CAUSES OF ANTERIOR CRUCIATE LIGAMENT INJURIES

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Summary – In order to prevent anterior cruciate ligament injuries it is necessary to define risk factors and to analyze the most frequent causes of injuries – that being the aim of this study. The study sample consisted of 451 surgically treated patients, including 400 sportsmen (65% of them being active and 35% recreational sportsmen), 29% female and 71% male; of whom 90% were younger than 35. Sports injuries, as the most frequent cause of anterior cruciate ligament injuries, were recorded in 88% of patients (non-contact ones in 78% and contact ones in 22%), injuries occurring in everyday activities in 11% and in traffic in 1%. Among sportsmen, reconstruction of the anterior cruciate ligament was most frequently performed in football players (48%), then in handball players (22%), basketball players (13%), volleyball players (8%), martial arts fighters (4%). However, the injury incidence was the highest among the active basketball players (1 injured among 91 active players). Type of footwear, warming up before the activity, genetic predisposition and everyday therapy did not have a significant influence on getting injured. Anterior cruciate ligament injuries happened three times more often during matches, in the middle and at the end of a match and training session (79%), at landing after the jump or when changing direction of movement (75%) without a contact with other competitors, on dry surfaces (79%), among not so well prepared sportsmen.

Key words: Anterior Cruciate Ligament (ACL), Sport Knee Injuries, Etiology, Risk Factors

Introduction

Anterior cruciate ligament (ACL) injuries represent a significant epidemiological problem in the world. A group of American authors [1] has determined the incidence of acute ACL injuries to be 1:3000 per a year. The number of recorded cases in USA per year has doubled from 100 000 to 200 000 in the last 5 years, so has the number of performed reconstructions, from 50 000 to 100 000 [1]. This fact has provoked much greater interest of authors for ACL traumatology. However, it is illogical that incomparably greater number of studies [2] are focused on the development of surgical techniques than on the analysis of injury causes, risk factors and injury prevention [3-23].

The reason for a larger number of recorded ACL injuries lies in a greater number of sportsmen, especially women (who are at a 2-9 times greater risk of ACL rupture in comparison to men) [5-9], development of diagnostics [2] (especially MRI), greater interest of physicians for these injuries, and because of the development of surgical techniques and excellent postoperative results [1,2]. There is also greater effort of experts to define the cause of injury with the most risk and to find proper training methods to prevent sport knee injuries. The aim of this study was to find specific risk factors and causes of ACL injuries in the Republic of Serbia.

Material and methods

The study included 451 patients surgically treated at Orthopedic Surgery and Traumatology Clinic in Novi Sad from 2006 to 2008. The study sample consisted mostly of men, 320 (71%), 131 were female patients (29%), and their age ranged from 15 to 49, the average age being 24. Of 451 patients in this sample 90% were younger than 35 years of age.

The left knee was injured in 235 patients (52%), and the right knee in 216 (48%). The height of the patients ranged from 163 cm to 204 cm, the average being 181 cm. The weight of the patients was in the range from 52 kg to 135 kg, the average being 80.23 kg.

The highest percentage in the sample was represented by professional sporsmen - 90 (20%), then high school population 81 (18%), college students 63 (14%), and others 217 (48%). The number of patients living in a town/city was 344 (76%), and 107 (24%) lived in the country; 25 (6%) patients had elementary school education, 296 (66%) graduated from a high school; 35 (6%) from a college, and 95 of the patients had a university degree (21%).

All of the participants volunteered to fill in an anonymous questionnaire consisting of the following groups of data:

1. Age, sex, profession, demographic data, and education.
2. Knee laterality, body height, and weight.
Out of 260 active sportsmen, 192 (74%) had one training session a day and 68 (26%) trained twice a day. A training session lasted from 45 to 150 minutes, mostly 90 minutes in 159 sportsmen (61%). Even though 140 patients went in for sports only for recreation, 21 patients (15%) were active once a day; 38 (27%) had trainings twice a week and 81 patients (58%) at least three times a week.

