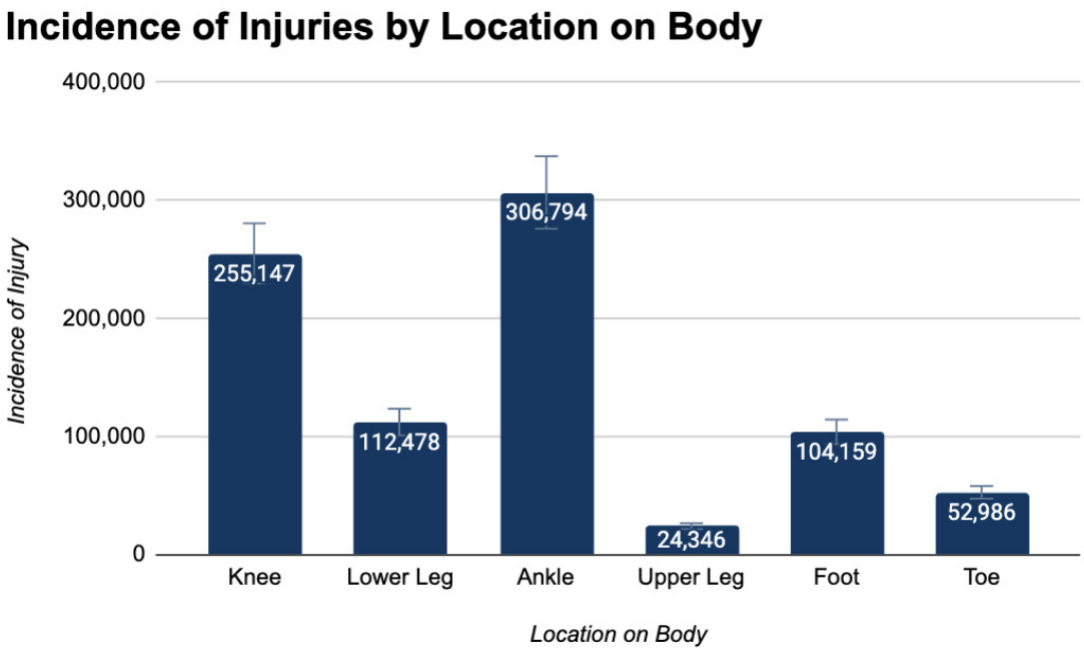

Figure 4. Bar chart, with error bars, showing incidence of injuries by location on body pertaining to soccer-related lower extremity injuries

2. Although this proportion could simply reflect the general proportion of male-to-female soccer players (approximately 1.47:1), it is of note that female athletes sustain more severe injuries than male athletes.[31,32] Male athletes were more likely to sustain minor fractures, dislocations, overuse injuries, and contusions, whereas females were more likely to sustain more serious fractures, ACL tears, and meniscus tears.[33] In general, women are 8 times more likely than men to tear their ACLs, a startling value only compounded by the sudden motion and jumping present in soccer.[34] Females, when compared to males, have a number of tantalizing neuromuscular risk factors regarding ACL injury. These include, lower muscle mass, a smaller femoral notch, and lower rates of knee stiffening, all of which, in

