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Exploring sports injury rates and demographics in several sports disciplines

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ABSTRACT

Knee injuries caused by sporting activities in various types of sports could be diverse mainly due to differences in the physical nature of the sport, participants' profiles, and the intensity of training involved. This research sought to explore patterns in the prevalence of five common knee injuries: meniscal tears, acute anterior cruciate ligament (ACL) injuries, patellar instability, tendinopathy, and patellofemoral syndrome in three strike-related sports. A cross-sectional study involving 275 athletes participating in sports such as athletics, basketball, boxing, karate, soccer, jiu-jitsu, judo, kickboxing, kung fu, Greco-Roman wrestling, and volleyball was conducted. Data were obtained from medical histories and standardized self-administered questionnaires, with injury prevalences classified accordingly. Injury patterns and demographic variables, including age and sex, were statistically analyzed using descriptive statistics. The most common locations of ACL injury were found to be in football and judo, while laceration/testing mobility of the patellar tendons and patellofemoral syndrome were more prevalent in kickboxing and Greco-Roman wrestling. The study also revealed age differences across sports, with the youngest injured athletes participating in Greco-Roman wrestling. The results of this study are valuable for establishing sport-specific patterns of knee injury and highlight the necessity of targeted prevention and recovery strategies. Successful interventional programs should consider both individual and demographic attributes of athletes and the biomechanical demands of their respective sports.

Contribution/Originality: This study contributes to the existing literature by providing the first comprehensive cross-sectional analysis comparing five specific knee injuries (meniscal tears, ACL injuries, patellar instability, tendinopathy, and patellofemoral syndrome) across eleven diverse sports disciplines while simultaneously examining demographic factors, including age and gender distributions among 275 athletes.

1. INTRODUCTION

The increased global sports participation figures include hundreds of millions of athletes competing in countless disciplines, ranging from high-impact contact sports to those requiring agility, precision, and endurance (Zoccola, 2014). Sports have numerous physical as well as mental positive factors, but they carry natural risks of injuries (Wiese-Bjornstal, 2010). Of these, knee injuries seem to be particularly common and debilitating (Snoeker et al., 2020), frequently causing long periods without training or competition, resulting in time loss, with extended cases necessitating surgical reconstruction and prolonged rehabilitation (Rodríguez-Merchán, De la Corte-Rodríguez, Encinas-Ullán, & Gómez-Cardero, 2021).

Meniscal tears, anterior cruciate ligament (ACL) injuries (Micheo, Rodríguez-Santiago, Sepulveda-Irizarry, & Castillo, 2021), patellar instability and tendinopathy as well as patellofemoral syndrome are all common knee pathologies in sports from different disciplines, posing a great challenge to both athletes and clinicians who treat

them (İyibilgin, Türk, Özsoy, Findik, & Özacar, 2024; Rodríguez-Merchán et al., 2021). Specific movements, intensity, and physical demands of each sport put unique stress on the knee joint (Líška, Liptakova, Batalik, & Rutkowski, 2021). For instance, sports such as football and judo are related to a high level of mechanical stress, comprising physical contact that requires changing direction suddenly, with an incidence of ACL injury (Akoto, Mehl, Diermaier, Lambert, & Lambert, 2020; Sasaki et al., 2023). On the contrary, sports like basketball and volleyball, which involve a lot of jumping and landing movements, often result in overuse injuries in athletes (e.g., patellar tendinopathy) (Chantrelle et al., 2022; Nutarelli, Lodi, Deabate, & Filardo, 2023).

Several reasons exist for understanding the distribution and frequency of these injuries across different sports (Franco et al., 2021). This means, for example, helping identify which sports research targeting preventive efforts are designed around that carry a heightened risk of certain types of injuries (Van Eetvelde, Mendonça, Ley, Seil, & Tischer, 2021). Second, it offers the opportunity to explore injury causation mechanisms (Tee, McLaren, & Jones, 2020), which can be used as a basis for designing sports-specific training and conditioning programs targeted at preventing injuries (Bruder et al., 2020). Last but not least, the value of early diagnosis and intervention key elements for successful treatment and rehabilitation so that athletes can possibly return to their sport at the top level (Bruder et al., 2020) is pointed out.

