The incidence of anterior cruciate ligament (ACL) injury in the young population is constantly increasing, especially among active athletes [1, 2]. Although it is well documented that females are at a significantly higher risk of ACL injury [1–4], the dilemmas remain: why males predominate in study samples and why does not ACL reconstruction prevent the development of osteoarthritis, especial-
Abbreviations
ACL – anterior cruciate ligament
BMI – body mass index
SD – standard deviation
KOOS – Knee Injury and Osteoarthritis Outcome Score

ly in obese patients, since it provides knee joint stability [1, 3]. Current dilemmas are also related to the prevention of risk factors of ACL rupture [1–7], identification of the best surgical techniques with as few complications as possible [8–14], as well as the best rehabilitation protocols providing safe return to sports activities after surgery [15].

Risk factors associated with ACL injury are divided into environmental factors, hormonal, neuromuscular, biomechanical, and anatomical factors [1–4, 16, 17]. Among the anatomical factors, the most commonly mentioned are ligament laxity, quadriceps angle, knee valgus, width of the femoral intercondyular notch, and posterior tibial slope [3, 16, 17]. Body mass index (BMI) is also considered to be a potential risk factor [18] since obesity may have negative effects on health, quality of life, and postoperative recovery of patients [19].

The purpose of ACL reconstruction is not only to improve the knee function, but also to provide an optimal quality of life. Current questionnaires point to the importance of the patient’s perception of his health status [7, 8, 20]. However, there is little data in the available literature on whether and how body weight, body height, and BMI affect quality of life. Therefore, we hypothesized that obesity decreases the quality of life of patients after ACL reconstruction, compared to normal weight patients; the aim of the study was to determine the quality of life among groups with different BMI after ACL reconstruction.

Material and Methods

The study was performed at the Clinic of Orthopedic Surgery andTraumatology of the Clinical Center of Vojvodina after the approval of the Ethics Committee. The retrospective study included 510 patients with ACL injury who underwent surgical treatment in the period from March 2013 to December 2015.

There were significantly more male patients (413, 81%) than female (97, 19%). The average age of patients was 27 years (15 to 59 years) with a standard deviation (SD) of 7.84.

The injury occurred during sports activity in 487 patients (95%), 13 patients had a fall injury (3%), and 10 (2%) were involved in a traffic accident. There were 282 persons in recreational sports (55%), 205 respondents were professional athletes (40%), while 23 respondents were not active in sports (5%). Among the athletes, 58 (11.4%) were competitors at international level, 105 (20.6%) at national, 101 (19.8%) at regional, and 225 (44.1%) at local level.

A total of 272 soccer players underwent surgery, as well as 46 handball players, 39 basketball players, 27 skiers, 21 volleyball players, 20 wrestlers, 18 judokas, 17 karate players, 11 American football players, 10 taekwondo competitors, 4 tennis players, 1 active in athletics and 1 in table tennis. Thus, most of our patients were soccer players (55.9%), since all other sports accounted for less than 10% of the total sample.

The right knee was operated in 281 cases (55.1%), the left in 212 (41.6%), while injuries of both knees were registered in 17 persons (3.3%).

Patients who signed a written consent to participate in the study were sent a Knee Injury and Osteoarthritis Outcome Score (KOOS) questionnaire by e-mail [21], to which they responded voluntarily at least one year after surgery. In addition to data on the postoperative quality of life, general data were collected about the etiology of injuries in terms of professional and recreational sports, daily activities and possible knee instability. Data on each patient included the following parameters: gender and age, mode of injury, type and level of sports activity, laterality, associated injuries, time elapsed from injury to diagnosis, from injury to surgery, and postoperative values of all segments of KOOS questionnaire including symptoms, pain, daily activities, issues related to sports and quality of life, as well as the Tegner Lysholm Knee Scoring Scale. The KOOS questionnaire is a 42-item self-administered questionnaire with five subscales. Each question has 5 possible answers (Likert boxes). The score is a percentage score from 0 to 100, with 0 representing extreme problems and 100 representing no problems.