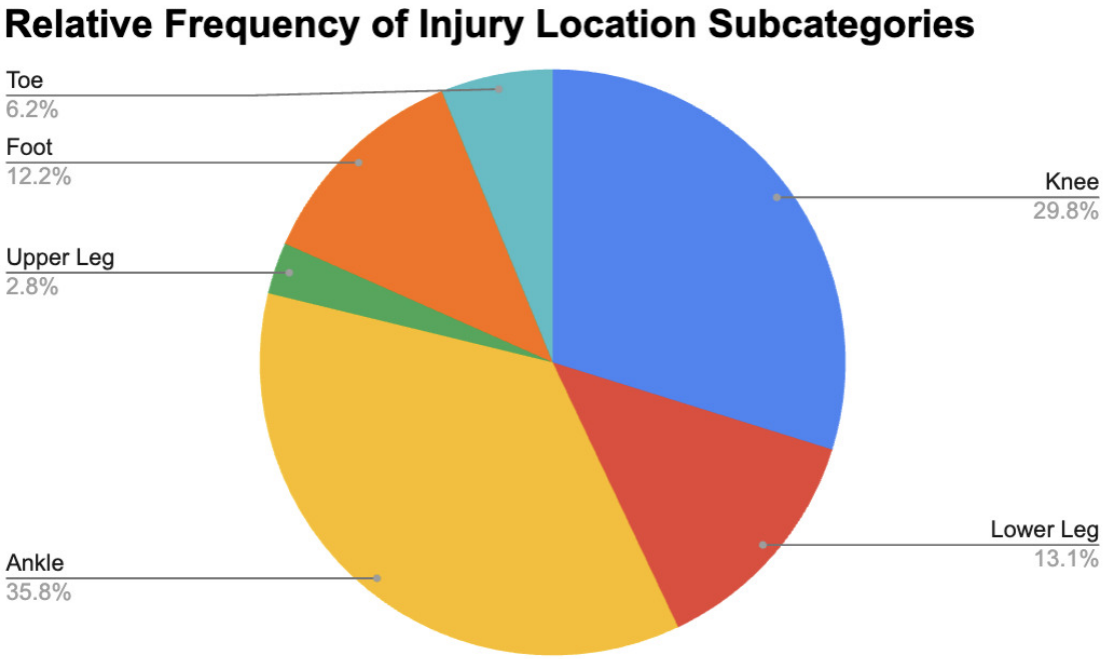

Figure 5. Pie chart showing relative frequencies of injury location subcategories pertaining to soccer-related lower extremity injuries

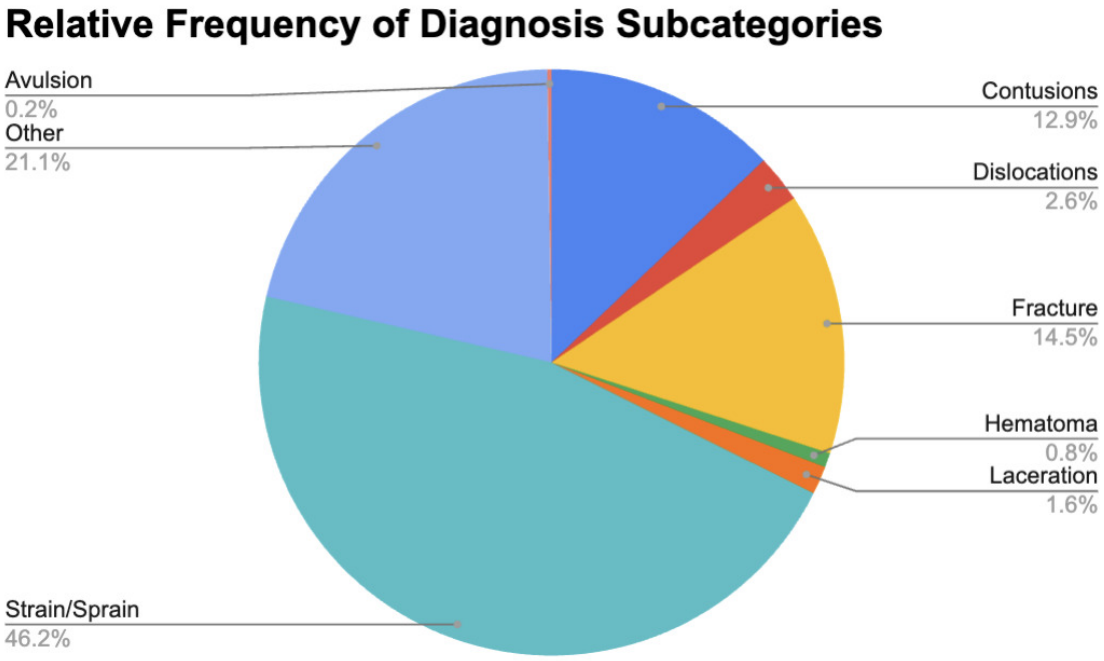

Figure 6. Pie chart showing relative frequencies of diagnosis subcategories pertaining to soccer-related lower extremity injuries

conjugation make females more likely than males to suffer an ACL injury.[35,36]