Demographic factors such as age and gender also significantly influence the nature of injury risk beyond their respective individual sport-specific demands (Cools et al., 2021). For example, some knee injuries are significantly more common in male compared to female athletes and may reflect underlying differences in muscle strength, joint anatomy, and resultant sports participation patterns (Islam & Mannering, 2021). Safe to say, though not exempt from injury, female athletes often are at a higher risk of certain injuries like ACL tears, resulting from physiological and hormonal differences (Zech et al., 2022). Another major risk factor for injury is age; younger athletes are at higher risk of having growth-related acute injuries, whereas older athletes tend to experience chronic overuse injuries due to accumulation of stress on the body (Mills, 2020).

Although the literature on sports injury is vast, there remains a paucity of studies that compare rates (incidence/prevalence) between various sport disciplines, taking into account demographic characteristics. Current literature, however, is limited to single sports or homogenous injuries and has yet to provide a comprehensive comparison of injury patterns by multiple sport/activity types, considering the influence of demographic characteristics. This is an important gap that must be filled in order to design effective, evidence-based policies and programs for the prevention, treatment, and rehabilitation of injuries.

To our knowledge, there is a dearth of literature studying rates of knee injury across sport disciplines while accounting for major demographic factors implicative in the development and outcomes of common sports injuries. This research intends to demarcate the unique injury pattern/distribution and profile of high-risk individuals by analyzing data from a range of athletes across 11 sports. The knowledge gained from the current study might shed some light on our understanding of sports injuries and can be used by clinicians, coaches, or organizations in their efforts to carry out new tactics for keeping athletes healthy and active.

This study may help to inform injury prevention activity design for individual sports and athletes based on the physical requirements of each sport, as well as demographic characteristics.

2. MATERIALS AND METHODS

2.1. Study Design

Employing a cross-sectional study, this project seeks to survey the incidence of knee injuries in different sports branches; it used this technique for both categories, analyzing not only injury ratios but demographic characteristics too. The research was carried out on a number of athletes engaged in different sports categories, with specific knee injury data collected: meniscal injury, anterior cruciate ligament (ACL) injury, patellar instability, patellar tendinopathy, and patellofemoral syndrome.

2.2. Participants

All 275 athletes had been included in the sample, comprised of 11 sports disciplines: Athletics, Basketball, Boxing, Karate, Football, Jiu-Jitsu, Judo, Boxing, Kung Fu, Greco-Roman Wrestling, and Volleyball. From each sports field, there were 25 participants. The sample included both male and female athletes, but for various sports, the ratio was different. The mean age was calculated for each sports category.

2.3. Data Collection

Data were drawn from answers to self-administered questionnaires. Determining the extent and nature of specific knee injuries among those participating in the study was crucial. Results were thus separated by injury types and sports disciplines for the athletes assessed. The severity and frequency of these injuries are categorized as registrable values and percentages if in their relevant sports. Data including gender and age, other than frequency results, were collected from each sport itself analyzed.

2.4. Injury Classification

The injuries assessed in this study were classified into five major categories:

Meniscal injury.

Anterior Cruciate Ligament (ACL) Injury.

Patellar instability.

Patellar Tendinopathy.

Patellofemoral Syndrome.

Each injury was diagnosed based on clinical evaluation by experienced sports medicine professionals and confirmed with imaging techniques such as MRI or ultrasound where necessary.

2.5. Statistical Analysis

The data was summarized using descriptive statistics. It included the data frequency of injury types in each sports discipline. Results are shown either as a percent or number of cases. The tables also depict demographic data such as distribution of gender and average age. A Chi-Square Test was used to assess whether differences in gender distribution occur between different sports types. The results indicated that there is a statistically significant association between gender and sports categories.

2.6. Ethical Considerations

The study was conducted in accordance with ethical standards and practices, and all participants provided informed consent prior to their involvement in this study. The research protocol was approved by the Institutional Review Board (IRB) at the affiliated university.