Anthropometric data of body weight and body height (Table 1) were collected and based on them the BMI was determined [19]. The BMI is calculated by dividing a person’s weight by the square of their height (kg/m² – BM/BH²). After the BMI was determined, patients were classified into 5 categories. Malnutrition is a BMI < 18.5, normal or healthy weight range is between 18.5 and 24.9, overweight is 25 – 29.9, mild obesity 30 – 34.9, and severe obesity is above 35 (Table 2).

The descriptive statistics included the following: mean, SD, minimum and maximum. We performed one-way analysis of variance (ANOVA) and F-test. The T-test for independent samples was used in comparative statistics. The results were analyzed and presented in tables. The respondents who did not fill out the KOOS questionnaire voluntarily or completely, as well as those who did not complete the rehabilitation, were excluded from the study.

Results

The average body weight of in our patients was 80.64 kg (SD 8.07). A female patient had the lowest body weight of 52 kg, and a male patient had the highest body weight of 125 kg (Table 1). The average body height was 1.80 m, minimum 1.56 m, maximum 2.05 m (SD = 0.8) (Table 1).

Most of the patients included in the study had a normal body weight (302, 59%); there were 179 who were overweight (35%), 24 were mildly obese (5%), 5
were malnourished, while there were no severely and extremely obese persons. The lowest BMI was 16.52, the highest 34.77, and the mean 24.65 (SD 3.01) (Table 3).

A statistically significant difference was found between BMI and gender of the participants, T (508) = 9.35, p = .00 (p < .01), because on average, men had higher BMI (25.21) than women (22.26).

There was a statistically significant correlation between the age of subjects and BMI. The difference was moderately high: r = .442, p .000 (p < .01). Thus, BMI increases with age.

A statistically significant relationship was found between age and BMI groups (malnourished, normally fed, overweight or slightly obese patients): F (3,507) = 27.763, p = .000, p < .001.

The mean BMI among patients who sustained a sports injury was within the normal range (18.5 - 24.9), while persons who suffered an ACL injury in a traffic accident or had a fall injury had an increased mean BMI (> 25). Thus, there is a statistically significant difference: F (2.508) = 29.334, p = .00, p < .001.

A statistically significant difference was observed between the BMI and the level of sports activity among the respondents: F (2.506) = 19.12, p = .000, p < .001. Athletes competing at the international, national and regional levels had ideal BMI, whereas recreational athletes and non-athletes had increased mean BMI (> 25).

We also found a significant correlation between BMI and Tegner score: r = -.282, p = .000 (p < .01) The results indicate that higher BMI is associated with lower Tegner score, which means that obese people are less engaged in professional sports with the highest risk of ACL injury. Therefore, we did not have a single obese soccer player at the national and international level of competition in the sample (with Tegner score of 10).

The BMI also showed a statistically significant correlation with the “pain” subscale of the KOOS questionnaire. The correlation of BMI with “activities of daily living” showed the following results: r = .126, p = .000 (p < .01), which indicates that subjects with higher BMI are less active in daily activities. The difference is not high, but it is significant.

The BMI also showed a statistically significant correlation with “sports and recreational activities”;

| Category                | No. patients | BMI (kg/m²) | SD/Stat. dev. | Minimum/Minimum | Maximum/Maksimum |
|-------------------------|--------------|-------------|---------------|-----------------|------------------|
| Never/Nikada            | 345          | 24.40       | 2.89          | 16.52           | 34.77            |
| Rarely/Retko            | 119          | 25.38       | 3.22          | 18.99           | 34.63            |
| Sometimes/Ponekad       | 39           | 24.82       | 3.26          | 19.41           | 33.14            |
| Mostly/Uglavnom         | 6            | 23.28       | 2.52          | 20.05           | 25.95            |
| Always/Uvek             | 1            | 23.83       | 23.83         | 23.83           | 23.83            |
| Total/Ukupno            | 510          | 24.65       | 3.01          | 16.52           | 34.77            |
The correlation of BMI and the KOOS subscale “subjective symptoms” showed a statistically significant difference only for the question: “How often do you feel knee instability?” The differences were found among those who answered: “rarely” and “mostly”. The one-way ANOVA showed a significant difference: \( F(4,505) = 2.715, p = .029 \) (Table 3).