Analyzing rates of injury location, the ankle is the most common area of injury in soccer athletes. The prevalence of ankle injuries is dependent on a number of factors, with the most contributing being: muscle and joint fatigue, frequent and rapid acceleration, sudden acceleration, and abrupt change in direction.[37] Regarding soccer-specific events which may stimulate ankle injury, these include being slide-tackled, contact with another player, contact with the goal post, awkward landing following a jump, awkward contact with the ball, and rapid or sudden acceleration or deceleration. The most common ankle injuries in soccer pertain to the external and internal lateral ligaments, with

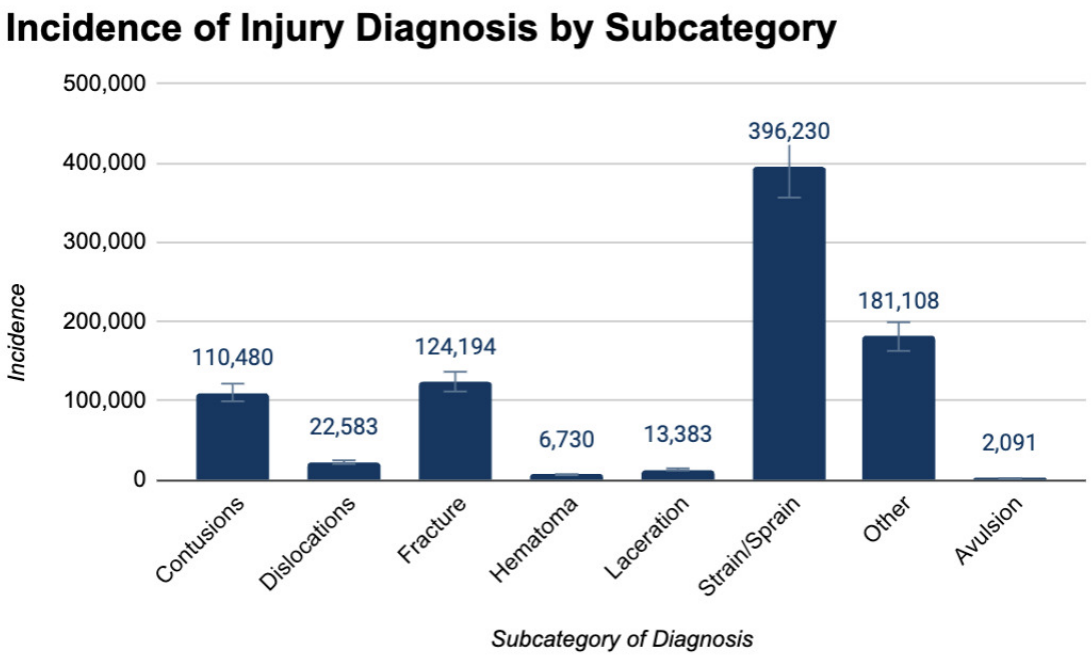

Figure 7. Bar graph, with error bars, showing incidence of each subcategory of diagnosis pertaining to soccer-related lower extremity injuries