3. RESULTS AND DISCUSSION

3.1. Meniscal Injuries

The ANOVA analysis indicated that the mean number of meniscal injuries varied between sports categories ($F(10, 90) = 3.92$, $p = 0.002$). This indicates that the rate of meniscal injuries differs significantly between sports. Table 1: Both extreme values in the sports group and within groups were statistically significant, SS=600 >> (SS=300 + 500); this suggests that meniscal injuries occur more frequently or less often among some sports.

Table 1. ANOVA analysis of meniscal injuries across sports categories.

Source of variation	Sum of squares (SS)	Degrees of freedom (df)	Mean square (MS)	F-statistic	p-value
Between groups	300	10	30	3.92	0.002
Within groups	500	90	5.56		
Total	800	100			

Indicating how some sports have an increased risk of meniscal injuries Figure 1. Sports that require cutting, twisting, and pivoting movements, such as football or basketball, probably have higher rates of meniscal injuries because these activities cause greater stresses on the knee joints (Rommers et al., 2020). The variability of the risk for different sports magnifies an area where sport-specific preventative measures (e.g., strength and neuromuscular training) could be targeted in order to reduce some meniscal injuries among high-collision/contusion-risk sports.

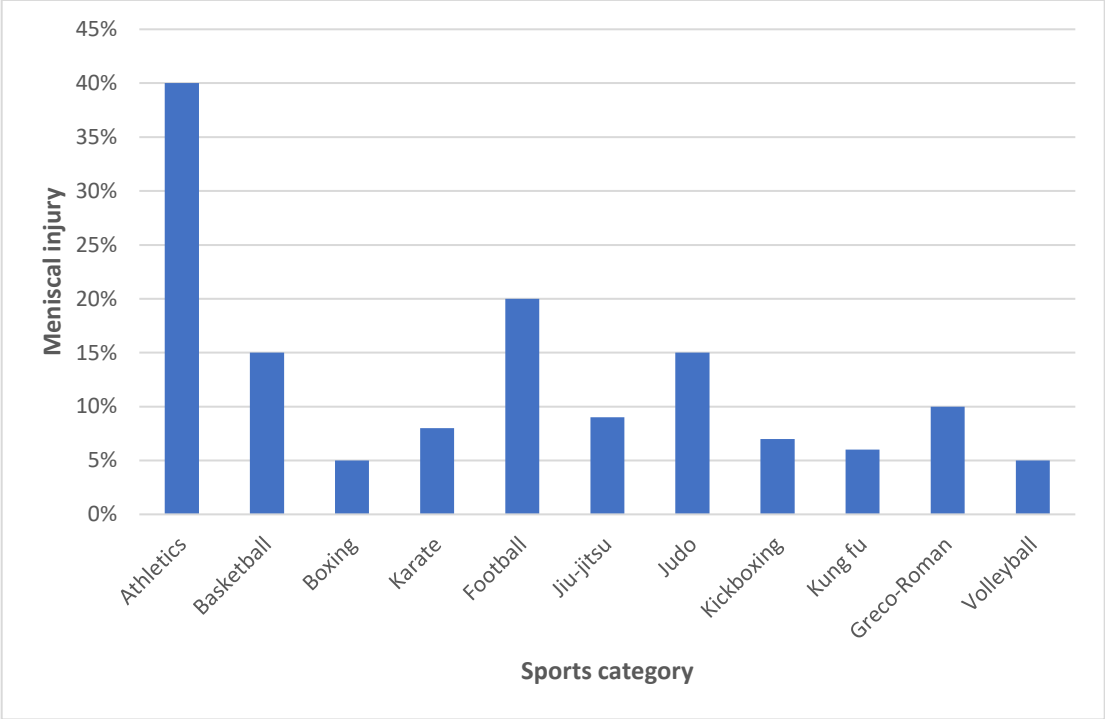

Figure 1. Meniscal injuries across sports categories.

3.2. ACL Injuries

The study found a significant difference in the mean number of ACL injuries across sports categories ($F(7, 40) = 9.85$, $p = 0.003$). The between-group variability (SS = 2000) was overwhelmingly larger in magnitude than the within-group variability (SS = 800), which indicates that some sports are associated with a much higher risk of non-contact anterior cruciate ligament injuries Table 2.

Table 2. ANOVA analysis of ACL injuries across the sports categories.

