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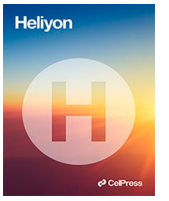

Research article

Pediatric meniscal surgery in Italy: A 10-year epidemiological nationwide registry study

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ABSTRACT

Purpose: Over the last two decades the incidence of meniscal injuries has grown amongst the pediatric population predominantly due to greater involvement in sporting activities. The treatment and the natural history represent a socioeconomic burden for healthcare systems. This study demonstrates the epidemiology of meniscal tears treated surgically in Italy from 2010 to 2019 in a population up to 18 years.

Methods: Data was collected from the National Archive of Hospital Discharges. ICD9-CM classification was used to select surgically treated meniscal injuries. Concomitant treatment of associated lesions were excluded. Data on the national population was retrieved from the Italian National Institute for Statistics (ISTAT). Statistical analyses were performed.

Results: 17,449 isolated meniscal tears were surgically treated with a mean incidence of 20.6 per 100.000 in the Italian population aged up to 18 from 2010 to 2019. The mean age of patients was 15.85 with 89 % aged 14 or older. 30 % of the population was female. The incidence of medial meniscal surgery was higher than for the lateral meniscus. A declining trend in surgical incidence was observed. The mean hospitalization time was 1.53 days.

Conclusions: Our study reveals a reduction in the total number of surgeries performed over the time frame and a significant rise in the incidence of meniscal lesions in pediatric patient above at the age of 13, especially in males. Despite a worldwide shift towards meniscal preservation, this trend is not evident in Italy as the current ICD9-CM classification does not differentiate between meniscectomy and meniscal repair, although an overall reduction in surgery may imply better management.

Study design: Cohort study; Level of evidence III.

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1. Introduction

Historically, meniscal tears in pediatric patients were considered rare. While the occurrence of lesions in the medial and lateral meniscus is infrequent among the skeletally immature population, a higher frequency of such lesions was observed among individuals with discoid menisci [1]; [2]. Recently, we observed increased traumatic meniscal injuries in children [3]; [4]. This may correlate to a larger involvement in sports and physical activity at a younger age, as well as improved clinical and diagnostic tools [5].

Mitchell et al. [6] studied meniscal injuries in US high school athletes and reported an overall meniscal injury rate of 5.1 per 100000 athletes, 68 % occurred in boys. In sex-comparable sports the injury rates were higher in females than males. Most Adolescent meniscal tears occur during sport competitions, and the typical mechanism of injury is a non-contact pivoting movement[7,8]. The sports considered high risk for these injuries are soccer, skiing, American football, basketball, and wrestling [7,9]. The most common patterns of meniscal tears are longitudinal peripheral or bucket handle [7].

Over the years the important concept of "save the meniscus" [10] has found large consensus among experts. Meniscectomy can compromise the future of the knee [11], leading to osteoarthritis, especially in young populations [12]. Moreover, the greater healing potential of the pediatric population in comparison to adults favours maximal meniscal tissue preservation [13].

Little is known about the actual prevalence of meniscal tears in children and adolescents.

To our knowledge no large-scale epidemiological studies about the meniscal injuries in skeletally immature patients aged between 0 and 18 years are reported. A recent study by Longo et al. [14], investigated the prevalence of pediatric meniscectomy in Italy from 2001 to 2016 among the young population aged between 0 and 14 years. The authors emphasized the socioeconomic burden of meniscal surgery and the importance of performing additional epidemiological studies. Therefore, the purpose of this study was to investigate meniscal tears surgically treated in Italy between 2010 and 2019 in pediatric and adolescent patients to determine the prevalence of the pathology, the trend over time and the demographic characteristics. Our hypothesis was that the observed increase in the number of meniscal injuries in the pediatric population reported in the literature would also be evident in Italy. The present study intends to provide insight into the socioeconomic impact of meniscal surgery on health care systema to improve the management of meniscal tears in the pediatric population.

2. Methods

Data was collected from the National Archive of Hospital Discharges (AHD) a database recording any episode of discharge from public and publicly funded structures throughout the Italian national territory. The AHD database was established in 1991 by the Italian Ministry of Health and collected demographic variables along with information on hospitalization and diagnosis. Surgical interventions and therapeutic procedures were reported using the ICD-9-CM classification with a distinction between planned or urgent hospitalization. We focused on discharges between January 2010 and December 2019 in pediatric and adolescent patients (age between 0 and 18 years). Meniscal tear was determined by ICD-9-CM primary diagnosis codes: 836.0, 836.1, 836.2, 717.0, 717.1, 717.3, 717.4, 717.40, 717.41, 717.42, 717.43, 717.49, 717.5. The exclusion criteria were the presence of associated ligamentous injuries such as Anterior Cruciate Ligament (ACL) or collateral ligaments.