Analyzing the quality of life after ACL reconstruction, we found that most patients (91.0%) felt that their general health was much better than before surgery showing that this surgery significantly improves the quality of life (Table 3).

Comparing the BMI and the patients’ personal perception of the impact of the injury on their quality of life, 345 (67.6%) of those with an ideal BMI responded that the surgery did not negatively affect their quality of life at all (Table 3).

Patients with ideal BMI have a better perception of their own health compared to patients with higher or lower BMI. Respondents are often aware of their knee problem, but no significant association was found between the BMI and their awareness of the knee problem.

The correlation of BMI and overall quality of life with the “KOOS” questionnaire showed a low but significant correlation: \( r = .133, p = .000 \) (\( p < .01 \)), meaning that people with higher BMI are less active in sports and recreational activities.

Discussion

Fifty years ago, complete ACL rupture was the most common reason for the termination of a sports career [10, 16]. Today, with the development of surgical techniques, about two thirds of athletes successfully return to unrestricted sports activities 6 – 9 months after the ACL reconstruction [10, 12, 14, 16, 20]. Of the total number, 67.6% of our patients with ideal BMI also believe that a year after the surgery their quality of life has not changed at all. Therefore, sports medicine and traumatology is focused on finding risk factors for injuries and the development of training processes to avoid them [3, 4, 16].

Depending on the type of sport and due to anatomical and hormonal reasons, women are at 2 – 6 times higher risk of ACL injury [1, 24–26], but there are few studies in Serbia in which the female sex dominates, which is also the case in our study (81% of respondents are men). Although women are at a higher risk of ACL injury due to lesser muscle strength, increased knee valgus, wider pelvis, hormones that affect ligamentous hyperelasticity, narrower intercondylar femoral notch and other factors [1–4, 16], surgeries are more common in the male population [5–14, 23]. The analysis of ACL reconstructions in America shows that 61% of high school students who train basketball are girls, and only 39% are boys [4]. However, after high school, in the same group males were almost 7 times more likely to be injured. The comparison of sex distribution among the athletes of the same first league shows that female basketball players are at a 3.5 times higher risk of ACL injury than male basketball players, and female soccer players are at a 2.67 times higher risk than male soccer players [26]. In our earlier study, we concluded that the overall quality of life after ACL reconstruction did not differ significantly between males and females [7].

In our study, the majority of examinees were athletes, aged between 18 and 25 years, because injuries commonly occur at that age [5–10, 23, 27]. The ACL ruptures are most often caused by non-contact mechanisms, during a sudden change in direction and single-legged landing, at the end of the competition, due to muscle fatigue and lack of concentration [5, 24, 25, 28]. It has been established that neuromuscular body control, especially of the hips and lower extremities, adequate strength and proprioception contribute to the prevention of knee injuries [3, 16]. Muscle fatigue is a significant risk factor for ACL injury, due to weaker neuromuscular stabilization and risky movements of the knee joint [24, 28].

High risk activities for ACL injury include contact sports with rapid changes in direction and landings: soccer [3, 5], basketball [25, 29], handball [22] and American football [30]. Skiing is a non-contact sport with the highest risk of knee injury [31]. The most popular sport in the world is soccer with an estimated 265 million active players [3], so in our study, recreational soccer players were the most often injured. The incidence of ACL injuries also depends on the popularity of a certain sport in different countries, so most studies in Serbia are dominated by soccer players [5–7, 9, 10, 14, 17, 20], in the Nordic countries by handball players and skiers [20, 32], in the USA by rugby and basketball players [4, 30], in Japan by female basketball players, wrestlers and skiers [31, 33]. Due to the absence of shoe-surface friction, ACL injuries are extremely rare among hockey players, skaters and ballet dancers [5–7]. In our previous studies, including about 4,000 operated patients, we did not have a single case of surgical treatment in professional ice hockey players, ballet dancers and dancers [5–10], so we mistakenly thought that injuries do not occur among them. However, in the American Hockey League, there are 6 – 7 hockey players with ACL injury in every season [34], because this sport also requires sudden changes in direction, rotation of the knee joint and pivoting. Although the incidence of ACL injuries among hockey players is significantly lower than in other contact sports, tangling skates and falling to someone’s knee can lead to rupture. Despite successful surgeries, American hockey players show that injuries have consequences, since the operated players...
have lower success in terms of achieving a lower average number of goals per match and season [34].

