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RISK FACTORS FOR BILATERAL ANTERIOR CRUCIATE LIGAMENT INJURIES

FAKTORI RIZIKA ZA NASTANAK OBOSTRANE POVREDE PREDNJEG UKRŠTENOG LIGAMENTA

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Summary

Introduction. The aim of this study has been to identify which risk factors can influence bilateral anterior cruciate ligament injury. **Material and Methods.** Thirty-two operated patients took part in this survey during the period of ten years. There were 5 women and 27 men, with average age of 30.46 years (19-55). The respondents filled in the questionnaire by answering the questions regarding the time when getting injured and operated, mechanism of injuries, genetic and anthropometric data, characteristics of sports and every day activities. **Results.** The incidence of reconstructed bilateral injuries in relation to unilateral ones was 2.3% (50/2168). The age of respondents and side of the injured knee did not correlate significantly with the achieved subjective physical activity level after the second knee surgery. The average time from the first injury to operation was 10 months and 4.3 years since that moment up to the injury of the other knee. It took more than 9 months on average until the reconstruction of contralateral anterior cruciate ligament. The most of athletes were injured in football matches. Three-quarters of athletes returned to competition activities after the first operation, which caused the same injury of the contralateral knee. **Discussion and Conclusion.** Anterior cruciate ligament rupture of the contralateral knee most often occurs in young active athletes within the first four years after the initial reconstruction. Its frequency is not affected by sex, side of extremity, genetic predisposition, type of sport, concomitant injuries and the choice of graft. Returning to the same or higher level of sports activities after the first reconstruction is one of the preconditions for injuring the other knee in the same way.

Key words: Risk Factors; Anterior Cruciate Ligament; Knee Injuries; Questionnaires; Activities of Daily Living; Sports

Introduction

The annual incidence of unilateral anterior cruciate ligament injury (ACL rupture) in general population ranges between 0.01 and 0.08%, while it is significantly higher in sports active population, being 1.5-1.7% [1-5]. The frequency of nonsimultaneous

Sažetak

Uvod. Cilj ovog rada predstavlja utvrđivanje koji faktori rizika pogoduju nastanku obostrane povrede prednjeg ukrštenog ligamenta. **Materijali i metode.** U istraživanju je učestvovalo 32 operativno lečena pacijenta, tokom desetogodišnjeg perioda. Među njima je bilo 5 žena i 27 muškaraca, prosečne starosti 30,46 godina (19-55). Anketirani pacijenti su dali odgovore na upitnik o: vremenu povređivanja i operacija, mehanizmu povrede, genetskim i antropometrijskim podacima, kao i karakteristikama sportskih i životnih aktivnosti. **Rezultati.** Incidencija rekonstruisanih obostranih povreda u odnosu na jednostrane iznosi 2,3% (50/2168). Korelacija uzrasta ispitanika sa postignutim subjektivnim nivoom fizičke aktivnosti posle druge operacije kolena ne pokazuje značajnu statističku razliku, kao ni lateralnost (dominantnost ekstremiteta). Prosečno vreme od prve povrede do operacije iznosilo je 10 meseci. Od tada do povrede drugog kolena proteklo je još prosečno 4,3 godine. Potom je prošlo još prosečno 9 meseci do rekonstrukcije kontralateralnog prednjeg ukrštenog ligamenta. Najviše sportista povređeno je na fudbalskim utakmicama. Tri četvrtine sportista se nakon prve operacije vratilo takmičarskom aktivnostima, koje su bile uzrok iste povredu drugog kolena. **Diskusija i zaključak.** Povreda prednjeg ukrštenog ligamenta kontralateralnog kolena najčešće nastaje kod mladih aktivnih sportista u toku prve četiri godine nakon prvobitne rekonstrukcije. Na navedenu učestalost ne utiču: pol, strana povređenog ekstremiteta, genetska predispozicija, vrsta sporta, udružene povrede i izbor kalema. Povratak na isti ili viši nivo sportske aktivnosti posle rekonstrukcije prednjeg ukrštenog ligamenta kolena predstavlja jedan od preduslova za nastanak iste povrede drugog kolena.