Sport activities were performed indoors by 224 study subjects (56%) and ‘‘outdoors’’ (mostly grass) by 176 (44%). Sport ACL injury occurred on following types of ground: floor in 178 (45%) cases, grass in 144 (36%), concrete in 46 (12%), taraflex in 14 (3%), and mat in 18 (4%) cases. The field in the moment of injury was dry in 316 cases (79%), wet in 31 (8%), and slippery in 25 (16%), muddy in 19 (5%) and frozen in 9 (2%) cases.

Footwear worn by the athletes at the moment of getting injured: low sport shoes in 182 (46%) cases, high sport shoes in 60 (15%), soccer boots in 122 (31%), ski boots in 9 (2%), and no shoes in 25 (6%) cases.

Previous illnesses were recorded in 44 patients. Every day therapy for other illnesses, mostly bronchodilators and NSAID, was taken by 10% of the patients and 107 subjects took no therapy (90%). Only 37 (8.3%) of the patients mentioned previous family history of ACL rupture (29 next-of-kin, 6 cousins and 2 relatives).

Out of 400 sportsmen, 26 (7%) had a specific diet: 21 of them were on their own diet, and 5 of them were on a diet prescribed by the club doctor. 93% of them had a standard diet. According to the body mass index (BMI), 59% of them were normally nourished, 32% were obese, and 9% were malnourished.

Sport injuries, being the most common causes, were recorded in 88% of the cases; 47 ACL ruptures happened while performing everyday activities (11%), and traffic accidents caused 4 ruptures, mostly with some other complex injuries, accompanied by other knee joint structures.

ACL ruptures caused by sport activities were recorded in 400 patients (Graph 1). Injuries with no contact with other athletes occurred in 312 (78%) patients, mostly: volleyball/basketball/handball players, gymnasts, and skiers. Contact injuries (hitting the knee and back of the lower leg during the knee extension or hitting the front of the upper leg) happened in 88 (22%) patients, mostly in martial arts fighters and soccer players (Graph 2). Most of the sportsmen, 144 (36%), got injured while landing after jumping in sports like volleyball, basketball, handball and even soccer; whereas 116 sportsmen (29%) got injured while changing the direction, running, or sudden running starts, 20 (5%) were injured because of a sudden stoppage (deceleration), especially in soccer, and 32 (8%) because of over extension of the lower leg.

The most common causes of ACL injuries among different sports are presented in Graph 3.
Discussion

The incidence and severity of ACL injury has been on the rise in the last few decades. At the same time there is a need in terms of demystifying risk factors, cause analysis, and finding out adequate training processes to prevent knee injuries. There are many inconsistencies in terms of significance of some risk factors [3].

The age of the patients in our study sample ranged from 15 and 49, which is in accordance with Woo’s epidemiologic data [4]. Stevenson and Orchard studies [5,6], have proven higher injury incidence in older sportsmen, whereas our and Geli’s study [7] have shown that incidence was higher in younger sportsmen because 90% of our surgically treated patients were younger than 35 years of age. Knee ligament injuries are the most frequent (90%) in the period before the second and fourth life decade [4].

The majority of our subjects came from an urban environment, which can be explained by the fact that most of elite sports clubs are located in towns and cities, which offer better conditions for professional engagement in sports than rural environments.

Potential risk factors for lower extremity lesions can be intrinsic and extrinsic [3]. The extrinsic ones are: competing level, skill level, footwear type, the coefficient of friction of flooring, prevention by wearing orthoses; and the intrinsic risk factors are: age, sex, previous injuries and inadequate rehabilitation, BMI, extremity dominance, flexibility and muscle strength, problems associated with balance and reaction time, postural stability, anatomic relations. The ACL injury incidence was found to be higher in women [3-7,15,16,19-21], during a competition rather than training sessions [8-10], on artificial playgrounds than on grass [11], in inadequately rehabilitated sportsmen [16], in cases of smaller intercondylar notch width of the femur [3-7], and with footwear of higher level of friction with the ground.