The largest published series of ACL ruptures among ballet dancers included 12 injuries during a five-year follow-up in New York [24]. Each ballet dancer performs over 200 jumps during a 1.5-hour workout per day, more than half of which involve landing on one leg [24], which is particularly risky for ACL injury. However, only 0.2% of ballet dancers and 0.4% of contemporary dance competitors experience ACL injury [24], while among team ball sports 1 – 8% of competitors suffer ACL injury [25, 29, 35]. The reason for a low incidence of ACL injuries among dancers lies in the fact that their professional activity requires special skills in balance movement and landing control. Unlike most sports, ballet is more focused on the technique of performing risky knee movements, whereas athletes are focused on scoring goals and points, as well as contact with opposing players [24]. Also, professional ballet dancers and contemporary dancers usually have ideal body weight, because those with ACL injury have a mean BMI of 26.5 and those without injury 25.5 [24]. The reason for rare ACL injuries in ballet dancers lies in the fact that their movements are routine, practiced daily, with elegant arm movements that contribute to balance, without improvisation and influence of the environment, field and opposing players [24]. So, although ballet dancers do not belong to obese people, they also experience ACL ruptures. Obesity is a major epidemiological problem, both in the world and in our country. Over the last 40 years, the mean BMI in the female population of Serbia has increased from 24.1 to 25.3 [36]. In males, obesity has increased even more, from 23.8, to a mean BMI of 26.3 [36]. Today, more than half (54%) of the adult population of Serbia is overweight and 37% are obese [36]. The mean BMI in the general population of Serbia is about 26 [36], and in our sample 24.6, because it is dominated by athletes. The mean BMI in other studies that followed athletes ranged between 23.3 and 27.6 [24, 27, 37, 38]. Our study shows that there is a statistically significant difference between BMI and gender of respondents, since males have a higher BMI (average 25.21) than females (22.26), which is consistent with other studies [26, 27, 37].

According to the literature, BMI is a risk factor for ACL injury, especially in young athletes [39 - 41]. Women with increased body weight are at more than three times the risk of ACL injury than women with a normal BMI [40, 41]. Body height, especially during growth of the tibia and femur at puberty, leads to a shift in the center of gravity, which complicates neuromuscular control [16]. The increase in body weight directly affects the increase of forces acting on the knee joint during sports movements of strong intensity [16]. The most hazardous positions for ACL injury are flexion, abduction, valgus, anterior translation, and external tibial rotation [4, 42, 43]. Athletes, like in our study, have statistically significantly lower BMI compared to non-athletes [44]. The analysis of 140 athletes of both sexes from Novi Sad training volleyball, basketball, soccer, handball, athletics and rowing, showed that BMI in all groups ranged in physiological limits, except in the group of female handball players, whose mean BMI was moderately higher (25.70) [45]. The average values of body fat percentage were significantly lower among female athletes, with the lowest values in women’s athletics, while, among men, basketball players had the highest percentage of fat [45].

Modern questionnaires prove the importance of the patient’s perception in assessing their own health [5, 7, 8], so we found that an increase in BMI reduces the quality of life in patients undergoing ACL reconstruction. Obese patients (BMI > 25) show a lower postoperative quality of life compared to normal weight patients. The difference is not high, but it is statistically significant. Kowalchuk et al. [46], like us, found that patients with BMI > 30 had less successful ACL reconstruction results than patients with physiological BMI. Other studies confirm that BMI can change the quality of life of patients after ACL reconstruction [47, 48]. It has also been shown that patients with BMI over 35 have poorer postoperative results after arthroscopic meniscectomy than patients with BMI < 30, because postoperative “KOOS” results are better in normal weight patients than in obese individuals [49, 50]. In an earlier study, we found that increased BMI was also associated with higher incidence of ACL injury associated with meniscus injuries [51].