We grouped DRGs into two mutually exclusive groups, medial meniscus lesions (DRGs: 836.0, 717.0, 717.1, 717.2, 717.3), and lateral meniscus lesions (DRGs: 836.1, 717.4, 717.40, 717.41, 717.43, 717.49). Furthermore, we divide DRGs into four mutually exclusive groups according to the type of lesions, as anterior horn (DRGs: 717.1, 717.42), posterior horn (717.2, 717.43), bucket handle (717.0, 717.41), other type of injuries (DRGs: 717.3, 717.4, 717.49).

2.1. Statistics

To implement the analysis STATA version 18.0 - MP (StataCorp LLC; 4905 Lakeway Drive; College Station, Texas 77845 USA) was used. For categorical data frequencies and percentages were calculated, whilst for continuous variables means and standard deviations were used. To measure the population incidence and obtain comparable measures across time and different geographical areas, the

Table 1
Statistics for the entire population, 2010–2019.

	n	Mean SD	Frequency (%)	(Min; Max)
Age	17,443	15.85 2.22		(4; 18)
Age group: older 14	17,443		15,437 (88.5 %)	
Gender: female	17,443		5145 (29.5 %)	
Citizenship: italian	17,443		16,763 (96.1 %)	
Urgency: not planned	17,443		3175 (18.2 %)	
Stay length (days)	17,443	1.53 1.18		(1; 45)
Location: lateral	17,443		7928 (45.45 %)	
Type: Anterior Horn	14,536		1290 (8.87 %)	
Type: Posterior Horn	14,536		5256 (36.16 %)	
Type: Bucket Handle	14,536		4126 (28.38 %)	
Type: Other	14,536		3864 (26.58 %)	

Note: data are calculated over the entire time span considered. Source: our calculation using AHD data.

ratios between actual cases and population were calculated. To measure differences in main classification of surgical intervention and age we used T-test. Data on population size was retrieved from the Italian National Institute for Statistics (ISTAT). To investigate the overall incidence trend over the ten-year period a quadratic fit was obtained, considering time and squared time (both expressed in differences in months from the beginning of the series) as dependent variable, and discharges per 100.000 target age individuals as independent. To investigate the differences between age and sex specific hospitalization rates, the 95 % confidence interval (CI) incidence rate (per 100000) was calculated for each age. Unless otherwise specified, confidence interval (CI) level was set at 95 %.

3. Results

In the 10 year study period, 17,449 meniscal tears were surgically treated in Italy in patients between 0 and 18 years of age (Table 1).

Only six patients were aged less than 4 years of age and were excluded from the incidence trend analysis, leaving a dataset of 17,443 observations. Mean age of patients who underwent surgery was 15.85 and 89 % were aged 14 years or older. The mean hospitalization time was 1.53 days (SD = 1.176). The proportion of female patients was 30 %.

The ratio between males and females patients was 2.39 overall, with remarkable differences driven by age, ranging from 0.32 for age 5 to values around or greater than three for age equal or greater than 16 (age 16, ratio: 2.88; age 17, ratio: 3.45, age 18: ratio: 3.7).

In Table 2 we report results for age according to main classification of surgical intervention and to type of lesion. There were no statistically significant differences in patient age when comparing the types of lesions. For those who were discharged after a lateral meniscus lesion admissions were 0.5 years younger than those with medial meniscus lesions (T-test: p-value$<$0.001).

The 2010–2019 mean incidence of meniscal surgery was 20.6 procedures per 100,000 target age individuals. In Table 3 we report the yearly mean incidence of meniscal surgery by ISCED level, the international classification of education. Incidence in children in pre-primary school age is close to 0 and it increases up to 77.1 cases per 100,000 in male students in upper secondary schools and to 29.3 cases per 100,000 in female students in upper secondary schools.

Throughout the 10 year period, a declining trend from the 25.9 surgeries per 100,000 individuals in 2010 to 16.81 in 2019 was observed (Fig. 1). Fig. 1 also showed that in the last years of our observational periods the overall incidence reached a stable volume of hospitalization.

The mean incidence of meniscal tears was different in females (12.6 cases per 100,000 inhabitants) and males (28.2 cases per 100,000 inhabitants). Moreover there was a significant increase in the incidence of meniscus tears in male patients for those above age 13 ranging from less than 20 cases per 100,000 inhabitants (age 13) to more than five times higher for those aged 17 or 18. Conversely, the female population showed a relatively small increase for the same age distribution. Lastly, male and female incidence rates significantly differed from age 14 onwards (Fig. 2).