Cljučne reči: Prednji ukršteni ligament; Faktori rizika; Bilateralne povrede

bilateral ACL injuries ranges from 1.1% up to even 14% of the total number of ACL injuries [5-11]. Simultaneous ruptures are very rare, and they are reported in the literature only as individual cases [4, 12-15]. The risk of injuring the other knee is even greater than the risks for primary rupture, and the

Abbreviations

ACL	– anterior cruciate ligament injury
BMI	– body mass index
BTB	– bone-to-bone

second injury happens most often within the first three years after the first operation [6–9].

The causes of bilateral ACL injuries have not been explained sufficiently although there are various assumptions. Specific internal factors which are being intensively studied include: anthropometric, biomechanical, neuromuscular, anatomical, hormonal, and genetic risks [3, 16, 17]. Reduced width of femoral intercondylar notch, increased posterior tibial slope, bad neuromuscular control, ligament laxity, increased body mass index (BMI), female sex and the valgus position of the knee are linked with an increased risk of ACL injury [3, 16, 17].

This study has been aimed at analyzing possible causes of bilateral ACL ruptures and identifying risk factors on our specimen of patients, which should result in the prevention of bilateral injuries.

Material and Methods

Having been approved by the Ethics Committee of Clinical Center of Vojvodina, this retrospective study was performed at the Department of Orthopedic Surgery and Traumatology in Novi Sad. The study sample included 32 of 50 patients operated for bilateral ACL ruptures in the period from January 01, 2003 until December 31, 2012, who had given their consent to participate in this study. The average time of monitoring from the knee operations to the check-up was 4.9 years. The respondents were 5 women and 27 men, whose average age was 30.46 years (ranging from 19 to 55 years).

A questionnaire was designed and sent by e-mail to all patients, who were asked to provide data on the amount of time before the first and the second injury, between the injuries, between the injuries and surgical interventions, between the interventions and return to trainings and competitions. They also provided information on their sports activities and activities in their daily life.

The following parameters were included in the more detailed coverage of data for each patients: age structure, gender structure, family history of the same injury, height, body mass, amount of time spent on training before the injury, the amount of

time between the first injury and operations, the amount of time between the first injury and return to training, the amount of time between the first operation and return to competition, the amount of time between the two injuries, the amount of time between the first operation and injuring the other knee, the amount of time between injuring the other knee and the second operation, the amount of time between injuring the other knee and return to training, the amount of time between injuring the other knee and return to competition, dominant leg, the achieved level of physical activities after the second operation.

The mean values, standard deviation, minimum and maximum were analyzed within descriptive statistics. The following statistical analyses were used: Spearman and Pearson's coefficient correlation and T-test for independent samples.

Results

During the study period lasting for ten years, 2168 unilateral ACL ruptures were operated. Fifty patients with reconstructed bilateral ruptures were among them, the incidence being 2.3%.

Out of 32 patients, 14 patients injured the right knee first and 16 patients injured first the left one, while both knees were simultaneously injured in two cases. The left leg was dominant in 19 patients (for jumping), and the right one was dominant in 13 patients. No statistically significant correlation was observed between the age of patients and their level of activity, nor the effect of the dominant leg on bilateral ACL injuries. The correlation of age and the activity level was $F(2,29)=1.59$, $p=.221$ ($p>.05$).

The periods between injuries and operations are shown in **Table 1**.

The injuries happened during the sports activities in all patients: 16 (75%) in competition, 8 during the training (25%) and 8 in recreational sporting activities (25%). The association between the type of sport and bilateral ACL rupture is shown in **Graph 1** and the competition level of sports activities of patients is given in **Graph 2**.

ACL and meniscus injuries during the first and contralateral knee injuries are shown in **Table 2**.