In our study sample of active sportsmen, ACL ruptures occurred 3 times more often during competition than training sessions because of more aggressive and riskier types of movement resulting in higher risk of getting injured. Competitive games presented 2.7 times higher risk than friendly games/matches, which also speaks in favor of the fact that injury occurs more often in important games. The injuries occur 3.8 times more often in the middle and final parts of the games, when the strain on the knee is the greatest, and when players are more concentrated on the result. Ekstrand et al [8] have stated that injuries occur 2 times more often during soccer games than during training sessions. Myklebust et al [9] and Seil et al [10] have concluded that ACL ruptures occur 30 and 24 times more often during handball matches than during training sessions respectively.

In our study sample, majority of injuries occurred on the floor (45%) because of the fact that handball, basketball and volleyball matches are almost always played indoors. ACL ruptures occurred on dry court (79%), which represented higher risk in contrast to muddy, slippery, wet and frozen fields because of the foot being fixed to the ground and under the influence of rotary forces on the knee. Powell et al [11] pointed to higher incidence of knee injuries on artificial surfaces in contrast to grassy and sand surfaces (beach volleyball), because of the higher friction level between the feet (footwear) and artificial grass.

Graph 1. Sports with highest risk for ACL injury (percentage does not correlate with incidence)

**Grafikon 1. Najrizičniji sportovi za povredu LCA (procenti ne koreliraju sa incidencijom)**

Graph 2. Causes of ACL injury

**Grafikon 2. Etiologija povređivanja LCA**

Graph 3. Percentages of the most common causes of ACL injuries among sports with highest risk in Vojvodina

**Grafikon 3. Procentna zastupljenost uzroka povređivanja LCA među najrizičnijim sportovima u Vojvodini**
Lambson et al [12] carried out a study including 3119 high school American football players and showed a statistical significance of ACL rupture incidence in players who competed on natural surfaces and wore specially designed sports footwear not allowing torsion of the feet on the ground thus enabling rotary forces to affect the knee and causing ACL injuries. However, both Barrett’s study [13] and ours have showed no correlation between footwear type and injury.

Due to the fact that the study sample consisted predominantly of sportsmen (59% of normally nourished patients), BMI had no significant influence on ligament rupture, although injuries occurred more often in obese subjects than in normally nourished ones, which is generally the case in the population of Vojvodina. Out of 451 study subjects, 135 had increased their body mass from 1 to 10 kg in the period of 6 months prior to the injury (4.87kg on average), which could indirectly show that 30% of the subjects had not been ideally fit prior to the injury. BMI was recorded as a risk factor in studies of Orchard and Jones [6,14], while no correlation between BMI and incidence was observed in other 9 studies [15-23].

Higher demands for world class sport results in women are followed by a higher incidence of ACL injuries in women. Although there were 2.4 times less women in our study sample, their proportional number of injuries is increasing both in the world and in our country. So, the percentage of women with ACL reconstruction was 19% in Novi Sad in 2005, whereas in 2008 it rose to 29% (in our study). In addition, sports-women are at a 2.9 times higher risk of getting ACL injuries than men according to some studies [3-7,15,16,19-21]. Anatomic differences can be a predisposing factor for higher incidence of injuries among women [7], because of their wider pelvis [3,5,6], increased knee valgus [6,7,19-21], increased external tibial rotation [6,7,19-21], narrower femoral intercondylar notch [3,5,7], smaller ligament dimensions [3,5,6], weaker neuromuscular response [15,17], higher ligament laxity [15,17], and hormonal variations during menstrual cycle [15]. Hewitt [15] observed that the highest number of ACL lesions occurred in the period of ovulation and that women on oral contraceptives were at a higher risk of getting injured. In our sample, only 6% of women mentioned using oral contraceptives prior to the injury, which does not speak of a significant correlation with ACL lesion, but that women in Serbia do not use this kind of pregnancy prevention as much as in the world.