Medial and lateral meniscus lesions showed different rates dependent on age and sex (Fig. 3). Male incidence rates showed a similar trend up until age 16 and remarkable differences for ages 17 and 18, where medial meniscus lesion incidence rates were higher than lateral meniscus lesion incidence rates. We observed an analogous result for females even though the magnitude of the difference between medial and lateral meniscus lesions was relatively smaller. Similar results were observed considering the impact of age and sex on meniscal tear type (Fig. 4).

4. Discussion

The main strength of our study lies in having the first actual epidemiological data on meniscal injuries in the Italian pediatric and adolescent population. Furthermore, it was possible to analyze the difference in terms of incidence rate according to age and gender, highlighting a significant increase in the male population aged 13 and above. Meniscal injuries in skeletally immature patients are considered to be less frequent than in adults [2,15,16]. The increase of sport participation in children and adolescents may be responsible for an increasing number of cases [17]. In this study we collected data from National Archive of Hospital Discharges (AHD) and investigated surgically treated meniscal tears in Italy between 2010 and 2019 in pediatric and adolescent patients.

Several studies have investigated the trends in meniscal pathology in adults [18]; [16,19,20] the epidemiology in pediatric and

Table 2
Statistics for age for the entire population, 2010–2019, broken down by type of lesion.

	Mean	SD
Age	15.85	2.21
Main classification		
Medial meniscus lesions	16.22	1.74
Lateral meniscus lesions	15.68	2.32
Type of lesion		
Anterior horn	15.97	1.98
Posterior horn	16.18	1.81
Bucket handel	16.08	1.80
Other injuries	15.72	2.38

Note: data are calculated over the entire time span considered. Source: our calculation using AHD data.

Table 3
Statistics for the entire population, broken down by ISCED level.

		Avg pop.	Avg cases	Incid. Rate
ISCED	Gender	(2010–19)	(2010–19)	(100,000 ab)
Pre-primary	Male	565,628	1.7	0.3
Pre-primary	Female	533,221	3.8	0.7
Primary	Male	1,449,830	21.5	1.5
Primary	Female	1,365,852	33.1	2.4
Lower secondary	Male	874,616	67.4	7.7
Lower secondary	Female	822,703	73.2	8.9
Upper secondary	Male	1,476,144	1138.6	77.1
Upper secondary	Female	1,381,685	405.0	29.3
Total		*8,469,679*	*1744.3*	*20.6*

This table reports for each ISCED level and gender the average (2010–2019) Italian population, the average (2010–2019) number of cases and the incidence rate, calculated as the ratio between average cases and average population per 100,000 target population.

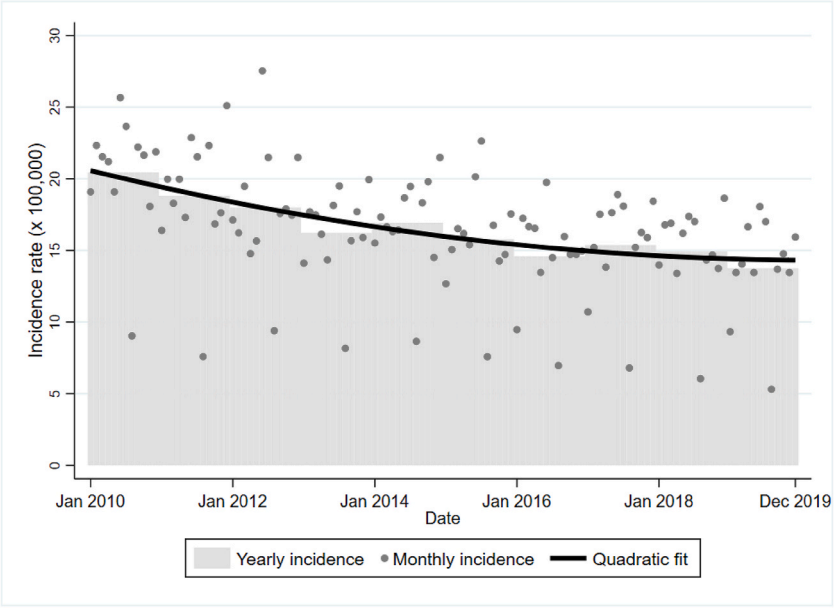

Fig. 1. Overall incidence trend over time.