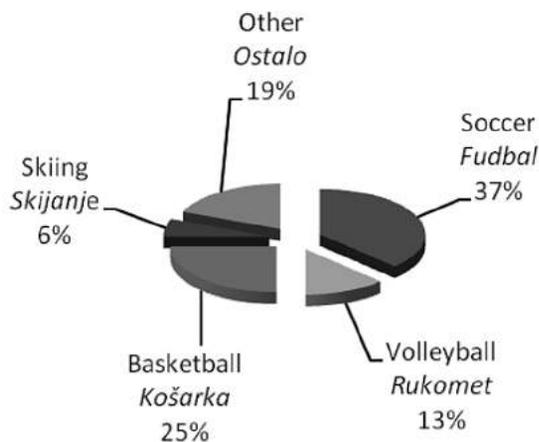
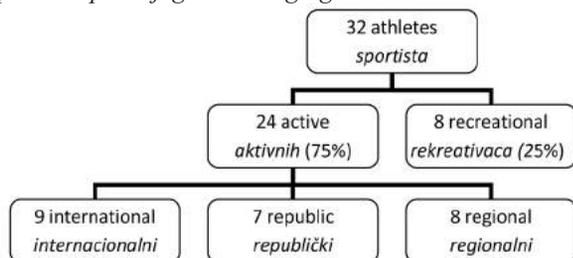
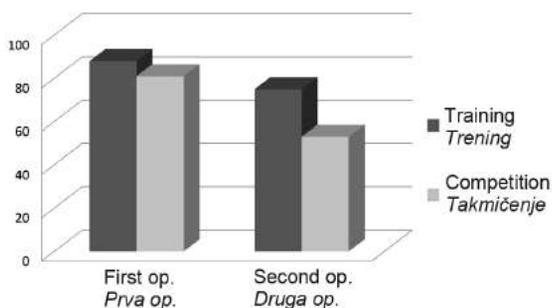
According to the answers in the questionnaire, 87.5% of respondents returned to trainings and 75% to competitions after the first operation. However, that percentage was lower after the second ACL

Table 1. Time of ACL injuries**Tabela 1.** Vreme povređivanja prednjeg ukrštenog ligamenta

	Time/Vreme	Average/Prosek
1 st injury – 1 st operation	25 days – 7 years	10.2 months
1. povreda – 1. operacija	25 dana – 7 godina	10,2 meseci
1st injury – 2nd .injury	9 months – 15 years	4.34 years
1. povreda – 2. povreda	9 meseci – 15 godina	4,34 godine
2 nd injury – 2 nd operation	5 days – 4 years	9.1 months
2. povreda – 2. operacija	5 dana – 4 godine	9,1 meseci

Table 2. ACL and meniscus injuries during the first and contralateral knee injuries**Tabela 2.** Udružene povrede prilikom inicijalne i povrede prednjeg ukrštenog ligamenta kontralateralnog kolena

Injury Povreda	Isolated ACL/Samo pred- nji ukršteni ligament	Both menisci Oba meniskusa	Medial meniscus Unutrašnji meniskus	Lateral meniscus Spoljašnji meniskus
The first/Prva	15	3	6	3
The second/Druga	17	1	3	3

**Graph 1.** Sport that caused bilateral ACL rupture
Grafikon 1. Vrsta sporta koja je dovela do obostrane povrede prednjeg ukrštenog ligamenta**Graph 2.** Sports activity and competition level of patients
Grafikon 2. Nivo sportske aktivnosti i rang takmičenja pacijenata**Graph 3.** Return to trainings and competitions after the first and second ACL reconstruction**Grafikon 3.** Povratak treninzima i takmičenjima nakon prve i druge operacije prednjeg ukrštenog ligamenta

reconstruction, being 81.2% and 53.1% of those who

returned to trainings and to competitions (matches), respectively (**Graph 3**).

Discussion

While the risk factors, etiology and mechanisms of primary ACL injuries have been widely studied, reasons for ACL ruptures of the contralateral knee are not clearly defined, although those injuries are not rare. The most voluminous study was published by a Swedish group of authors [9] thanks to the National Register of Knee Ligaments Injuries [2]. Out of 9061 reconstructed ACL in the study sample, 270 bilateral reconstructions (3%) were done. Souryal et al. [10], Myklebust et al. [6] and Falstrom et al. [7] reported 4%, 9%, and 12% of bilateral injuries, respectively. The incidence increases with the length of the monitoring period of the patients, so in our sample it resembles the Swedish register and amounts to 2.3%.

