Tennis-Related Injuries: A NEISS Database Study

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With over 23.6 million tennis players in the United States, there is an increasing need to better understand the injury trends within the sport. There is a lack of analysis on general tennis injury trends, and this lack of understanding puts tennis players at higher risks for injury. This study aims to identify common tennis injuries in the US using the National Electronic Injury Surveillance System, consisting of injury reports from 100 emergency departments across the country. A NEISS query was used to acquire the data for tennis-related injury reports from 2003 to 2022. Using NEISS coding, specific categories were filtered to create tables and subtables. Graphs were made using the GraphPad Prism software. National estimates show that sprain/strain, fracture, contusion/abrasion, laceration, and internal organ injury were the most common diagnoses and that there were 90,631 head/face/neck injuries, 113,624 upper extremity injuries, 62,986 trunk injuries, 144,458 lower extremity injuries, and 24,923 with unknown etiology or caused by excessive heat. Fractures were most common in the upper extremity, while strains and sprains were most common in the lower extremity. Narrative data identifies distal radius fracture as the most common type of wrist fractures, with females being more prone to left wrist fractures. Older age groups were more prone to fractures. Tennis coaches and sports medicine practitioners can use this data to create targeted safety measures based on the athlete's demographic characteristics and the most prevalent injuries within the sport.

Keywords: Tennis injuries, NEISS, Data Analysis, Demographics, GraphPad Prism 10, Sports Medicine

Introduction

In 2022, there were over 23.6 million tennis players in the United States[1]. Although tennis is a non-contact sport, the repetitive nature of play places stress on muscles, ligaments, tendons, and bones, making overuse injuries very common[2]. Acute injuries often occur from falling onto the hard court. Injury data analysis is essential to identify common injury trends that prevention programs and safety measures must target. Most prior research on tennis injuries has either focused on a specific subset of tennis injuries or multiple racket sport injuries grouped together[3–6]. General trends in tennis injuries is a research area that has not been fully explored, even with such widespread participation in the sport across the United States. These past studies have identified commonly injured body parts and the most prevalent diagnoses, but have not conducted adequate stratification of the data or used more detailed information from each injury case narrative, a comprehensive description of the injury that elaborates on its specific location. Additionally, these studies do not include more recent injury data. This study included recent injury data, more stratification, and an analysis of injury information from the narratives, addressing the gaps within the existing literature.

This research is tied to sports medicine, a branch of medicine focused on injury prevention[7]. The findings can help sports medicine clinics understand what injuries tennis athletes are most at risk of, which in turn can help these centers create tennis injury prevention programs and safety measures to help prevent or manage the most prevalent injuries. The analysis of injury patterns based on sex, age, and race can determine what types of injuries players are most prone to base on their demographic characteristics. To achieve our objective, we reviewed tennis injury reports from 2003-2022 with the National Electronic Injury Surveillance System (NEISS) database, a collection of consumer product and activity related injury reports from approximately 100 emergency departments across the country[8]. The NEISS database is a nationally representative probability sample, and findings made using the database can be generalized to all emergency departments across the United States. Since this study aimed to analyze U.S. tennis injuries, this database was the appropriate source for injury data.

The study included only reports that were submitted through United States emergency department visits following tennis injuries, and excluded international tennis injuries and injuries that were seen at other places of care, such as urgent care or physician practice sites. The database's limitation to only emergency departments could have resulted in a selection bias, as different areas of care might see certain types of injuries more frequently depending on the severity and urgency. ED settings do not adequately capture less severe and urgent injuries such as sprains and bruises and excessively capture severe injuries demanding immediate attention such as fractures[9]. Another

limitation was the lack of specificity in some of the injury case narratives, as some did not specify an injury mechanism or the bone that was injured for fractures.

The data for this study was gathered using the NEISS query, which acquired the injury reports and placed them into an excel file. Each injury case from the sample has a weight, the estimated total number of injuries it represents nationally, which was calculated based on the size of the emergency department. The national estimate, rather than the number of cases in the sample, was primarily used for comparative analysis. Both the NEISS coding and the information extracted from the narratives were used to create tables. Certain codes, such as each body part and age, were grouped together to simplify the data and make it more comprehensible. Then, the tables were converted into understandable pie and bar graphs using the Graphpad Prism 10 software.