In our study sample, persons active in sports are 8 times more often injured than inactive ones. ACL injuries did not occur in those beginning an activity, and surgery was not performed on any patients who had not been at least recreationally active for 2 years. Peterson et al [16] have proved that sportsmen less physically fit are at a higher risk of getting injured and the results of our study, as well as those of Hopper et al [17] and Hoesa et al [18], have proved that injuries occurred mostly in sportsmen with long careers.

More than three quarters of ACL injuries occurred in the most popular sports in Vojvodina (Serbia): soccer, handball, and basketball. Unlike Serbia, the riskiest sports in Scandinavian countries are handball and skiing [19,20] and football and basketball in the USA [16,17].

The limitations of this study are connected with subjectivity of patients when answering the questionnaire and because of the lack of video material to objectivize the analysis of the most frequent causes and mechanisms of getting injured. Our survey is comparable with similar ones [24,25] and creates conditions for prevention of ACL injuries.

**Conclusion**

Young population active in sports is at the highest risk of getting an anterior cruciate ligament injury.

Our study has shown that anterior cruciate ligament injuries happen most often in football players, than in handball/basketball/volleyball players and martial arts fighters, whereas active basketball players are at the highest risk of getting injured.

Our study has not shown statistical significance of correlation between anterior cruciate ligament lesion and footwear type, body mass index, warm up, previous illnesses, everyday therapy and genetic profile.

Anterior cruciate ligament injuries are more frequent in sportsmen with longer career, during matches rather than training sessions, in the middle or by the end of a match or game, on dry surfaces, without a contact with other competitors, when landin and changing the direction of movement.

By defining risk factors, injury cause analysis, and education of physicians, sportsmen and coaches, conditions for preventing injuries of anterior cruciate ligament can be created.

**Literatura**


Zaključak
Povrede su se dešavale: tri puta češće na utakmicama, u srednjem i završnom delu utakmica i treninga (75%), na suvim terenima (75%), kod slabije pripremljenih sportista (62%).

Sažetak
Povrede prednjeg ukrštenog ligamenta mogu se redukovati u 40-90% slučajeva. Među faktorima rizika povređivanja ove strukture kolenog zgloba stvaraju se uslovi za prevenciju povreda prednjeg ukrštenog ligamenta. Cilj studije je da analizira incidenciju, etiologiju i faktore rizika povređivanja ove strukture kolenog zgloba.

Materijali i metode
Sprovedeno je ankетiranje 451 operativno lečenog pacijента, među kojima 400 sportista (65% aktivnih, 35% rekreativaca), 29% ženskog pola, 71% mladih od 35 godina i 70% slabije pripremljenih sportista.

Rezultati
Kod 88% pacijenata uzrok povređivanja bila je sportska trauma (nekontaktnim mehanizmom kod 78% slučajeva, kontaktnim u 22%). Ostale povrede događale su se pri svakodnevnim aktivnostima kod 11% i pri saobraćajnim utakmicama u 1% slučajeva. Među sportistima, najviše rekonstrukcija prednjeg ukrštenog ligamenta izvršeno je kod fuđbalerica (48%), potom rukometara (22%), košarkaša (13%), odbojača (8%), borilačkih sportova (4%), ali je incidencija povrede najveća među aktivnim košarkašima (1:91). Na povređivanje nisu značajno uticali: tip obuće, zahvati košarka i odbojkaša, borilački sporti, uslov u kojem se sportistima, najviše rekonstrukcija prednjeg ukrštenog ligamenta kod 11% i pri saobraćajnoj traumi u 1% slučajeva. Među drugim povredama, najčešće se događala je traumata na 3. protjeru, ptica, ruke i noge.

Ključne reči: Koleno; Povrede kolena + etiologija; Faktori rizika; Predenji ukršteni ligament + hirurška; Sportske povrede

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