

Anterior Cruciate Ligament Injury in Pediatric and Adolescent Soccer Players: An Analysis of Insurance Data

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Abstract: Injury claims from an insurance company specializing in soccer coverage were reviewed for a 5-year period. A total of 8215 injury claims (3340 females, 4875 males) were divided into three categories: (1) all injury, (2) knee injury, and (3) ACL injury. Knee injuries accounted for 22% of all injuries (30% female, 16% male). ACL injury claims represented 31% of total knee injury claims (37% female, 24% males). The youngest ACL injury was age 5. The ratio of knee injury/all injury increased with age. Compared with males, females demonstrated a higher ratio of knee injury/all injury and a higher ratio of ACL injury/all injury. This study demonstrates that ACL injury occurs in skeletally immature soccer players and that females appear to have an increased risk of ACL injury and knee injury compared with males, even in the skeletally immature. Future research related to ACL injury in females will need to consider skeletally immature patients.

Key Words: anterior cruciate ligament injury, knee injury

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The incidence of mid-substance anterior cruciate ligament (ACL) tears in skeletally immature subjects is unknown, although there is evidence that the incidence of this injury may be increasing. Prior to 1980, very few articles were written about this subject, and there has been a steady increase in the number of articles addressing this topic since 1990.^{2,3,6,8,11–13,15,16,18–20,23,29,36,37,40–44,48,50,55,61}

Several studies on ACL injury rates have been conducted on ACL injury in NCAA collegiate athletes,^{4,27,38,59} military personnel,^{7,26} and other adult athletes.^{10,51} To our knowledge, there has been very little published information related to ACL injury rates in pediatric groups. Limited epidemiological information is available for adolescents and high school age athletes.^{22,46,47,54}

In the United States, the number of participants in youth soccer has continued to increase over the last 20 years,⁴⁷ and soccer is recognized as a sport with a relatively high risk for ACL injury.^{4,10,26,54} This study reviewed the injury claims from an insurance company that specializes in providing medical coverage for youth soccer leagues. The purpose of this study was to assess the incidence of ACL injury in pediatric and adolescent soccer athletes.

MATERIALS AND METHODS

Bene-marc, Inc. (Fort Worth, TX) specializes in insurance for youth soccer leagues throughout the United States. Soccer insurance policies are provided by Bene-marc to individual soccer leagues. The policies are written to cover the number of athletes in the leagues. In most cases, information about age, sex, or other demographic features are not collected by the insurance company, nor are these variables used to determine insurance rates. Insurance officials from Bene-marc have estimated that approximately 48% of the athletes are female and 52% are male, based upon their experience providing insurance coverage to youth soccer leagues throughout the United States. The age of the athletes listed on filed claims ranged from 5 to 18 years of age.

In the event of an injury, claims may be filed with Bene-marc, which is the primary insurance for injuries that occur at soccer events. Claims are filed using ICD-9 Codes and CPT (Current Procedural Terminology, American Medical Association) codes, which are used to classify injury. Parents of the injured athlete also have the option to file a claim with their own private insurance, either for secondary or primary coverage. Between the years 1995 and 1999, individual annual policies were written to cover individual soccer leagues. During this period, approximately 1 to 1.5 million athletes were covered annually for a total of 6 million. The injury claims filed during this period were analyzed. The injury claims were analyzed for age and gender and were divided into three categories: total claims, total knee injury claims, and total ACL injury claims. These three categories were evaluated by chronological age to assess the age of onset for ACL injury and to assess the percentage of knee injury claims that were filed for ACL injuries.

RESULTS

During the 5-year period, 8215 claims (3340 females, 4875 males) were submitted to the insurance company. Knee injury claims accounted for 1793/8215 or 22% of the claims

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(Table 1). When analyzed by sex, knee injury claims accounted for 30% of total claims in females and 16% in males (Tables 2 and 3).

The youngest subject filing a claim for an ACL injury was age 5 in a male and age 12 in a female. Claims for ACL injuries accounted for 553/1793 of 31% of total knee injury claims (Table 1). When analyzed by sex, ACL injury claims accounted for 37% of total knee injury claims in females and 24% in males (Tables 2 and 3, Fig. 1).

The ratio of total knee injury claims to total injury claims increased with age, for both male and females (Tables 2 and 3). The ratio of total ACL injury claims to total injury claims increased throughout the age groups. The ratio of total ACL injury claims to total knee injury claims increased throughout the age groups. When compared with males, the females demonstrated an increase in the ratio of total ACL injury claims to total injury claims and in the ratio total ACL injury claims to total knee injury claims (Tables 2 and 3, Figs. 2 and 3).