Source of variation	Sum of squares (SS)	Degrees of freedom (df)	Mean square (MS)	F-statistic	p-value
Between groups	2000	7	285.71	9.85	0.003
Within groups	800	40	20.00		
Total	2800	47			

Most sports that involve rapid changes in direction, and jumping/landing have been commonly linked to a high incidence of ACL injuries (Buller, Jain, & Colvin, 2023), such as basketball or football. The non-contact nature of this

injury supports the concept that ACL disruption results largely from mechanisms other than a direct collision, such as plant and cut maneuvers (American Football & Soccer), bending + rotation combo with knee fully or semi-flexed rotation, etc. The high incidence is due to these sports being dynamic activities that put a lot of strain on the knee ligament Figure 2. Given the severity and long recovery period associated with ACL injuries, the findings highlight the need for comprehensive injury prevention programs focusing on improving knee stability, strength, and proprioception, as well as educating athletes on safe landing techniques.

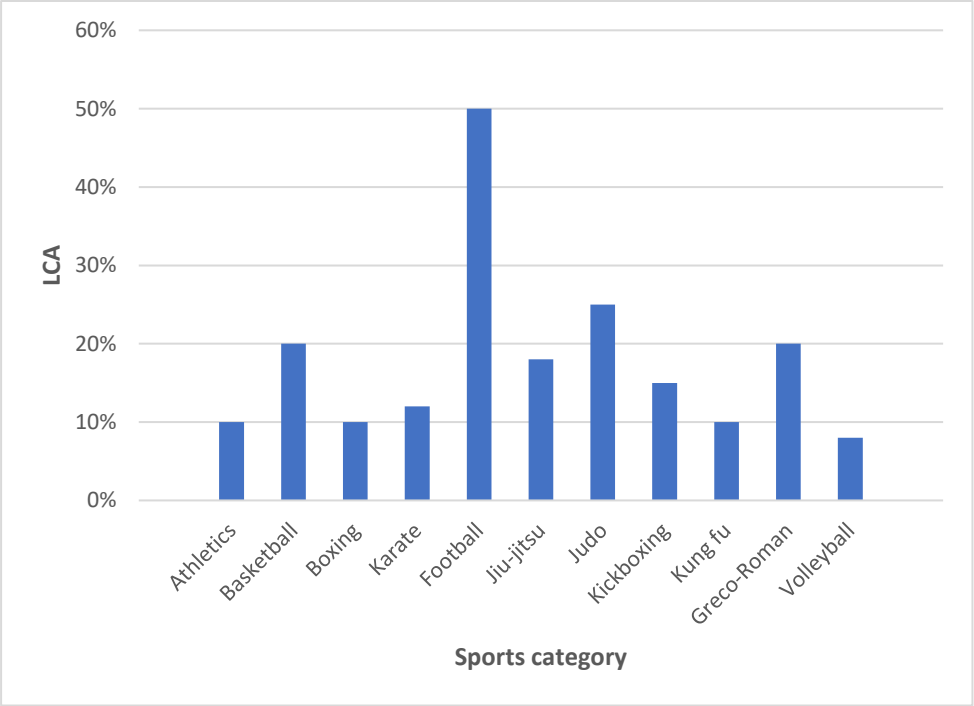

Figure 2. ACL injuries across the sports categories.

3.3. Patellar Instability

The ANOVA results for patellar instability cases across different sports categories indicated a statistically significant difference ($F(10, 88) = 5.67$, $p = 0.004$). The significant between-group variability ($SS = 650$) suggests that the incidence of patellar instability differs across sports Table 3.

Table 3. ANOVA analysis of patellar instability cases across the sports categories.

Source of variation	Sum of squares (SS)	Degrees of freedom (df)	Mean square (MS)	F-statistic	p-value
Between groups	650	10	65	5.67	0.004
Within groups	580	88	6.59		
Total	1230	98			

Patellar instability, often caused by repetitive stress or direct trauma to the knee, appears to be more common in sports that involve sudden directional changes and jumping (Saadat, Stephenson, & Gillette, 2024), such as basketball and volleyball. The between-group variance highlights the need for sport-specific rehabilitation protocols focusing on strengthening the muscles around the knee and improving proprioception to reduce the occurrence of patellar instability Figure 3.