While in some countries, such as Japan, bilateral ACL injuries are dominant in women [19], in Scandinavian countries sexes are almost equally represented [7, 9]. In our study, as well as in some others [10] men are most affected. The above mentioned does not suggest that men represent a group of athletes at risk, only that they are operated 2-8 times more often than women [19-22]. The group at highest risk for ACL injury is young, sports active population. Women are at 2-10 times greater risk than men, depending on the type of sport [3, 6, 18]. The reasons for epidemic appearance of ACL injuries among women in the world lie in the anatomic differences between gender: size of Q angle, increased valgus of knee joint, narrow intercondylar notch, wider pelvis, impact of estrogen hormone on ligaments during menstruation cycle, general laxity of ligaments and different time of contractions between anterior and posterior groups of thigh muscles [3, 6, 18].

Branch et al. [23] used robotics to measure and compare rotatory stability of knee joints without ACL rupture and with bilateral ruptures. The latter had significantly increased internal and decreased external rotation of tibia. Both internal and external rotation was increased in women compared to men. Rotatory instability may cause a simultaneous rupture of ACL, medial meniscus and medial collateral ligament because those injuries most often happen during forced valgus, moderate flexion and rotation of tibia [23].

According to our previous studies [20], the following factors did not significantly influence injur-

ing ACL in 450 operated patients: type of sport shoes, warming, genetic predisposition and taking daily therapy. Injuries occurred more often during competitions, at the end of matches, in activities without contact with other competitors, during landing or sudden change of direction, on dry surfaces, in athletes who had not prepared well.

Today, anatomic variations of knee joint are in the focus as risk factors, so we have found that patients with increased posterior tibial slope are at a greater risk of ACL rupture [25]. A narrow femoral intercondylar notch can also represent an anatomic risk factor for bilateral ACL rupture [10, 18].

Sward et al. [8] believe that the most prominent risk factor for a contralateral ACL injury is return to a high (competitive) level of physical activity. Our results are in agreement with the above mentioned because 75% of our operated patients returned to competition level of activities after the first operation, and then had another knee injury within the first 4 years after the primary operation. Most authors [5, 9, 25] confirm the above mentioned time frame, while Orchard et al. [26] found that the greatest risk factor for a contralateral ACL injury was a history of an ACL reconstruction in the previous 12 months.

Contralateral ACL rupture is most commonly associated with younger people, athletes under 20 years of age [9, 10]. We have observed, as Falstrom et al. did [7], that the second injury happened at somewhat older age, the average being 30.5 years of our patients and 29.1 years of theirs. Due to the fact that sports career is on the wane in those years, contralateral knee injury in the fourth decade may mean an end of career, while this happens less frequently in the second decade of life. In addition, every second active athlete has cartilage damage in the fourth decade [6], which can cause pain and lasting disruption of sports activities. Statistical analysis considering the correlation between the participants' age and the subjective level of physical activities which the respondents have achieved after the second knee surgery does not show a significant difference. The correlation is extremely low, so we can say that there is no connection between the age and activity level.

Family history may be considered a possible risk factor for bilateral ACL injuries according to some literature data. Although this issue is still being debated, no consensus has been reached. While some authors advocate this theory strongly [17, 27], the authors of this paper as well as others have not found the correlation [5, 10, 27]. Flynn et al. [28] found that patients having the history of ACL ruptures in their family: in the first generation (parent, brother or sister, child), the second (brothers and sisters of their parents) or in the third, are at a risk twice higher of injuring their ACL than general population without family history of injuries. Our study could not confirm this claim, because only four of our patients had ACL injuries in their family history (two fathers, a brother, and a sister), which is statistically insignificant representation.

Studies which have found a significant correlation between the side of the injured extremity and bilateral ACL injury are rare. Although there are some authors who believe that the reconstruction of nondominant limb is a potential predictor of contralateral ACL injury [29], we have not observed such a correlation.

The choice of graft can also be a risk factor. Leys and Sward et al. [8, 25] have concluded that reconstruction with bone-to-bone (BTB) graft carries a greater risk for bilateral ACL rupture (26%) than hamstring tendons (12%). Ardernord et al. [9] claim that graft harvesting of hamstring tendons from the contralateral unharmed knee significantly increased this risk. This probably weakens the function of the healthy knee resulting in it being injured later because the tendons cannot regenerate during a short period of time until the next rupture. However, the majority of studies [9, 21, 30] have proved that the choice of graft does not affect the bilateral ACL ruptures significantly. Our previous studies have also failed to find the correlation between the choice of graft and ACL re-ruptures [19, 21]. The cause may lie in the fact that ACL are reconstructed with BTB graft in professional athletes, while hamstrings tendons are usually applied in women and those who go in for recreational sporting activities, which impose less burden on the operated and uninjured knees.