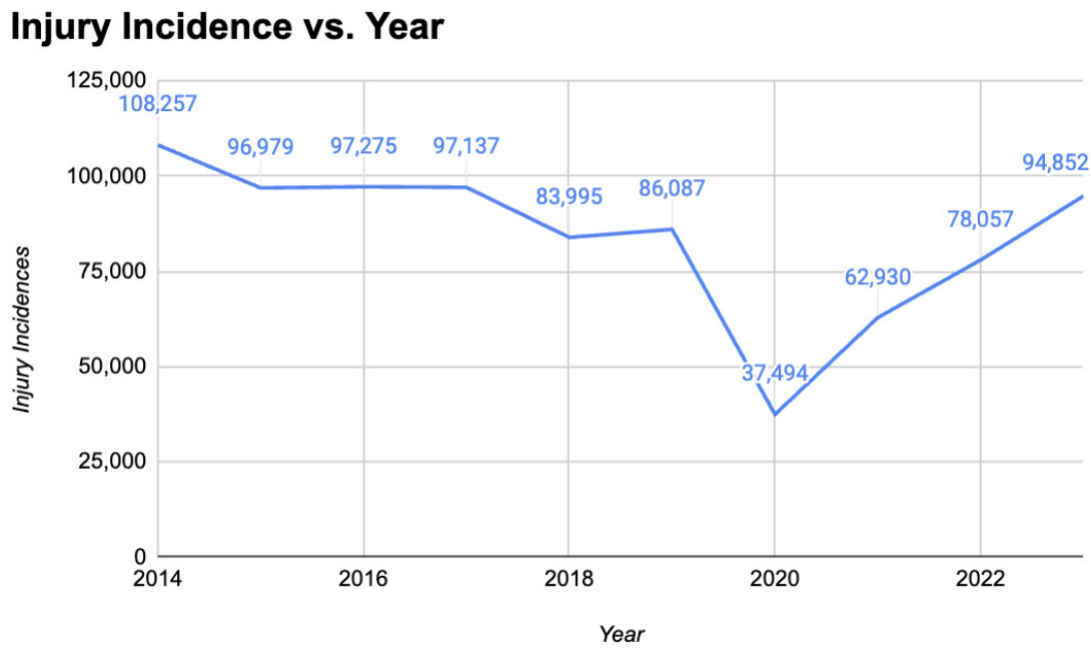

Figure 8. Line graph showing trend regarding injury incidences and year of lower extremity soccer-related injuries

66.82% of total occurrences at the external lateral ligaments and 8.71% of occurrences at the internal lateral ligaments.[38] External and internal lateral ligament injuries are commonly known as sprains and require little medical intervention with most cases being resolved via RICE.[39] However, in cases of persistent injury or re-injury, physical therapy along with orthopedic consultation may be recommended in order to mitigate the risk of permanent damage and future injury.[40]

Following the ankle, the knee was the most commonly injured location across the dataset. Knee injuries often present the most serious injuries in soccer, with ACL and other ligament sprains being included in the category.[41] Knee injuries, akin to ankle injuries, are most readily caused, es-