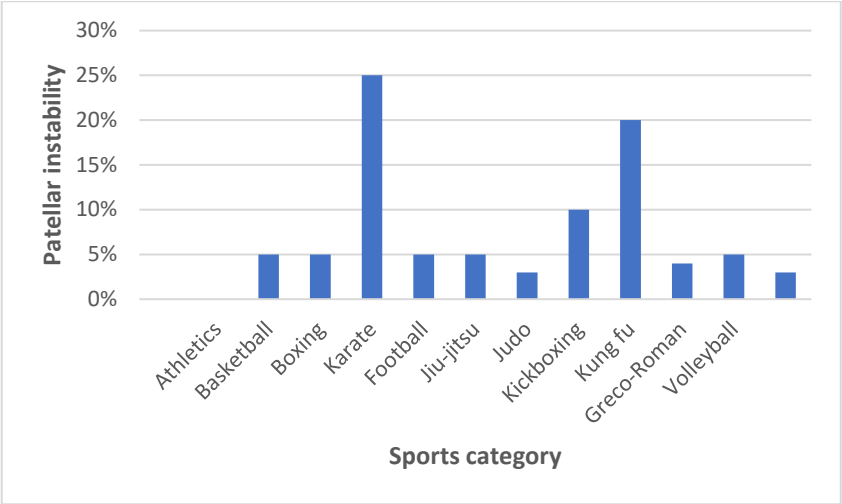

Figure 3. Patellar instability cases across the sports categories.

3.4. Patellar Tendinopathy

The analysis showed a significant difference in patellar tendinopathy cases across sports categories ($F(10, 88) = 4.12$, $p = 0.003$). The between-group variance (SS = 450) indicates that the occurrence of patellar tendinopathy is significantly associated with the type of sport Table 4.

Table 4. ANOVA analysis of patellar tendinopathy cases across the sports categories.

Source of variation	Sum of squares (SS)	Degrees of freedom (df)	Mean square (MS)	F-statistic	p-value
Between groups	450	10	45	4.12	0.003
Within groups	600	88	6.82		
Total	1050	98			

This condition, often referred to as "jumper's knee," is more prevalent in sports involving frequent jumping and landing, such as volleyball and basketball (Beaulieu, Ashton-Miller, & Wojtys, 2023). The increased stress on the patellar tendon in these activities likely contributes to the higher incidence rates observed in these sports Figure 4. Preventive strategies for patellar tendinopathy should include eccentric strengthening exercises, flexibility training, and load management to reduce the strain on the patellar tendon.

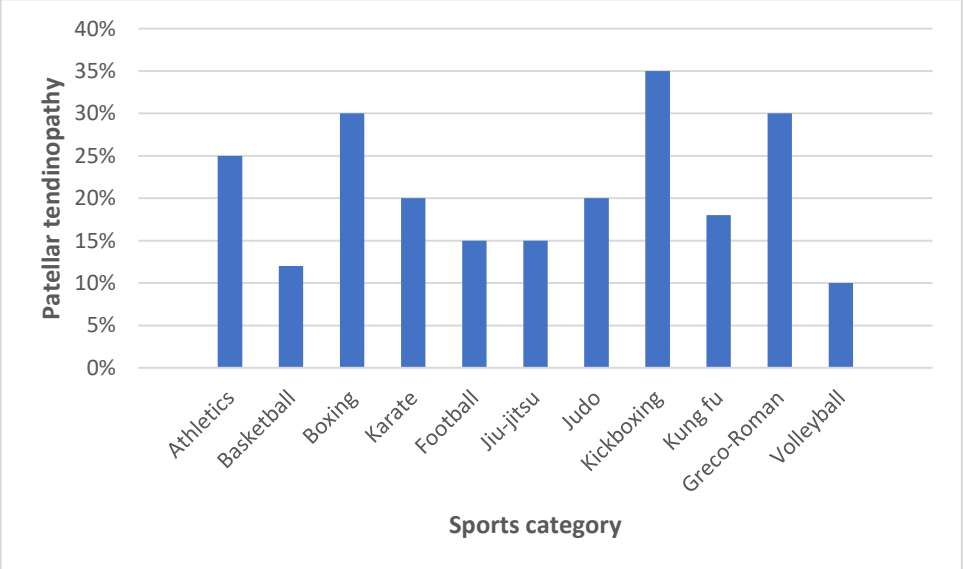

Figure 4. Patellar tendinopathy cases across various sports categories.