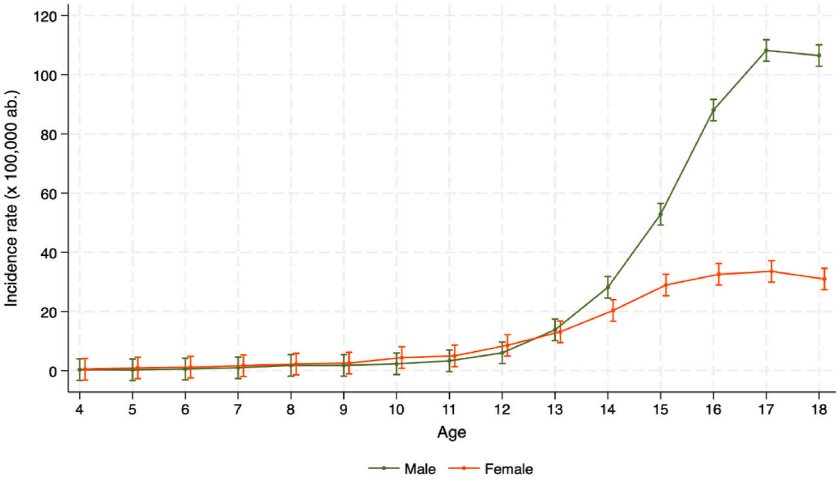

Fig. 2. Age and sex specific hospitalization rates. Note: 95 % CI included.

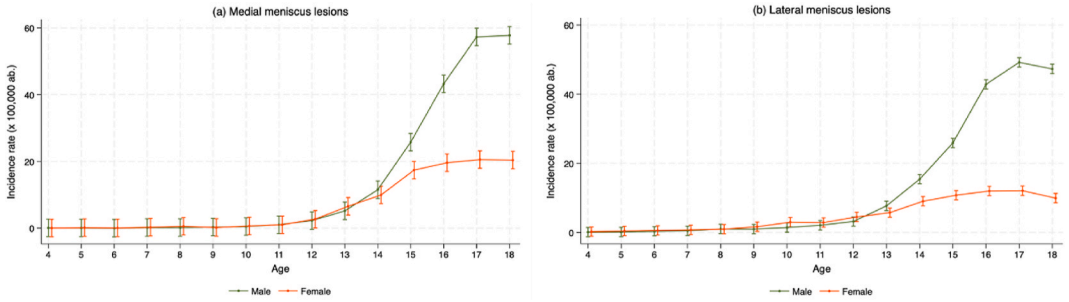

Fig. 3. Age and sex-specific hospitalization rates for (a) lateral – left-hand panel – and (b) medial lesions – right-hand panel. Note: 95 % CI included.

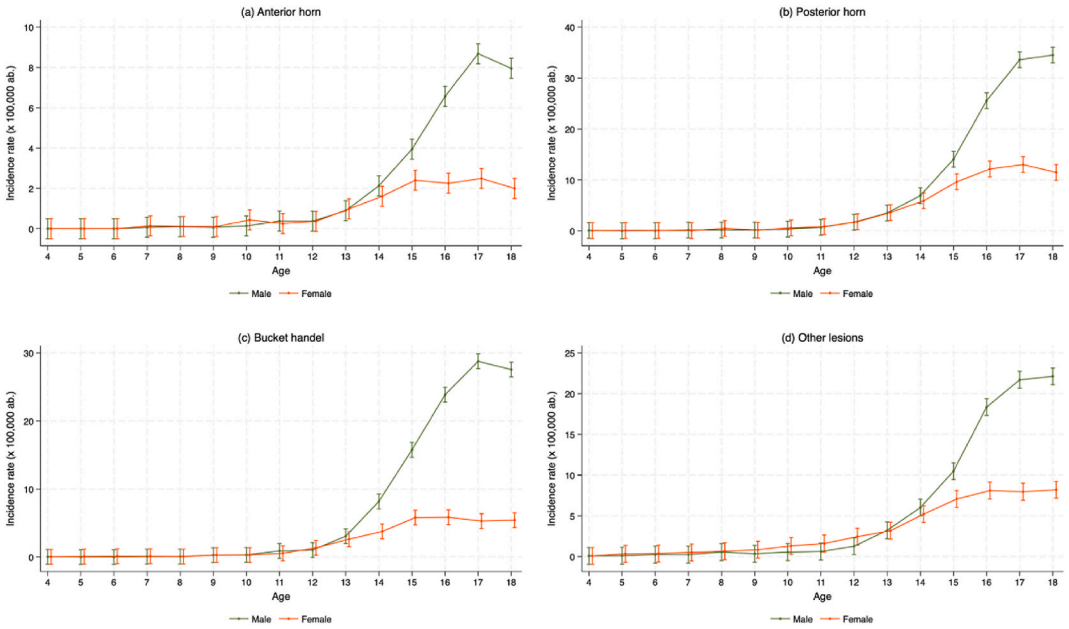

Fig. 4. Age and sex specific hospitalization rates by type of meniscal tear: (a) Anterior horn tear – upper left panel, (b) Posterior horn tear – upper right panel, (c) Bucket Handle tear – lower left panel, (d) other lesions – lower right panel. Note: 95 % CI included.