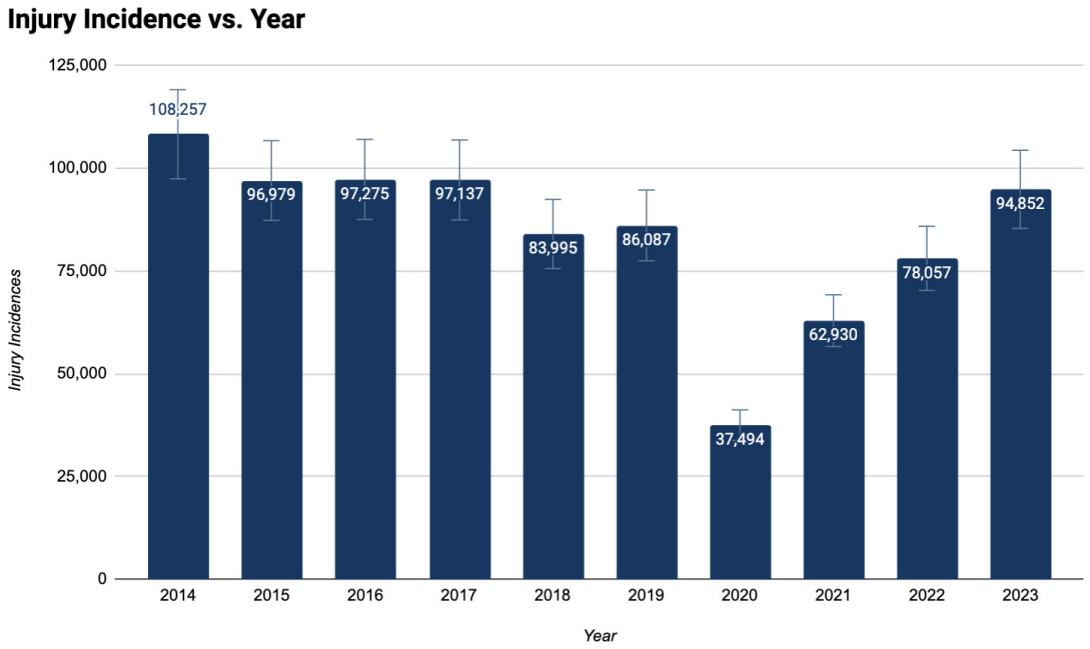

Figure 9. Bar graph, error bars, showing injury incidences pertaining to soccer-related lower extremity injuries per year within the defined study period

pecially in soccer, by a sudden change in direction, sudden twisting or bending motions putting stress on the knee, an unnatural landing following a jump, or rapid accelerations and decelerations.[42] While many of the presented ankle injuries could be treated via RICE, knee injuries often require a larger level of medical intervention and longer recovery times.[43] As mentioned, ACL injuries are one of the most common, and worrying, knee injuries in soccer, with an overall incidence of 0.063 injuries per 1000 game hours.[44] Depending on the grade of injury surgical intervention may be required, warranting a recovery time of up to one year, the high prevalence of ankle and knee injuries warrant targeted intervention efforts to mitigate the risk of these injuries.[23]

Succeeding the relatively high rates of ankle and knee injuries, upper leg, lower leg, foot, and toe injuries were relatively low. This trend can most readily be explained by the utilization of protective equipment. The International Federation of Football Association (FIFA) mandates the utilization of shin guards by all players thus reducing rates of lower leg injuries. Shin guards have been shown to drastically reduce the rate of major injuries, and carbon shinguards, in particular, were shown to be most effective.[45] The injuries that did occur are most likely overuse injuries, such as shin splints, which can be prevented by game play and muscle stress management.[16,17] Additionally, the utilization of cleats in soccer commonly reduces the risk of foot and toe injuries, providing coverage and support for feet and toes, cutting rates of most injuries. It is imperative to ensure that an individual's soccer cleats fit snugly and are comfortable as overly tight or loose cleats can increase risk of injury.[46] Lastly, rates of upper leg injuries were reported to be the lowest relative injury location, as the utilization of the upper leg in soccer is relatively low compared to the other body regions listed.[47]

Furthermore the COVID-19 pandemic played a significant role in dictating soccer injury rates, as reflected by the year-by-year trend. While most years followed a predictable and relatively constant trend, with minor fluctuations, 2020, and the years following, saw outliers in the trend with low rates of injury.[48] The COVID-19 pandemic interrupted and, in most cases, halted all sports from youth leagues to professional organizations.[49] This stop, predictably caused a decrease in the amount of sports-related injuries across the board. Even towards the end of 2020 and the beginning of 2021, when some leagues re-opened and restarted play, regular course of play was often interrupted based on relevant quarantine procedures.[48,49] The full scale restart of sports, seen in mid-2021, in most cases followed a phase plan. The following four-phase plan, albeit simplified, was utilized by several European soccer leagues. Phase 1 denoted that no more than ten players could practice together at a time, with those ten practicing relevant social distancing guidelines. Phase 2 recommended the restart of full team practices, with drills restricted to one-on-one practice with social distancing. Phase 3 allowed the restart of full team practice without any restrictions within a single team environment or bubble and phase 4, which broke the bubble, allowed full competition between local and regional teams. All phases, except phase 4, would be operated under quarantine precautions, isolation before interactions and between interactions with regular COVID-19 testing, and would be halted if team quarantine was broken or a positive COVID-19 test result was returned by one of the team members, coaches, or associated parties.[50]