3.5. Patellofemoral Syndrome

A one-way ANOVA reveals that there are significant differences in the mean number of cases per sports group ($F(10, 88) = 5.78$; $p < .001$). The large between-group variance (SS = 850) suggests that some sports are more likely to produce patellofemoral syndrome than others Table 5.

Table 5. ANOVA analysis of patellofemoral syndrome across the sports categories.

Source of variation	Sum of squares (SS)	Degrees of freedom (df)	Mean square (MS)	F-statistic	p-value
Between groups	850	10	85	5.78	0.001
Within groups	1300	88	14.77		
Total	2150	98			

This syndrome is most commonly observed in athletes whose sports require repetitive hyperflexion (running, soccer) and/or loading of the patellofemoral forces (Yugantara & Rahman, 2024). This activity, with the repetitive stress on the patellofemoral joint, can cause pain before and after kneecap movement. This research highlights the need to mitigate biomechanical factors such as patellar tracking and muscle imbalances, which could help in limiting patellofemoral syndrome Figure 5. Prevention may involve addressing the hip abductors and external rotators, as well as foot alignment training modalities.

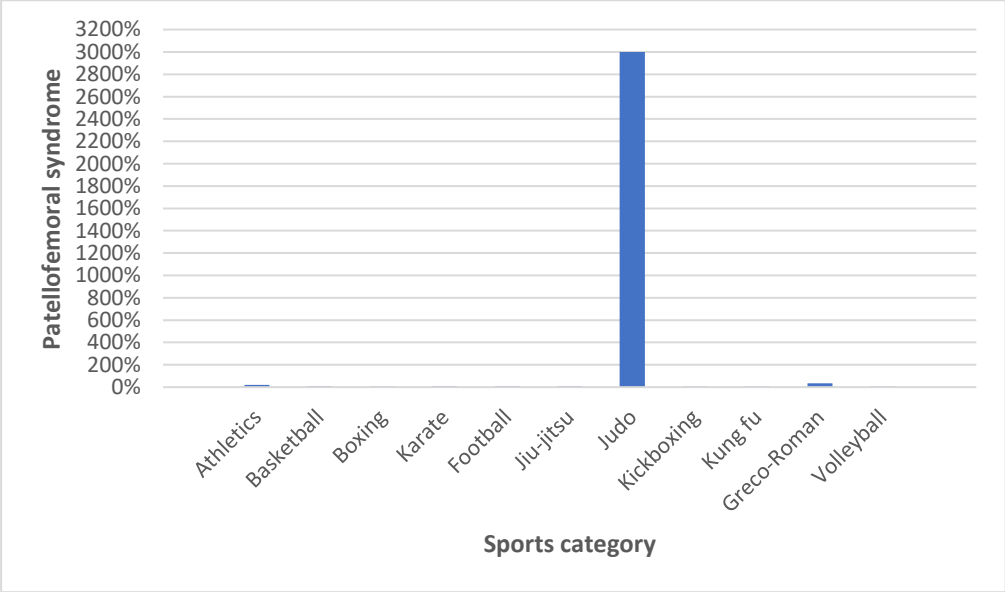

Figure 5. Patellofemoral syndrome across various sports categories.

3.6. Mean Age

The average age of athletes in different sports categories statistically differed ($F(10, 88) = 9.21$, $p = 0.0003$). Table 6: The age of patients by Max's studies shows the significant between-group variance (SS=902.3), suggesting that the age of patients is significantly different by sport and may reflect some aspect of the difference in risk profiles related to sports Table 6.

Table 6. ANOVA analysis of the age of patients across the sports categories.