DISCUSSION

Injury of the ACL is a common injury in adult athletes.^{4,22,24,26,27,31,38} The age of onset of ACL injury is not well defined in the literature, as most epidemiologic studies have focused upon adult athletes. Based on insurance claims data, this study demonstrates several findings for ACL tears in pediatric and adolescent soccer athletes. The first ACL injury occurred at age 5, although ACL injury appears rare before the age of 11. At ages 11–12, both males and females demonstrated an increased frequency of ACL injury claims, and the risk appeared to increase up to age 18 years. Females demonstrated a higher ratio of total knee injury claims to overall injury claims compared with males, as well as a higher ratio of total ACL injury claims to total knee injury claims when compared with males.

Although epidemiological information on ACL tears in skeletally immature athletes is limited, the number

of articles related to knee injuries in this population has increased significantly over the last 10–15 years.^{2,3,6,8,11–13,15,16,18–20,23,29,36,37,40–44,48,50,55,61}

This trend could represent an increased incidence of this injury, an increase in the detection rate of these injuries, or both. The increased use and availability of MRI scanners may also increase the detection rate for previously unrecognized injuries. A recent study by Micheli et al⁴⁹ demonstrated an increase in ACL reconstructive procedures for adolescent athletes between 1992 and 1997 at a single institution.

Several studies demonstrate that adult female athletes sustain ACL injuries at rates ranging from three to seven times higher than male athletes in the same sports.^{4,7,28,46,52,54,59} Studies on soccer athletes also demonstrate that adult female athletes have a higher ratio of ACL injury to knee injury, when compared with males, as well as an increased overall risk of ACL injury when adjusted for exposure.^{4,39,54} The data in our study suggest that pediatric and adolescent females may also have an increased risk of ACL injury, compared with males, and that females sustain higher rates of knee injury and ACL injury compared with males.

The difference in knee injury rates between adult male and female athletes has been defined through epidemiological studies, although an explanation for this discrepancy still eludes researchers. Several potential etiologic factors have been identified, including hormonal differences, anatomic differences, neuromuscular differences, training differences, joint laxity, and differences in jump-landing mechanics.^{24,33,34} At this time, no single theory has emerged, and this problem may be multifactorial. Numerous studies are addressing this problem currently, and we believe that these studies will need to address the pediatric and adolescent age groups in addition to adults.

Recent studies have looked at the relationship between the menstrual cycle and the incidence of ACL injury. Wojtys et al^{62,63} monitored ACL injuries and menstrual history and found statistical associations between ACL injury rates and

TABLE 1. Injury Claims Distribution-Sexes Combined

Age	ACL Injuries	All Knee Injuries	All Injuries	Knee Injuries/All Injuries	ACL Injury/Knee Injury	ACL Injury/All Injuries
5	1	2	24	0.08	0.50	0.04
6	0	1	37	0.03	0.00	0.00
7	0	2	71	0.03	0.00	0.00
8	0	2	142	0.01	0.00	0.00
9	1	17	251	0.07	0.06	0.00
10	0	35	389	0.09	0.00	0.00
11	4	39	591	0.07	0.10	0.01
12	13	107	796	0.13	0.12	0.02
13	37	198	1076	0.18	0.19	0.03
14	60	258	1256	0.21	0.23	0.05
15	107	294	1224	0.24	0.36	0.09
16	141	372	1118	0.33	0.38	0.13
17	114	289	821	0.35	0.39	0.14
18	75	177	419	0.42	0.42	0.18
Total	553	1793	8215			
Average				0.22	0.31	0.07

TABLE 2. Male Injury Claims Distribution

Age	ACL Injuries	All Knee Injuries	All Injuries	Knee Injuries/All Injuries	ACL Injury/Knee Injury	ACL Injury/All Injuries
5	1	1	18	0.06	1.00	0.06
6	0	0	23	0.00	0.00	0.00
7	0	2	51	0.04	0.00	0.00
8	0	1	89	0.01	0.00	0.00
9	1	9	169	0.05	0.11	0.01
10	0	20	243	0.08	0.00	0.00
11	4	37	352	0.11	0.11	0.01
12	6	61	476	0.13	0.10	0.01
13	11	81	618	0.13	0.14	0.02
14	10	89	686	0.13	0.11	0.01
15	40	123	713	0.17	0.33	0.06
16	35	138	646	0.21	0.25	0.05
17	43	136	502	0.27	0.32	0.09
18	39	106	289	0.37	0.37	0.13
Total	190	804	4875			
Average				0.16	0.24	0.04

the three phases of the menstrual cycle (follicular, ovulatory, luteal). Results from the hormone assays indicated that the women had a significantly greater than expected percentage of ACL injuries during midcycle (ovulatory phase) and a less than expected percentage of those injuries during the luteal phase of the menstrual cycle. It is interesting to note that the age of onset of ACL injury claims in female athletes in our study is close to the onset of menses (age 12 for Caucasian females). Other factors may also influence the age of onset of ACL tears, including body size, speed, etc.