Additionally, regarding age groups, the ages most afflicted with injury were children and young adults and as the considered subgroups were defined by older individuals the rates of injury decreased. This is most readily a reflection of the age populations that play soccer. Soccer is most popular within pediatric subgroups and young adults, as they play recreationally, in school, and with their friends, but becomes less and less popular as individuals grow older.[31,32] Sports are also generally less participated in by older individuals due to a heightened risk of injury.[51] Problems, including but not limited to fractures, scrapes, and contusions, which may heal quickly and without issue for younger individuals, may cause further complications and health issues in older populations. These complications, all of which could be sustained from a relatively minor injury, could cause long-term health issues.[52,53] Additionally, a general decrease in athleticism, stamina, muscle mass, movement capability, and flexibility make participating in sports less appealing and feasible for older individuals.[51]

Lastly, regarding diagnosis types, strains/sprains were the most common subgroup by far, an understandable finding considering the reliance on lower extremity muscles in the regular playing of soccer. 92% of all muscle strains in soccer were confined to one of four muscle subgroups, being the adductors, hamstrings, quadriceps, and the calf muscles. Additionally, once a muscle has been strained/sprained it is more likely to re-injure, with approximately 16% of all muscle sprains, in soccer-related incidences, being re-sprains.[54] Thankfully, muscle sprains are relatively simple in terms of treatment and recovery, with most cases being resolved using RICE.[55] Followed by muscle injuries, fractures and contusions represented the most represented subgroups in terms of injury diagnosis. The relatively high prevalence of these subgroups are both explained by the high-impact nature of soccer as standing tackles, sliding tackles, player-on-player impact, and falls, represent common reasons for fractures and contusions. Tibia and fibula fractures represented the majority of fractures sustained while playing soccer and shin guards were shown to greatly reduce the risk of injury.[45,56] Avulsions, lacerations, hematomas, and dislocations all appeared in the dataset with relatively low frequencies of incidence, as the causes of these injuries are uncommon in regular soccer play.

Although the complete extinction of soccer-related lower extremity injuries is impossible, mitigation and prevention can help reduce the current rate. Among the most serious injuries discussed, the prevention of ACL injuries is of the utmost importance.

Exercise based injury programs have been shown to significantly decrease the frequency of ACL injuries, with a sizeable reduction of 41-59% observed upon regular participation. These programs also showed a 32-58% reduction in knee injuries and a 30-60% reduction in ankle injuries in male athletes and a 15-17% reduction in knee injuries and a 17-22% reduction in ankle injuries in female athletes.[57] An example of this type of program being mandated by a large soccer governing body is the FIFA 11+ program. During this program, athletes focus on training and conditioning specific muscle groups with targeted and personalized training, thus minimizing risk of injury.[58] In addition to the implementation of standardized programs by governing bodies, individual athletes should ensure the utilization of standardized protective equipment, such as cleats or shin guard, and ensure proper sizing and a comfortable fit before play.[45] Lastly, individuals should ensure proper rest between sessions of play, as on the professional level congested fixture schedules and regular play without proper recovery times have been shown to increase the risk of injury and re-injury.[59] Utilizing a combination of predictive treatment, proper protective equipment utilization, and rest between sessions of play can help in mitigating the risk of injury and reduce the incidences of soccer-related lower extremity injuries.

CONCLUSION

The increasing popularity of soccer in the United States reflects a general increase in the sports player base. Featuring a number of health benefits, regular participation in soccer, or any sport, should be encouraged. However, as is the case in any physical activity, the risk of injury is present. In contrast to American sports, most injuries in soccer are sustained in the lower extremities. In an effort to mitigate risk this study analyzed trends regarding year of injury, sex, age group, location of injury, and diagnosis of injury regarding lower extremity injuries sustained while playing soccer between the time period of 2013 to 2024 and within the age range of 0 to 69 years old. Using these statistics, organizational agencies and soccer leagues can make adjustments to regulations, implement preventive training programs, and recommend the utilization of specific protective equipment in an effort to lower rates of soccer-related lower extremity injuries.

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