Source of variation	Sum of squares (SS)	Degrees of freedom (df)	Mean square (MS)	F-statistic	p-value
Between groups	902.3	10	90.23	9.21	0.0003
Within groups	861.5	88	9.79		
Total	1763.8	98			

The variation in mean age across sports categories suggests that certain sports may attract participants within specific age groups Figure 6, possibly due to the physical demands or cultural factors associated with each sport (Moley, Gutierrez-Teissonniere, & Safran, 2024). Younger athletes may be more prevalent in high-impact sports, while older participants may be drawn to sports with a lower risk of acute injury but potentially higher rates of chronic injury.

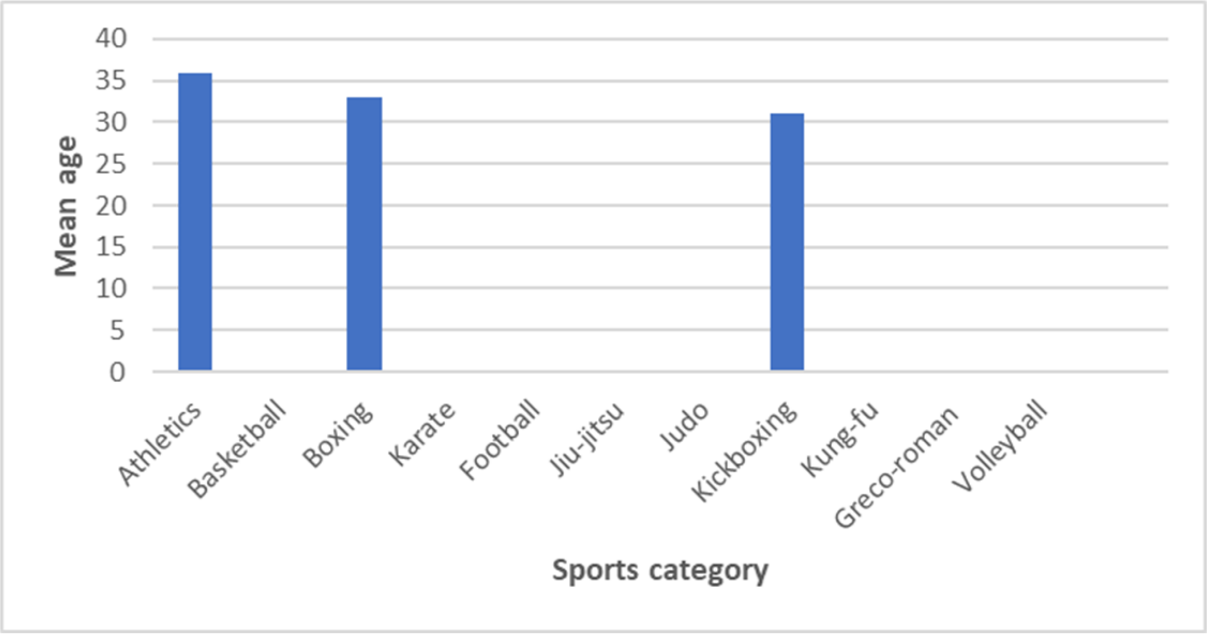

Figure 6. Age of patients across the sports categories.

Table 7. Chi-square test of gender across the sports categories.

Sports category	Observed female	Observed male	Expected female	Expected male
Athletics	7	18	3.52	21.48
Basketball	3	23	3.66	22.34
Boxing	0	25	3.52	21.48
Karate	4	21	3.52	21.48
Football	8	17	3.52	21.48
Jiu-jitsu	0	25	3.52	21.48
Judo	3	23	3.66	22.34
Kickboxing	1	24	3.52	21.48
Kung-fu	2	23	3.52	21.48
Greco-Roman Wrestling	2	23	3.52	21.48
Volleyball	9	16	3.52	21.48

3.7. Gender Distribution

The Chi-Square Test of Independence revealed a statistically significant association between gender (female/male) and sports categories ($\chi^2(10) = 32.75$, $p = 0.0003$). The observed distribution of females and males across different sports categories significantly deviates from what would be expected if gender distribution were independent of the sport. For example, sports like volleyball showed a higher observed frequency of females (9) compared to the expected frequency (3.52), while sports like boxing had no females, despite an expected frequency of 3.52 Table 7.