The study was aimed to analyze tennis-related injuries in the United States by identifying the most common types of injuries and determining if injury patterns varied based on different demographic characteristics. The first objective was to conduct comparative analysis between participants of different demographic characteristics and identify different injury patterns between them. The second objective was to identify the most common specific types of injuries by conducting stratification of diagnosis and injury location data.

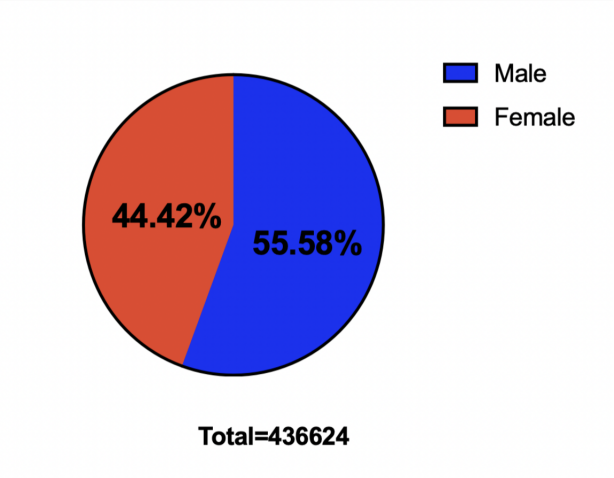

Fig. 1 National estimates of tennis injuries in men and women

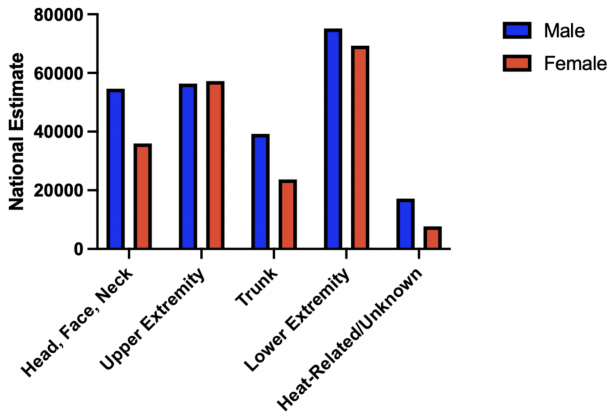

Fig. 2 National estimates of injured body regions observed in male and female tennis players

Results

There were 11,031 tennis-related cases in the NEISS database from 2003-2022, with a total national estimate of 436,625. The following results are based on the national estimate data acquired through the NEISS database. All percentages were rounded to the hundredth place.

Sex

There was a national estimate of 242,669(55.58%) male injuries and 193,955(44.42%) female injuries . This roughly matches the participation rate, as 57% of tennis participants are male and 43% tennis participants are female in the United States as of 2023[10].

Female players had a higher percentage of upper and lower extremity injuries than male players, 29.51% and 35.71% compared to 23.24% and 30.98%, respectively. Male players had a higher percentage of head/face/neck, trunk, and heat-related/unknown injuries than female players, 22.51%, 16.16%, and 7.08% compared to 18.56%, 12.23%, and 3.99%, respectively. Female players were more prone to lower arm and wrist injuries, while male players were more prone to heat-related injuries.

Lacerations were much more common for male players, with 10.78% of injuries being lacerations for males compared to 5.58% for female players. Fractures were much more common for female players, with 18.67% of injuries being fractures for females compared to 12.02% for males.

Male players had significantly more shoulder and trunk/upper rib fractures, while female players had significantly lower arm, wrist, and ankle fractures.

Age

There was a national estimate of 20,469(4.69%) injuries in the 0-9 age group, 100,838(23.09%) injuries in the 10-18 age group, 26,038 (5.96%) injuries in the 19-25 age group, 72,235 (16.54%) injuries in the 26-45 age group, 109,727(25.13%) injuries in the 46-65 age group, and 107,315(24.58%) injuries in the 66+ age group. The average age of the injured players was 38 years old. The mode age was 16 years old, with a national estimate of 15,460.