adolescent patients is not well characterised. There are several differences in the characteristics and treatment of meniscal pathology between adult and pediatric patients. The fact that only the outer 10–30 % of the medial and 10–25 % of the lateral meniscus receive a sufficient blood supply, known as the 'red–red' zone, is well-established. The remaining two-thirds of the meniscus depend on nourishment through diffusion ("red–white" and "white–white" zones). In contrast to the adult population, a higher percentage of the meniscus is vascularized in children, facilitating the repair process[14]. The location of the meniscal tear plays an important role in the pediatric population. While in adults a lesion occurring in the red-white zone is often treated with meniscectomy, in children and adolescents meniscal repair should be considered due to a higher potential of healing. Meniscectomy in the pediatric population leads to poor long-term outcomes with increased rate of early arthritis, knee pain and deficit in muscle strength [21]. Conversely, meniscal suture leads to long-term chondroprotection with a low risk of complication [22]; [23]. The meniscal repair ensures good outcomes even after a revision surgery for a failure in a previous suture [24]; [25]. Recent epidemiological studies focus on surgical treatment comparing trends of meniscectomy and meniscal repair, particularly following the 2016 ESSKA consensus [26]. In France, between 2005 and 2017, 1,564,461 meniscectomies (20.05/10,000 inhabitants on average per year) and 63,142 meniscal repair procedures (0.81/10,000 inhabitants on average per year) were performed. There was a 21.4 % reduction in the number of meniscectomies performed and a 320 % increase in the number of meniscus repair procedures [27]. In the United States from 2005 to 2011, there were 387,833 meniscectomies and 23,640 meniscal repairs, with an increasing number of meniscal repair (11.4 % increase) and a stable number of meniscectomies performed in patients less than 65 years of age [28]. At present, in Italy it is not possible to conduct a large-scale epidemiological study on the trends of meniscectomy and meniscal repair as the AHD is based on the ICD-9-CM classification and at this time there is not a specific code for meniscal repair.

In Italy, between 2010 and 2019, 17,449 meniscal tears were surgically treated in pediatric and adolescent patients. Mean age of patients who underwent surgery was 15.85 and the mean incidence was 20.6 procedures per 100,000 target age individuals. The

overall ratio between male and female is 2.39 and the mean incidence is 12.6 cases per 100,000 inhabitants for female and 28.2 cases per 100,000 inhabitants for male. The most frequent lesion was the injury to the posterior horn of the medial meniscus (20.6 % of all procedure). Terzidis et al. [29] studied the features of isolated meniscal tears in athletes with intact cruciate ligaments: they evaluated 378 knees (78.6 % males) and 69.3 % of lesions were in the medial and 30.7 % in the lateral meniscus. Moreover, the most common pattern was bucket-handle (23.1 %). This percentage is similar to our data: bucket handle lesions in both medial and lateral meniscus (ICD-9-CM code 717.0 and 717.41) with a total of 4126 cases represented 23.7 % of the total.

The difference in incidence in male and female meniscal surgery changes according to age. The male-female ratio increases from 0.32 for age 5 to 3.7 at 18 years of age. Both the incidence of male and female procedures increases from 14 years of age onward, but with a different magnitude: male incidence changes from less than 20 cases per 100,000 inhabitants (age 13) to more than five times higher for those aged 17 or 18. Lateral and medial injury distribution shows a similar trend in both sexes: male incidence rates show an upward trend until age 16 and stand out for older patients, where medial meniscus lesions are far higher than lateral meniscus. The higher incidence of meniscal injury in male patients above the age of 13 may have multiple causes. Meniscal tears are more likely to occur in high-energy contact sports, making participation in these activities a recognized risk factor. Sports involving contact and frequent pivoting, like football, are strongly linked to these injuries [30]. So one of the potential factors is the higher participation of male in sports considered at risk. Additionally, male adolescents have a higher body mass index (BMI) and muscle mass compared to children and female which ultimately leads to greater momentum traveling through the knee making them more vulnerable to injury [2].