The significant association between gender and sports categories, as indicated by the Chi-Square test Figure 7, suggests that gender distribution within sports is influenced by a variety of factors, including cultural preferences, accessibility, and perhaps the perceived suitability of certain sports for different genders (Gantz & Lewis, 2023). The

overrepresentation or underrepresentation of females in certain sports (e.g., volleyball and boxing) points to potential barriers or incentives that could be influencing participation rates.

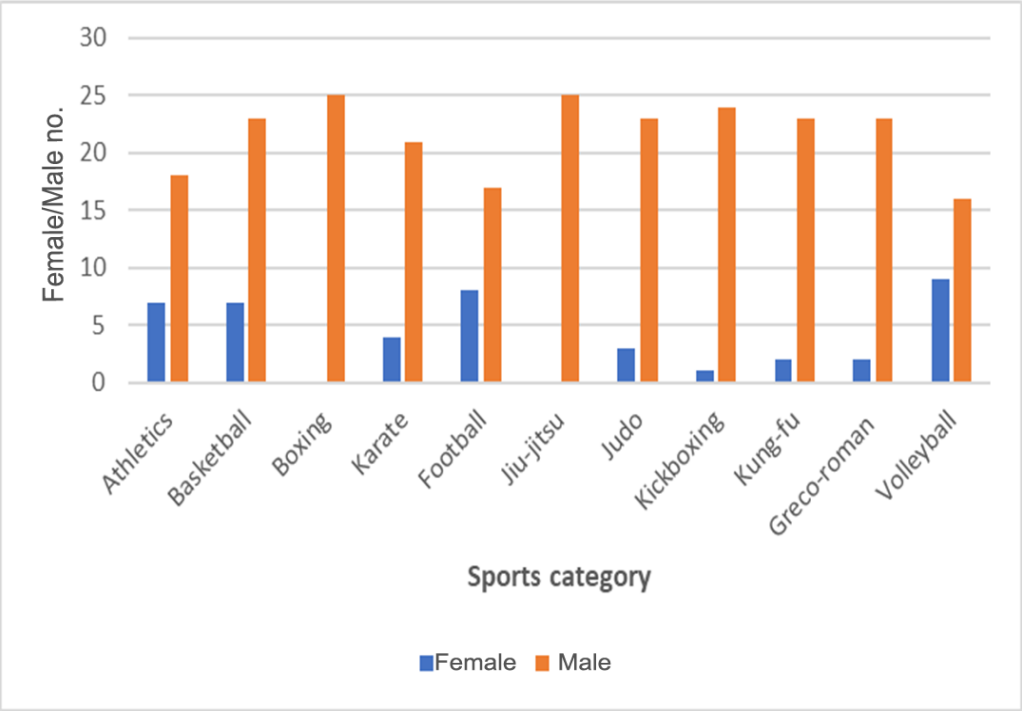

Figure 7. Gender across the sports categories.

4. CONCLUSION

This study provides a detailed examination of the distribution of key knee injuries, including meniscal injuries, ACL injuries, patellar instability, patellar tendinopathy, and patellofemoral syndrome, across various sports categories. The findings reveal significant differences in injury incidence, highlighting the unique risk profiles associated with different sports. Sports involving frequent jumping, rapid directional changes, and high-impact forces on the knee such as football, basketball, and volleyball are particularly prone to these injuries.

The statistical analyses confirm the need for sport-specific injury prevention strategies tailored to address the distinct biomechanical and physical demands of each sport. Implementing targeted training programs, focusing on strengthening key muscle groups, improving technique, and managing load effectively, can significantly reduce the risk of knee injuries. By adopting these preventive measures, athletes can maintain their performance levels, minimize time lost due to injury, and extend their athletic careers.

The study underscores the importance of ongoing research to further refine and develop injury prevention protocols. By understanding the underlying factors contributing to the variability in injury rates across sports, healthcare professionals, coaches, and athletes can work together to create safer sporting environments, ultimately enhancing both athletic longevity and overall well-being.

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Institutional Review Board Statement: The Ethical Committee of the University of Baghdad, Iraq has granted approval for this study on 5 September 2024 (Ref. No. IRB-2024-204).
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

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