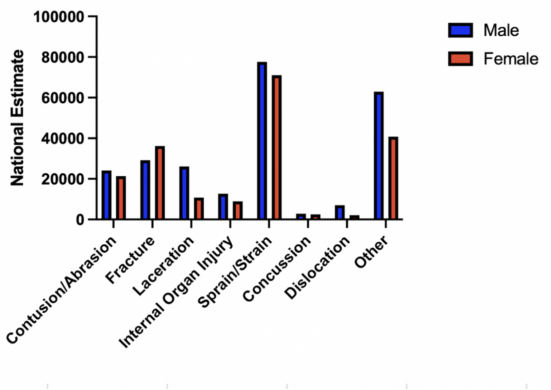

Fig. 3 National estimates of diagnoses observed in male and female tennis players

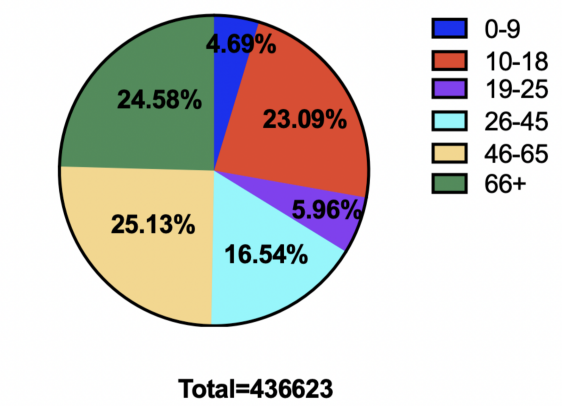

Fig. 4 National estimates of tennis injuries among various age groups

Fractured Body Part	Male National Estimate	Female National Estimate
Shoulder(30)	1,945	825
Trunk, upper(rib)(31)	2,353	711
Elbow(32)	1,469	1,512
Lower Arm(33)	2,749	6,778
Wrist(34)	6,533	11,354
Knee(35)	396	432
Lower Leg(36)	1,012	1,076
Ankle(37)	2,354	4,348
Head(75)	433	141
Face(76)	1,236	554
Lower Trunk(79)	1,551	1,483
Upper Arm(80)	1,133	1,228
Upper Leg(81)	294	303
Hand(82)	1,466	915
Foot(83)	2,024	2,155
Neck(89)	224	0
Finger(92)	1,547	2,038
Toe(93)	448	357

Table 1: National estimates of fractured body parts observed in male and female tennis players

The percentages of the diagnoses being fractures for each age group were 7.90%, 11.94%, 11.17%, 11.03%, 19.63%, 18.03%, respectively, indicating a trend of fracture being more predominant at older ages (46-65 and 66+). The percentage of the diagnoses being sprains/strains for each age group were 8.42%, 35.70%, 47.11%, 51.49%, 37.28%, 19.25%, respectively, indicating that those sprains and strains are less predominant in the 0-9 and 66+ age groups.

The most commonly injured body part region for each age group was head/face/neck, lower extremity, lower extremity, lower extremity, lower extremity, and trunk, respectively.

Race

There were 171,182(39.21%) injuries without a stated race, 216,501(49.59%) injuries from White players, 23,892(5.47%) injuries from Black players, 9,287(2.13%) injuries from Asian players, 269(0.06%) injuries from American Indian/Alaska Native players, 502(0.11%) injuries from native Hawaiian/Pacific Isalnder players, and 14,990(3.43%) injuries with a race classified as “other”.

Diagnosis

Sprains and strains had the highest national estimate, at 148,646(34.04%). Fractures were second, with a national estimate of 65,395(14.98%).

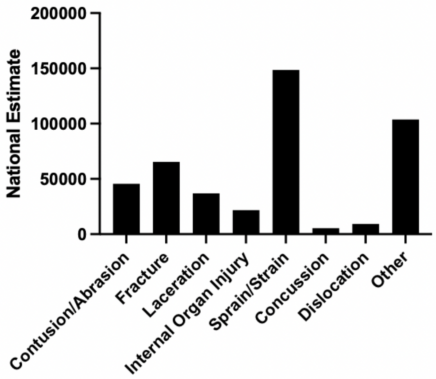

Fig. 5 National estimates of diagnoses observed in tennis players

Body Part

The lower extremity was the most commonly injured body part region, with a national estimate of 144,459(33.09%). The upper

extremity had a national estimate of 113,624(26.02%).