Mitchel et al. [6] studied a population of U.S. High School Athletes from 2007/08 to 2012/13. Out of a total of 1082 meniscal injuries, they found that 68 % occurred in males. Our study, with a larger number of cases, reported comparable findings (our rate: 69 % in males).

Longo et al. [14] studied a younger population with similar findings. They observed that in the Italian population aged up to 14 from 2001 to 2016, the incidence of meniscectomy increased with age, as demonstrated by the 10-14-year-old group, which represented 89.3 % of the procedures performed. Their global incidence was lower than ours, with 3.9 procedures versus 20.6 per 100,000 target individuals due to the younger age. In fact, we found that 89 % of meniscal procedures were performed on individuals aged 14 or older. A declining trend in meniscal procedures over the years was shown by both Longo et al. and our study. More specific studies are needed to better understand this finding, as it contrasts with our personal experience in a center specialized in pediatric sport medicine, which reports a significant increase of meniscal pathologies in the last years. The causes of this result may be multifactorial: mis-coding of procedures, a reduction in revision surgery, better diagnosis and treatment of ACL injuries, judicious use of MRI that allows to operate fewer cases with better imaging.

This investigation has limitations due to selection bias within the Italian medical coding system: the patients with non-surgically treated meniscal tears and those with associated lesions were not included. Moreover, as highlighted, specific codes for meniscal repair do not exist and specific details about surgical treatments were not available Then potential mis-coding errors in data entry may exist. Moreover the overall reduction of meniscal surgery may be in part due to absence of ACL associated meniscal lesions in our study. We know that ACL injury is increasing in pediatric and adolescent patients, but the focus of this work is on isolated meniscal tears [31,32].

5. Conclusions

The present study provides information about the epidemiology of meniscal surgery in pediatric and adolescent patients on a national level. To our knowledge this is the first European study describing large-scale epidemiology data of pediatric meniscal lesion treatment. The results reveal a reduction in the total number of surgeries performed over the time frame and significant rise in the incidence of meniscal lesions, particularly among males, above at the age of 13. This data can help health care systems plan and organize resources, even if further research is required to better understand risk factors and work on prevention initiatives. In Italy the current ICD9-CM classification does not differentiate between meniscectomy and meniscal repair, so the global trend towards meniscal preservation here it is not perceptible. A homogenous medical coding system with comparable data between different countries would facilitate a large scale International study.

Declaration of generative AI and AI assisted technologies in the writing process

During the preparation of this work the authors did not use any AI technologies.

Data availability statement

Original data were granted by the Italian Ministry of Health – General Directorate of Healthcare Planning – SDO database and are freely accessible upon request to the Directorare itself at the following email address: dgprog@postacert.sanita.it.

Submission declaration

This manuscript has not been published previously and is not under consideration for publication elsewhere. The publication of this article has been approved by all authors and by the responsible authorities where the work was carried out. We declare that, if accepted, this manuscript will not be published elsewhere, including electronically in the same form, in English or in any other language, without the written consent of the copyright-holder.

CRediT authorship contribution statement

Andrea Riganti: Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Marco Bigoni:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization. **Edoardo Pierpaoli:** Writing – review & editing, Writing – original draft, Visualization, Investigation, Formal analysis, Conceptualization. **Marco Caliandro:** Writing – original draft, Visualization, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Daniele Piscitelli:** Writing – review & editing, Visualization, Validation, Supervision, Software, Methodology, Investigation, Formal analysis, Data curation. **Nicolas Nicolaou:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Luca Rigamonti:** Writing – review & editing, Visualization, Software, Methodology, Investigation, Formal analysis, Conceptualization. **Marco Turati:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] M. Turati, F.M. Anghilieri, F. Accadbled, M. Piatti, P. Di Benedetto, F. Moltrasio, G. Zatti, N. Zanchi, M. Bigoni, Discoid meniscus in human fetuses: a systematic review, Knee 30 (2021) 205–213, https://doi.org/10.1016/j.knee.2021.04.006.

[2] A. Asokan, A. Ayub, M. Ramachandran, Pediatric meniscal injuries: current concepts, J Child Orthop 17 (2023) 70–75, https://doi.org/10.1177/18632521221149056.

[3] M. Gottliebsen, M. Turati, The paediatric knee: traumatic injuries, J Child Orthop 17 (2023) 3, https://doi.org/10.1177/18632521221149053, 3.