In adults, increased BMI is often associated with knee osteoarthritis [27], which explains why obese people with elevated BMI have a lower level of postoperative activity after ACL revision. Ankle injuries are about 19 times more common among athletes with increased BMI and a previous ankle sprain, compared to athletes with a previous ankle sprain and with normal BMI [52]. Considering that after surgery most patients spend most of their time inactive, there may be an imbalance between energy intake and expenditure. Therefore, after some time, they gain weight and even though they are athletes, they have an increased BMI [27]. The postoperative quality of life is also affected by subsequent ACL injuries, because within 2 – 3 years after unilateral injury, about 3% of patients experience contralateral rupture [53, 54]. Also, ACL injuries may cause chronic knee instability, muscle weakness, and early onset of osteoarthritis [54, 55]. Professional sports and biomechanical joint stress are the main reasons for the pathogenesis and progression of knee osteoarthritis [56]. Losing 1 kg of body weight results with a 4-fold reduction in the load exerted on the knee per step during daily activities [56]. A loss of 5% of the total body weight in obese adults with knee osteoarthritis over 18 months results in an 18% improvement in the knee function and if combined with exercise, the mobility improves by 24% [56].

Some studies have concluded that increased BMI may also be a potential risk factor for revision surgery after primary ACL reconstruction [18, 30]. American rugby players also have a significantly increased risk for new injuries if they are overweight and had a former ACL injury [30]. In contrast, other authors believe that
there is still insufficient evidence that BMI is a significant risk factor for ACL rupture [38, 47, 57], since the mean BMI of patients with primary rupture is 27.6, and it is slightly higher among revision surgeries (27.8) [38]. Our study showed similar findings (24.65 in primary vs. 24.80 in revision). The above studies, like ours, found that factors such as gender, body weight, height, and BMI were not significant factors for re-injury and revision ACL reconstruction [38, 47, 57], and the causes should be sought in incorrect position of bone tunnels, new traumas, and premature return to sports activities [7, 9, 10, 58, 59].

The disadvantage of this study is the subjectivity of the respondents. The study raises dilemmas related to surgical treatment of obese patients (whether they should undergo surgery or lose weight first). There is no consensus on whether to define a marginal BMI for safe ACL reconstruction, which may be the basis for future research. Since we did not have extremely obese respondents in the sample, our study imposes a potential hypothesis of future studies: are excellent results of ACL reconstructions partly due to the fact that obese people get injuries less often because they do not play sports, or obese persons with injuries do not want surgery. Perhaps orthopedic surgeons adhere to strict selection of patients for reconstruction, so that being overweight would not lead to bad results.

A recent large-scale study [57] showed that fear of surgical procedures in obese patients is irrational; it compared the outcomes of primary ACL reconstructions between the normal weight and overweight patients (BMI > 25) and found that in obese patients the risk for arthritis was significantly higher, but the risk for revision surgery or contralateral ACL tear was lower [57]. There was no significant difference in complication rates and in the majority of Functional scores [57]. In addition, if we knew all the causes of injuries, we would know how to prevent them and treat them more successfully.

**Conclusion**

By determining the body mass index, it was established that the highest prevalence of patients undergoing anterior cruciate ligament reconstruction were normal weight patients (athletes). Men have a higher mean body mass index than women and older athletes have an increased mean body mass index. Individuals injured in traffic accidents and in daily activities have a higher mean body mass index than those injured in sports. Professional athletes have a body mass index within ideal limits, while recreational and non-athletes have elevated mean values. The association between the body mass index and the level of sports activity is significant. The body mass index is not a significant factor for re-injury and revision reconstruction. The anterior cruciate ligament reconstruction contributes to better quality of life since the majority of patients (91.0%) rated their general health as much better than before surgery, and 67.6% of patients with ideal body mass index thought that surgery did not affect their quality of life at all. Increased body mass index (> 25) is associated with lower quality of life after surgery.

**References**

1. Allen MM, Pareek A, Krych AJ, Hewett TE, Levy BA, Stuart MJ, et al. Are female soccer players at an increased risk of second anterior cruciate ligament injury compared with their athletic peers? Am J Sports Med. 2016;44(10):2492-8.

2. Falststrom A, Haglund M, Magnusson H, Forsblad M, Kvist J. Predictors for additional anterior cruciate ligament reconstruction: data from the Swedish national ACL register. Knee Surg Sports Traumatol Arthrosc. 2016;24(3):885-94.