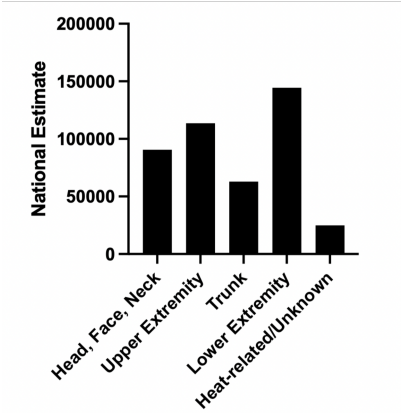

Fig. 6 National estimates of injured body regions observed in tennis players

Diagnosis and Body Part

The lower extremity had more sprains and strains than the upper extremity, with a national estimate of 98,331 compared to 31,312. However, the upper extremity had more fractures than the lower extremity, with a national estimate of 41,497 compared to 15,746.

The wrist was the most fractured body part, with a national estimate of 17,887 wrist fractures. The ankle was the most sprained/strained body part, with a national estimate of 45,215 ankle strains/sprains.

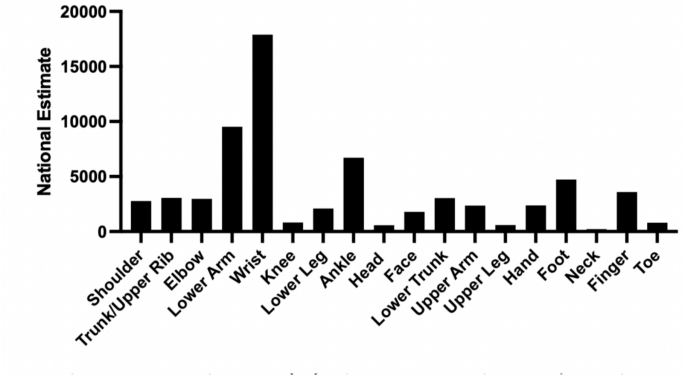

Fig. 7 National estimates of fractured body parts observed in tennis players

Narrative Data

The distal radius was the most common bone injured for wrist fractures, with a national estimate of 1,525 distal radius fractures.

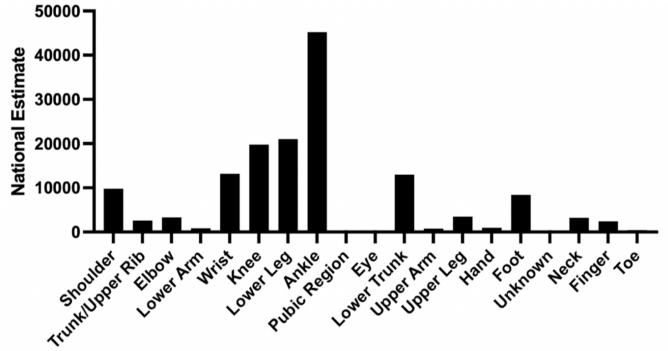

Fig. 8 National estimates of sprained/strained body parts observed in tennis players

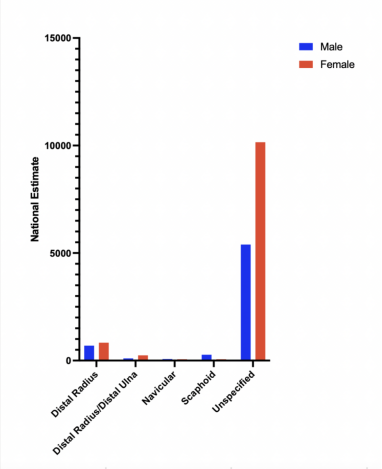

Fig. 9 National estimates of fractured wrist bones observed in male and female tennis players

There was a national estimate of 6,568 left wrist fractures and 2,598 right wrist fractures, indicating that left wrist fractures were significantly more common. Left wrist fractures were significantly more common for female tennis players than male tennis players, with a national estimate of 4,296 compared to 2,272 for male players.

Discussion

Results Summary

Trends in different demographics were established. Female players were more prone to upper and lower extremity injuries, while male players were more prone to head/face/neck, trunk, and heat-related/unknown injuries. Male players were more prone to lacerations, while female players were more prone to fractures. Players of older age groups were more prone to fractures, while players aged 0-9 and 66+ had a much lower percentage of sprain/strain injuries.