There are epidemiological limitations to this study, because of the nature of the data. Although injury events are recorded, the number of athletes in each age group was not

available for data analysis. The absence of this data makes specific calculations impossible, including confidence intervals, and ACL injury rate calculation for individual age or sex groups. Although ratio comparisons of variables can be performed with this analysis, comparative injury rates between the sexes and age groups cannot be assessed with accuracy. These data are not reported in terms of exposure, as this information was not available. Most epidemiological studies for sports injury provide information about exposure.⁴⁵

Studies that rely on insurance claim forms may not represent the true injury incidence, as not all athletic injuries result in insurance claims.⁴⁵ Some knee injuries are not evaluated initially by medical personnel, and insurance claims

TABLE 3. Female Injury Claims Distribution

Age	ACL Injuries	All Knee Injuries	All Injuries	Knee Injuries/All Injuries	ACL Injury/Knee Injury	ACL Injury/All Injuries
5	0	1	6	0.17	0.00	0.00
6	0	1	14	0.07	0.00	0.00
7	0	0	20	0.00	0.00	0.00
8	0	1	53	0.02	0.00	0.00
9	0	8	82	0.10	0.00	0.00
10	0	15	146	0.10	0.00	0.00
11	0	2	239	0.01	0.00	0.00
12	7	46	320	0.14	0.15	0.02
13	26	117	458	0.26	0.22	0.06
14	50	169	570	0.30	0.30	0.09
15	67	171	511	0.33	0.39	0.13
16	106	234	472	0.50	0.45	0.22
17	71	153	319	0.48	0.46	0.22
18	36	71	130	0.55	0.51	0.28
Total	363	989	3340			
Average				0.30	0.37	0.11

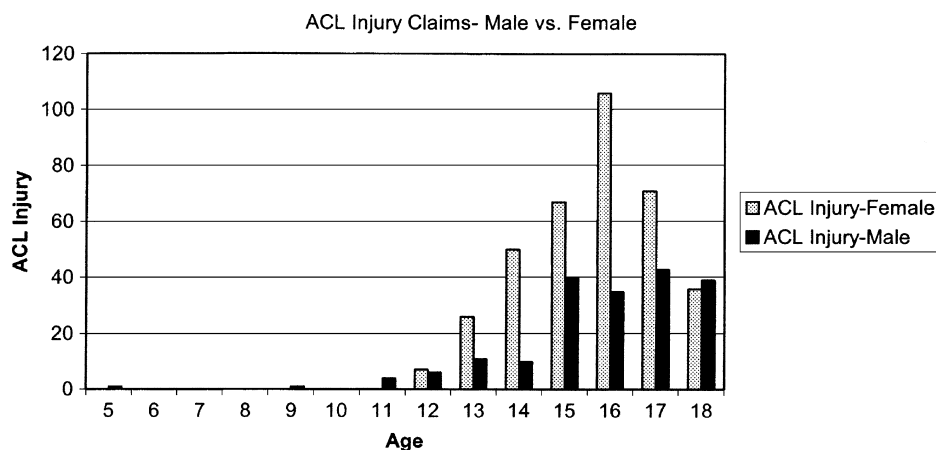


FIGURE 1. ACL injury claims—male versus female.

may not be filed in a timely fashion. Claims may also be filed with another insurance company, as many subjects will have more than one insurance policy. In both of these circumstances, the injury event would be missed and not included in the analysis.

Another limitation to the study is the lack of data for individual age groups. Bene-marc does not require this information for insurance policies. Policies are written to cover the number of athletes in a youth league, regardless of age. With the insurance data provided for this study, the numerator was a known value, but the denominator was not known for individual age categories. Because of this limitation in the data, injury incidence rates were not calculated for individual age groups.

Although there are several limitations to our study, studies of this nature are of benefit. This study provides evidence that injuries to the ACL do occur in children under the age of 15 years, and in fact, according to these data, as young as age five. In addition, these data suggest that when a knee injury occurs in female soccer players, there is a greater likelihood that it involves the ACL when compared with her male counterpart. Such information provides a means to monitor the health of populations at risk for medical conditions, quantification of risks, and a means to monitor long-term

disease trends.⁴⁵ In athletic medicine, epidemiologic data can also be used to identify causes of injuries, assess the effectiveness of preventative measures, and quantify the risks of various types, frequencies, and intensities of exercise activities.⁴⁵

Several recent studies have suggested that noncontact ACL injuries can be reduced with training programs, and these researchers have suggested that these programs should be recommended to older athletes to reduce the incidence of knee injury.^{14,30,32} In particular, these studies advise that female athletes, who have higher incidence of ACL injury compared with males,^{4,10,49} should participate in these programs.³² The results of these studies are preliminary, and definitive proof of the effectiveness of these training programs has not been established.^{58,60} If these exercise programs are eventually proven effective for reducing knee injuries, they should be implemented on a large scale. Injury prevention programs may be beneficial if started prior to the onset of age for ACL injury. These programs will need to address pediatric, adolescent, and adult age groups.