[4] T. Jackson, P.D. Fabricant, N. Beck, E. Storey, N.M. Patel, T.J. Ganley, Epidemiology, injury patterns, and treatment of meniscal tears in pediatric patients: a 16-year experience of a single center, Orthop J Sports Med 7 (2019), https://doi.org/10.1177/2325967119890325.

[5] D.E. Kramer, L.J. Micheli, Meniscal tears and discoid meniscus in children: diagnosis and treatment, J. Am. Acad. Orthop. Surg. 17 (2009) 698–707, https://doi.org/10.5435/00124635-200911000-00004.

[6] J. Mitchell, W. Graham, T.M. Best, C. Collins, D.W. Currie, R.D. Comstock, D.C. Flanigan, Epidemiology of meniscal injuries in US high school athletes between 2007 and 2013, Knee Surg. Sports Traumatol. Arthrosc. 24 (2016) 715–722, https://doi.org/10.1007/s00167-015-3814-2.

[7] T. Kraus, N. Heidari, M. Švehlík, F. Schneider, M. Sperl, W. Linhart, Outcome of repaired unstable meniscal tears in children and adolescents, Acta Orthop. 83 (2012) 261–266, https://doi.org/10.3109/17453674.2012.693017.

[8] I.D. McDermott, (ii) Meniscal tears, Curr. Orthop. 20 (2006) 85–94, https://doi.org/10.1016/j.cuor.2006.02.010.

[9] B.A.M. Snoeker, E.W.P. Bakker, C.A.T. Kegel, C. Lucas, Risk factors for meniscal tears: a systematic review including meta-analysis, J. Orthop. Sports Phys. Ther. 43 (2013) 352–367, https://doi.org/10.2519/jospt.2013.4295.

[10] P. Beaufils, R. Becker, S. Kopf, M. Englund, R. Verdonk, M. Ollivier, R. Seil, Surgical management of degenerative meniscus lesions: the 2016 ESSKA meniscus consensus, Knee Surg. Sports Traumatol. Arthrosc. 25 (2017) 335–346, https://doi.org/10.1007/s00167-016-4407-4.

[11] C. Xu, J. Zhao, A meta-analysis comparing meniscal repair with meniscectomy in the treatment of meniscal tears: the more meniscus, the better outcome? Knee Surg. Sports Traumatol. Arthrosc. 23 (2015) 164–170, https://doi.org/10.1007/s00167-013-2528-6.

[12] N.C. Duethman, R.R. Wilbur, B.M. Song, M.J. Stuart, B.A. Levy, C.L. Camp, A.J. Krych, Lateral meniscal tears in young patients: a comparison of meniscectomy and surgical repair, Orthop J Sports Med 9 (2021) 23259671211046056, https://doi.org/10.1177/23259671211046057.

[13] T. Stein, A.P. Mehling, F. Welsch, R. von Eisenhart-Rothe, A. Jäger, Long-term outcome after arthroscopic meniscal repair versus arthroscopic partial meniscectomy for traumatic meniscal tears, Am. J. Sports Med. 38 (2010) 1542–1548, https://doi.org/10.1177/0363546510364052.

[14] U.G. Longo, R. Papalia, A. Mazzola, L. Ruzzini, S. De Salvatore, I. Piergentili, P.F. Costici, V. Denaro, Epidemiology of pediatric meniscectomy: a Nationwide study in Italy from 2001 to 2016, J. Clin. Med. 11 (2022), https://doi.org/10.3390/JCM11216259.

[15] R.N. Tandogan, O. Taşer, A. Kayaalp, E. Taşkiran, H. Pinar, B. Alparslan, A. Alturfan, Analysis of meniscal and chondral lesions accompanying anterior cruciate ligament tears: relationship with age, time from injury, and level of sport, Knee Surg. Sports Traumatol. Arthrosc. 12 (2004) 262–270, https://doi.org/10.1007/s00167-003-0398-z.

[16] P.C. Yeh, C. Starkey, S. Lombardo, G. Vitti, F.D. Kharrazi, Epidemiology of isolated meniscal injury and its effect on performance in athletes from the National Basketball Association, Am. J. Sports Med. 40 (2012) 589–594, https://doi.org/10.1177/0363546511428601.

[17] C.A. Popkin, A.F. Bayomy, C.S. Ahmad, Early sport specialization, J. Am. Acad. Orthop. Surg. 27 (2019) e995–e1000, https://doi.org/10.5435/JAAOS-D-18-00187.

[18] A. Hede, D.B. Jensen, P. Blyme, S. Sonne-Holm, Epidemiology of meniscal lesions in the knee. 1,215 open operations in Copenhagen 1982-84, Acta Orthop. Scand. 61 (1990) 435–437, https://doi.org/10.3109/17453679008993557.