The most common types of injuries were identified. Sprains

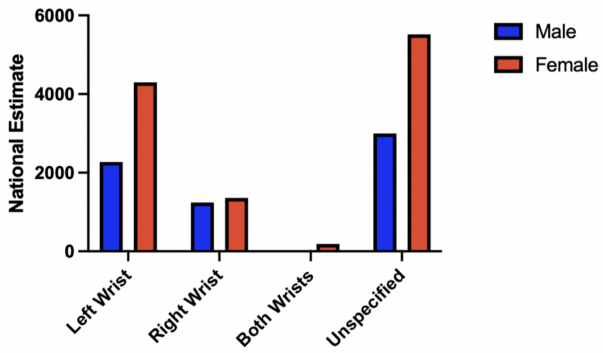

Fig. 10 National estimates of wrist fracture side observed in male and female tennis players

and strains were the most common diagnosis by a large margin. The lower extremity was the most commonly injured body part region, followed by the upper extremity. Fractures were more common in the upper extremity, while sprains/strains were more common in the lower extremity. The distal radius was the most commonly injured bone for wrist fractures, and there were significantly more left wrist fractures than right wrist fractures.

Explanation of Key Findings

One possible reason for why female players were more prone to extremity injuries and fractures is due to lower bone mineral density and smaller bone size, especially at older ages [11]. This could make female players more prone to fractures from falls, an injury mechanism where players often instinctually put their arms out to catch themselves.

The reason for fractures being more common at older age groups could be the decrease in bone mineral density from aging [12]. The reason for sprains and strains not being common in the 0-9 age group could be that growth plates are weaker than muscles or tendons at that age, placing the growth plates, rather than the muscles and tendons, at higher risk for injury [13]. A likely explanation for why sprains and strains were the most common diagnosis is because tennis is a sport heavily reliant on directional changes, putting players at high risk for sprains and strains [14]. The lower extremity was the most commonly injured body part region because tennis players use their legs to make the directional changes, placing their legs at highest risk for sprains and strains [14]. Fractures were more common in the upper extremity because players will reach their arms out to catch their fall, putting their upper extremity at risk for fracture.

Distal radius fractures being the most common matches general wrist fracture trends, as the distal radius fracture is the most common type of wrist fracture overall and often occurs when players fall on an outstretched hand, a common occurrence in tennis [15]. The most likely explanation for why there were more left wrist fractures is because right-handed people hold the racket with their right and dominant hand and will thus use their left arm to catch their fall [16].

Gaw et al. (2014), a similar study, identified sprain/strain to be the most common diagnosis and the lower extremity to be the most injured body part region [17]. Chevinsky et al. (2017) identified that there were more male injuries than female injuries and that sprain/strain was the most common diagnosis [18].

There are also potential confounding factors that could influence injury patterns, as hard courts and competitive play have an increased injury risk [19].

Implications

The two objectives of identifying injury patterns for different demographics and identifying the most common types of tennis injuries were both met, as the findings of the study helped achieve both objectives.

The comparative analysis of injuries between different demographics and the identification of trends contributed to the field of sports medicine, as there is a greater understanding of the influence sex and age have on tennis injuries. Sports medicine clinics could utilize this information to create safety measures and provide safety advice for each athlete based on their sex and age. For example, given the prevalence of sprains and strains caused by the overuse of muscles, ligaments, and tendons, proper racket swing technique should be emphasized to limit the stress placed on them. Given the prevalence of acute fractures caused by falls, especially in female players and players of older age groups, tennis players should be educated on proper footwork to minimize the risk of falling. The findings also suggest that tennis players should use proper tennis footwear to minimize the risk of injuries, especially those of the lower extremity. Coaches should properly educate players on proper swinging technique to minimize the risk of overuse injuries, and athletes should play in moderation to limit the strain placed on their bodies.

There is also an academic significance of these demographic injury patterns, because they could provide information on anatomical differences between males and females and different age groups. Additionally, the findings of this study match prior studies, further supporting the tennis injury data. This study both validated findings in the existing body of literature and brought new findings, such as the wrist fracture information extracted from the narratives.