3. Alentorn-Geli E, Myer GD, Silvers HJ, Samitier G, Romero D, Lázaro-Haro C, et al. Prevention of non-contact anterior cruciate ligament injuries in soccer players. Part 1: mechanisms of injury and underlying risk factors. Knee Surg Sports Traumatol Arthrosc. 2009;17(7):705-29.

4. Griffin LY, Albohm MJ, Arendt EA, Bahr R, Beynnon BD, Damera M, et al. Understanding and preventing noncontact anterior cruciate ligament injuries in soccer players. Part 1: mechanisms of injury and underlying risk factors. Knee Surg Sports Traumatol Arthrosc. 2009;17(7):705-29.

5. Ristić V, Ninković S, Harhaji V, Milankov M. Causes of anterior cruciate ligament injuries. Med Pregl. 2010;63(7-8):541-5.

6. Ristić V, Ristić S, Maljanović M, Dan V, Milankov V, Harhaji V. Risk factors for bilateral anterior cruciate ligament injuries. Med Pregl. 2015;68(5-6):192-7.

7. Ristić V, Šumar V, Milankov V, Harhaji V, Milović M. The effects of age and gender on the quality of life after anterior cruciate ligament reconstruction. Med Pregl. 2020;73(1-2):13-20.

8. Ninković S, Avramov S, Harhaji V, Obradović M, Vranješ M, Milankov M. Uticaj različitih nivoa sportske aktivnosti na kvalitet života posle rekonstrukcije predrnjeg ukrštenog ligamenta. Med Pregl. 2015;68(3-4):116-21.

9. Ninković S, Mišićić A, Savić D, Stanković M, Radić S, Milankov M. Correlation between radiological and clinical findings after anterior cruciate ligament reconstruction. Med Pregl. 2006;59(9-10):421-5.

10. Milankov M, Mišićić A, Savić D, Stanković M, Ninković S, Matijević R, et al. Revision anterior cruciate ligament reconstruction due to knee instability. Med Pregl. 2007;60(11-12):587-92.

11. Milankov MZ, Mišjković N, Ninković S. Femoral guide breakage during the anteromedial portal technique used for ACL reconstruction. Knee 2009;16(2):165-7.

12. Ristić V, Ninković S, Harhaji V, Stanković M, Savić D, Milankov M. Reconstruction of anterior cruciate ligament by using two different techniques. Med Pregl. 2010;63(11-12):845-50.

13. Ristić V, Ilić M, Bjelobrk M, Harhaji V, Milankov V. Cyclac syndrome - a complication after anterior cruciate ligament reconstruction. Med Pregl. 2019;72(1-2):17-24.

14. Ristić V, Vranješ M, Obradović M, Bjelobrk M, Harhaji V, Milankov M. Complications of anterior cruciate ligament reconstructions. Med Pregl. 2017;70(11-12):449-58.

15. Shelbourne KD. ACL rehabilitation [Internet]. [cited 2014 Aug 14]. Available from: http://www.fxsknee.com/learn-about-knee-pain/acl-rehabilitation/

16. Hewett TE, Myer GD, Ford KR. Anterior cruciate ligament injuries in female athletes: part 1, mechanisms and risk factors. Am J Sports Med. 2006;34(2):299-311.
17. Ristić V, Maljanović MC, Perićin B, Harhaji V, Milankov V. The relationship between posterior tibial slope and anterior cruciate ligament injury. Med Pregl. 2014;67(7-8):216-21.

18. Hettrich CM, Dunn WR, Reinke EK, Spindler KP. The rate of subsequent surgery and predictors after anterior cruciate ligament reconstruction: two and 6-year follow-up results from a multicenter cohort. Am J Sports Med. 2013;41(7):1354-40.

19. Rančić N, Nikolović M, Deljanin Z, Petrović B, Kocić B, Ilić M. Ispitivanje uticaja prekomerne telesne mase na kvalitetu života zdravstvenih radnika. Med Pregl. 2009;62(1-2):74-8.