[19] J.C. Jones, R. Burks, B.D. Owens, R.X. Sturdivant, S.J. Svoboda, K.L. Cameron, Incidence and risk factors associated with meniscal injuries among active-duty US military service members, J. Athl. Train. 47 (2012) 67–73, https://doi.org/10.4085/1062-6050-47.1.67.

[20] M. Majewski, H. Susanne, S. Klaus, Epidemiology of athletic knee injuries: a 10-year study, Knee 13 (2006) 184–188, https://doi.org/10.1016/j.knee.2006.01.005.

[21] M.L. Francavilla, R. Restrepo, K.W. Zamora, V. Sarode, S.M. Swirsky, D. Mintz, Meniscal pathology in children: differences and similarities with the adult meniscus, Pediatr. Radiol. 44 (2014), https://doi.org/10.1007/s00247-014-3022-0.

[22] M. Manzione, P.D. Pizzutillo, A.B. Peoples, P.A. Schweizer, Meniscectomy in children: a long-term follow-up study, Am. J. Sports Med. 11 (1983), https://doi.org/10.1177/036354658301100301.

[23] R.C. Medlar, J.J. Mandiberg, E.D. Lyne, Meniscectomies in children: report of long-term results (mean, 8.3 years) of 26 children, Am. J. Sports Med. 8 (1980), https://doi.org/10.1177/036354658000800205.

[24] M.H. Hagmeijer, N.I. Kennedy, A.J. Tagliero, B.A. Levy, M.J. Stuart, D.B.F. Saris, et al., Long-term results after repair of isolated meniscal tears among patients aged 18 Years and younger: an 18-year follow-up study, Am. J. Sports Med. 47 (2019), https://doi.org/10.1177/0363546519826088.

[25] A. Schmitt, F. Batisse, C. Bonnard, Results with all-inside meniscal suture in pediatrics, J. Orthop. Traumatol.: Surgery and Research 102 (2016), https://doi.org/10.1016/j.otsr.2015.12.018.

[26] S. Kopf, P. Beaufils, M.T. Hirschmann, N. Rotigliano, M. Ollivier, H. Pereira, R. Verdonk, N. Darabos, P. Ntagiopoulos, D. Dejour, R. Seil, R. Becker, Management of traumatic meniscus tears: the 2019 ESSKA meniscus consensus, Knee Surg. Sports Traumatol. Arthrosc. 28 (2020) 1177–1194, https://doi.org/10.1007/S00167-020-05847-3.

[27] C. Jacquet, N. Pujol, V. Pauly, P. Beaufils, M. Ollivier, Analysis of the trends in arthroscopic meniscectomy and meniscus repair procedures in France from 2005 to 2017, Orthop Traumatol Surg Res 105 (2019) 677–682, https://doi.org/10.1016/J.OTSR.2019.01.024.
[28] G.D. Abrams, R.M. Frank, A.K. Gupta, J.D. Harris, F.M. McCormick, B.J. Cole, Trends in meniscus repair and meniscectomy in the United States, 2005-2011, Am. J. Sports Med. 41 (2013) 2333–2339, https://doi.org/10.1177/0363546513495641.
[29] I.P. Terzidis, A. Christodoulou, A. Ploumis, P. Givissis, K. Natsis, M. Koimtzis, Meniscal tear characteristics in young athletes with a stable knee: arthroscopic evaluation, Am. J. Sports Med. 34 (2006) 1170–1175, https://doi.org/10.1177/0363546506287939.
[30] M. Turati, L. Boerci, M. Piatti, N. Zanchi, G. Zatti, F. Accadbled, M. Bigoni, Updates on etiopathogenesis of musculoskeletal injuries in adolescent athletes, Minerva Pediatr. 75 (2023) 133–135, https://doi.org/10.23736/S2724-5276.20.05944-7.
[31] C. Tang, T.A. Kwaees, F. Accadbled, M. Turati, D.W. Green, N. Nicolaou, Surgical techniques in the management of pediatric anterior cruciate ligament tears: current concepts, J Child Orthop 17 (2023) 12–21, https://doi.org/10.1177/18632521221149059.
[32] C.E.V.W. Kooy, R.B. Jakobsen, A.M. Fenstad, A. Persson, H. Visnes, L. Engebretsen, G.R. Ekås, Major increase in incidence of pediatric ACL reconstructions from 2005 to 2021: a study from the Norwegian knee ligament register, Am. J. Sports Med. 51 (2023) 2891–2899, https://doi.org/10.1177/03635465231185742.