Limitations

One main limitation of our study and the NEISS database is the restriction to emergency departments. Injuries managed at

urgent care, doctor's offices, and other areas for care were excluded, and it is possible that the results from these places could vary due to selection bias. Thus this makes the results of this study less generalizable to non-ED settings. For example, ED settings do not adequately capture injuries of less severity and urgency such as sprains and bruises and excessively capture severe injuries demanding immediate attention such as fractures[9].

The information provided in the database also limits our study, as many injury cases did not provide a very specific injured body part or mechanism of injury. Some narratives lacked specificity and detail. Having this information could allow for the establishment of more trends and patterns from the narrative data.

Further Research

Future studies could work to address the limitations of our study. Analyzing injuries from other sources of care could provide more insight into injury patterns and address the selection bias present with the NEISS database findings. Utilizing data that provides information such as specific injured body parts and injury mechanisms could allow for deeper analysis. In order to make sports safer for the millions of athletes in the United States, sports injury research must be a priority.

Future studies should use the findings from our study to create hypotheses in the field of tennis injuries and conduct statistical analysis to confirm or disprove the hypotheses.

Methods

Overview

This study was observational, as it analyzed existing tennis injury data within the public National Electronic Injury Surveillance System (NEISS) database. The sample for this study was all tennis injuries from 2003-2022 in the NEISS database, a database of emergency department injury reports from a nationally representative probability sample of approximately 100 of hospitals throughout the U.S. This year's range was selected to ensure a sufficiently large sample size to draw reliable conclusions. Tennis rackets have become more lightweight and tennis shoes have become safer since 2003[20]. NEISS is operated by the Consumer Product Safety Commission (CPSC), and it is a public tool used by the media, consumers, researchers, and people of a specific industry for a variety of purposes.

The study analyzed the five following aspects of the player/injury: sex, age, race, diagnosis, and injured body part. This allowed the detection of both injury trends within different demographics and the most common types of injuries.

In order for the sample to accurately represent all injuries nationwide, each injury report in the sample has an assigned weight, which is the number of injuries it represents nationally based on the size of the hospital that the injured player visited. This national estimate, rather than the number of cases, was used for comparative analysis in order to accurately represent the entire U.S tennis player population.

Data Collection

We submitted a NEISS query for all injuries with the product code for tennis(3284) from the past 20 years(2003-2022), and selected all diagnoses, body parts, and dispositions. After the completion of the query, we downloaded the injury reports as a Microsoft Excel file. Since we sought to analyze tennis injury trends for the entire U.S tennis player population, we included all demographics in our study.

Management of the Data

We removed injuries that weren't related to playing tennis based on the injury narratives, a short description for each case that provides additional information on the injury mechanism, diagnosis, and/or area of injury. Certain injuries involved tennis equipment but were not caused by playing the sport, such as people cutting tennis balls to use them as chair legs. Injuries that were caused by playing the sport were clearly specified in the narratives by stating that the person was playing tennis. Additionally, we extracted the specific bone injured and side of injury for wrist fractures using the narrative data, and we added two additional columns to store this information on the spreadsheet.

Table/Graph Creation

With the updated excel sheet, we created tables for the five main injury aspects. Each aspect had a designated column in the excel spreadsheet, so we used the "filter" feature in excel and then recorded the national estimate for each category within the injury aspect. Sub-tables were created by filtering two columns at once and recording the national estimates. Tables based on the narratives were created using the same method.

The individual ages were grouped into six age groups and the body parts were grouped into five body part regions. The diagnoses with very small national estimates were grouped into the "other" category. Afterwards, tables were converted into graphs using the GraphPad Prism 10 software. Pie graphs were used for the sex and age tables, while bar graphs were used for everything else.

Ethical Considerations

There are no ethical considerations associated with this study, as the NEISS is a publicly available database.

Conclusion

Clear trends were established within the NEISS tennis injury data, for both the type of injury and patterns between different demographics. Strains and sprains were the most common diagnosis, and the lower extremity was the most injured body part region. Lacerations were much more common for male players, while fractures were more common for female players. Fractures were more common for older ages.

The findings from this study can be used to make tennis a safer sport. Tennis players can be taught how to minimize the risk for the common injuries in the sport. Players can be informed on what injuries they are more at risk for based on their demographics. Future studies could use cases from other sources of care and different databases.

Acknowledgements

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