Despite several studies demonstrating poor outcomes in children with ACL tears, surgical reconstruction carries the risk of growth plate injury.^{9,17,21,25,35,40,41,53} Several studies of the natural history of nonsurgical treatment of ACL tears in skeletally immature athletes have demonstrated poor

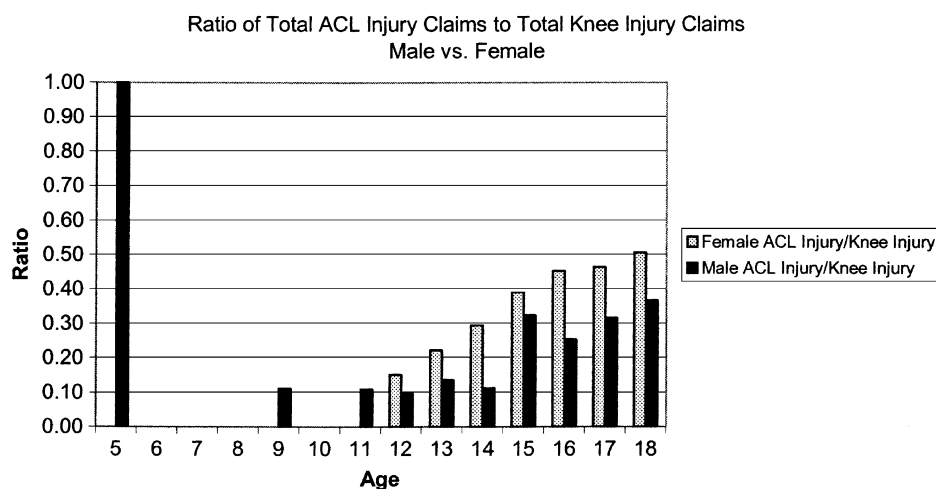


FIGURE 2. Ratio of total ACL injury claims to total knee injury claims—male versus female.

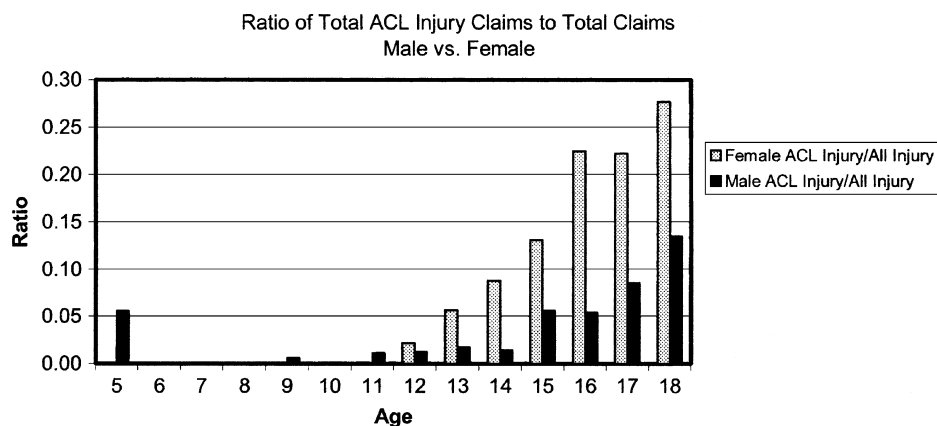


FIGURE 3. Ratio of total ACL injury claims to total claims—male versus female.

outcomes. Studies by Graf et al,²³ McCarroll et al,⁴³ Mizuta et al,⁵⁰ and Pressman et al⁵⁵ have demonstrated problems with recurrent instability, meniscal tears, and osteochondral injuries in untreated ACL tears in young athletes. These problems are especially common in athletes that return to high demand sports.^{1,3,19,23,50} Although the treatment recommendations for ACL injury in skeletally immature athletes remain controversial,^{5,56} the natural history studies of untreated ACL injury in young athletes suggest poor outcomes in a high percentage of patients.^{1,3,19,23,50} Further research on the appropriate treatment of ACL injury in skeletally immature athletes is necessary.⁵⁷

This study demonstrates that ACL injury occurs in skeletally immature soccer players, with a significant increase in ACL injury at age 11–12 years. Like adult female athletes, skeletally immature females also demonstrate a higher risk of ACL injury compared with their male counterparts. Future research that focuses upon injury prevention and treatment of ACL injuries will need to focus upon skeletally immature athletes, as well as adult athletes.

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