20. Ristić V, Ristić S, Maljanović M, Milankov V, Harhaji V, Duričin A. Quality of life after bilateral anterior cruciate ligament reconstructions. Med Pregl. 2015;68(9-10):308-9.

21. Asocijacija za sportsku traumatologiju i arthroskopsku hirurgiju Srbije. Upitnik o vašem zdravlju [Internet] [cited 2018 Jun 15]. Available from: http://www.astas.rs/dokumenti/upitnik o kvalitetu života posle rekonstrukcije prednjeg ukrštenog ligamenta kolen. pdf

22. Myklebust G, Holm I, Maehlum S, Engebretsen L, Bahr R. Clinical, functional, and radiologic outcome in team handball players 6 to 11 years after anterior cruciate ligament injury: a follow-up study. Am J Sports Med. 2003;31(6):981-9.

23. Mannon S, Kartus J, Sernert N. Health-related quality of life after anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc. 2011;19(3):479-87.

24. Liederbach M, Dilgen FE, Rose DJ. Incidence of anterior cruciate ligament injuries among elite ballet and modern dancers. A 5-year prospective study. Am J Sports Med. 2008;36(9):1779-88.

25. Agel J, Arendt EA, Bershadsky B. Anterior cruciate ligament injury in National Collegiate Athletic Association basketball and soccer: a 13-year study. Am J Sports Med. 2005;33(4):524-30.

26. Prodromos CC, Han Y, Rogowski J, Joyce B, Shi K. A meta-analysis of the incidence of anterior cruciate ligament tears as a function of gender, sport, and a knee injury-reduction regimen. Arthroscopy. 2007;23(12):1320-5.e6.

27. Brophy R, Haas AK, Huston LJ, Nwosu SK, Wright RW; MARS Group. Association of meniscal status, lower extremity alignment, and body mass index with chondrosis at revision anterior cruciate ligament reconstruction. Am J Sports Med. 2015;43(7):1616-22.

28. Orihishimo KF, Kremeniec IJ. Effect of fatigue on single-leg hop landing biomechanics. J Appl Biomech. 2006;22(4):245-54.

29. Dick R, Hertel J, Agel J, Grossman J, Marshall SW. Descriptive epidemiology of collegiate men's basketball injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. J Athl Train. 2007;42(2):194-201.

30. Dodson CC, Scerist ES, Bhat SB, Woods DP, Deluca PF. Anterior cruciate ligament injuries in national football league athletes from 2010 to 2013. Orthop J Sports Med. 2016;4(3):232596716631949.

31. Urabe Y, Ochi M, Onari K, Ikuta Y. Anterior cruciate ligament injury in recreational alpine skiers: analysis of mechanisms and strategy for prevention. J Ortho Sci. 2002;7(1):1-5.

32. Renstrom P, Ljungqvist A, Arendt E, Beynnon B, Fukubayashi T, Garrett W, et al. Non-contact ACL injuries in female athletes: an International Olympic Committee current concepts statement. Br J Sports Med. 2008;42(6):394-412.

33. Takahashia S, Okuwa T. Epidemiological survey of anterior cruciate ligament injury in Japanese junior high school and high school athletes: cross-sectional study. Res Sports Med. 2017;25(3):266-76.

34. Longstaffe R, Leiter J, MacDonald P. Anterior cruciate ligament injuries in the National Hockey League: epidemiology and performance impact. Clin J Sport Med. 2020;30(3):224-30.

35. Dallalana RJ, Brooks JH, Kemp SP, Williams AM. The epidemiology of knee injuries in English professional rugby union. Am J Sports Med. 2007;35(5):818-30.

36. Republička stručna komisija za izradu i implementaciju vodiča u kliničkoj praksi. Nacionalni vodič za lekare u primarnoj zdravstvenoj zaštiti: gojaznost. Beograd: Centar za izdavačku, bibliotečku i informacionu delatnost, Medicinski fakultet Univerziteta u Beogradu; 2004. 22p.

37. Nešić M, Lolić E, Lolić V, Srdić V, Meholić-Šetohavić A. Body mass index as a factor in the choice of sports and recreational activities at university. Sportske nauke i zdravlje. 2018;11(1):37-46.