The structure of sporting activities which the respondents were engaged in only confirmed our earlier epidemiological studies [20]. Intensive sports that involve movements of pivoting, forced valgus and anterior translation of tibia during one-leg landing represent activities of high risk for ACL rupture. The fact that in Vojvodina [20-22] 37-50% of patients get injured in football (soccer) only reflects sports preference of young population in Serbia due to the popularity of that sport among young professionals and recreational activities among the middle-aged population. Football is also the most prominent sport in this study, and the second and third place is taken by basketball and handball, respectively. In the study done by Souryal et al. [10], American football (rugby) was in the first place with 25.6%, followed by basketball (20.7%) and soccer (11%) This is in accordance with the findings of our studies. The difference is only in the fact that rugby is more popular sport in North America than soccer. Swedish authors [6] consider handball to be sport of a high risk due to rapid change of movement direction and pivoting, which says more about popularity of that sport in Scandinavian countries. Authors from Japan think that basketball and gymnastics are sports carrying the highest risks [18].

The most prominent risk factor for a contralateral ACL injury is returning to a high level of activity during intense trainings and competitions [7] which include sports with a lot of jumping, pivoting, leap aside and change in movement direction. This is in line with our results since only four participants (13%) did not return to training after the initial injury, and all the others resumed the previous

sporting activities at the level of training or competitions. According to earlier results, the most commonly injured athletes are those who are active in sports between 11 and 20 years of age, most often in competitive matches, and considerably less in friendly matches and during training. The parts of competition that have the highest risk are its middle part and end of match [20]. Competitive athletes, who train at least once a day most often for 90 minutes, are at a higher risk of injuring ACL. Our results showed that the patients who were at the competitive level of sports activities were mostly present in the structure of our participants (15 of them), while 8 of them were injured while training.

By correlating the associated injuries during the second knee injury and the reached level of physical activity in our study group, it has been proved that meniscus ruptures do not play a crucial role in restitution of activities. Statistical parameters do not show any statistically significant difference. The reason for such a result is again significant disproportions in the representation and associated absence of ruptures within the group, as well as the high percentage of those respondents who were not able to provide the information on associated knee injuries. Only 9.4% of the respondents had the rupture of medial meniscus, 9.4% had the lateral meniscus rupture, and 3.1% suffered from both menisci rupture simultaneously. As many as 25% of participants did not know if they had injury of menisci, while 53.1% of them had an isolated ACL rupture. Faltstrom et al. [7] found ruptures of medial meniscus in 15.4% of cases during initial injuries and 31.1% during the contralateral injuries [7]. Associated lateral meniscus injury was reported in 15.4% of initial ACL injuries and in 13.1% of contralateral ones. Both menisci got injured simultaneously during the initial rupture in 4.6% of cases and in 3.3% of cases during contralateral ACL rupture. Ardernord et al. [9] also concluded that the

previous meniscal and chondral injuries were not predictors of future contralateral ACL reconstruction, although they noted significantly higher percentages than we did (40% menisci and 27.5% chondral lesions).

Since there are several aspects of doing physical activities, our study and similar ones need more detailed questionnaires to analyze the length of training before injuries, as well as the intensity and phases of sports activities (warming up, training, activity in other types of sports in relation to the primary one) in order to check the data obtained for that particular aspect of training-competitive process. Low statistical significance in the correlation between the associated initial and contralateral injuries with the reached level of physical activities after the second operations leads to the conclusion that it is necessary to study this issue on a sample greater than 32 patients, which is the main drawback of this study. The existence of a National Register, similar to the Swedish one, would certainly lead to a more comprehensive analysis.

Conclusion

Anterior cruciate ligament rupture of contralateral knee occurs in young active athletes most often within the first four years after the initial reconstruction.

Sex, side of extremity, genetic predisposition, type of sport, concomitant injuries and choice of graft do not affect bilateral injury.

Returning to the same or higher level of sports activities after the first reconstruction is one of the preconditions for the appearance of the same injury of the second knee.

Determination of predisposing factors could help in preventing bilateral anterior cruciate ligament injuries.

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