38. Pullen WM, Bryant B, Gaskill T, Sicignano N, Evans AM, DeMaio M. Predictors of revision surgery after anterior cruciate ligament reconstruction. Am J Sports Med. 2016;44(12):3140-5.

39. Hamilton LH, Hamilton WG, Warren MP, Keller K, Molnar M. Factors contributing to the attrition rate in elite ballet students. J Dance Med Sci. 1997;1(4):131-8.

40. Ulhorschak JM, Scoville CR, Williams GN, Arciero RA, Pierre P, Taylor DC. Risk factors associated with noncontact injury of the anterior cruciate ligament: a prospective four-year evaluation of 859 West Point cadets. Am J Sports Med. 2003;31(6):831-42.

41. Buchler Yund C. A longitudinal study of injury rates and risk factors in 5 to 12 year old soccer players [dissertation]. Cincinnati: University of Cincinnati; 1999. 16p.

42. Krosshaug T, Nakamae A, Boden BP, Engebretsen L, Smith G, Slaterbeck JR, et al. Mechanisms of anterior cruciate ligament injury in basketball: video analysis of 39 cases. Am J Sports Med. 2007;35(3):359-67.

43. Ingersoll CD, Grindstaff TL, Pietrosimone BG, Hart JM. Neuromuscular consequences of anterior cruciate ligament injury. Clin Sports Med. 2008;27(3):383-404.

44. Popadić-Gaćeša J, Barak O, Drapšin M, Klasića A, Srdić B, Karaba-Jaković D. Komparativna analiza antropometrijskih i sprijemirskih parametara kod sportistica. Praxis medica. 2008;36(3-4):57-61.

45. Karan V, Rakovac A, Karan M, Popović M, Klasića J, Lukač D. Procena telesnog sastava i mišićne snage kod različitih aktivnosti u promešanoj kliničkoj praksi. Nacionalni vodič za lekare u primarnoj zdravstvenoj zaštiti: gojaznost. Beograd: Centar za izdavačku, bibliotečku i informacionu delatnost, Medicinski fakultet Univerziteta u Beogradu; 2004. 22p.
52. Tyler TF, McHugh MP, Mirabella MR, Mullaney MJ, Nicholas SJ. Risk factors for noncontact ankle sprains in high school football players: the role of previous ankle sprains and body mass index. Am J Sports Med. 2006;34(3):471-5.

53. Heijne A, Hagströmer M, Werner S. A two and five year follow-up of clinical outcome after ACL reconstruction using BPTB or hamstring tendon grafts: a prospective intervention outcome study. Knee Surg Sports Traumatol Arthrosc. 2013;21(3):799-807.

54. Beynnon BD, Johnson RJ, Abate JA, Fleming BC, Nichols CE. Treatment of anterior cruciate ligament injuries, part I. Am J Sports Med. 2005;33(10):1579-602.

55. Silverwood V, Blagojevic-Bucknall M, Jinks C, Jordan JL, Protheroe J, Jordan KP. Current evidence on risk factors for knee osteoarthritis in older adults: a systematic review and meta-analysis. Osteoarthritis Cartilage. 2015;23(4):507-15.

56. Messier SP, Loeser RF, Miller GD, Morgan TM, Rejeski WJ, Sevick MA, et al. Exercise and dietary weight loss in overweight and obese older adults with knee osteoarthritis: the Arthritis, Diet, and Activity Promotion Trial. Arthritis Rheum. 2004;50(5):1501-10.

57. DiSilvestro KJ, Jauregui JJ, Glazier E, Cherkalin D, Bennett CH, Packer JD, et al. Outcomes of anterior cruciate ligament reconstruction in obese and overweight patients: a systematic review. Clin J Sport Med. 2019;29(4):257-61.

58. Ristić V, Ristić N, Harhaji V, Bjelobrk M, Milankov V. Radiographic analysis of tibial tunnel position after anterior cruciate ligament reconstruction. Med Pregl. 2018;71(1-2):15-20.

59. Milankov M, Obradović M, Vranješ M, Budinski Z. Bone-patellar tendon-bone graft preparation technique to increase cross-sectional area of the graft in anterior cruciate ligament reconstruction. Med Pregl. 2015;68(11-12):371-5.