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# REHABILITATION PROGRAM DURATION AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION: A COMPARATIVE STUDY BETWEEN PROFESSIONAL AND RECREATIONAL ATHLETES

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*Original research*

ABSTRACT

*Introduction*: Anterior cruciate ligament injury is an injury that occurs in both sexes and in the population of all ages. The anterior cruciate ligament (ACL) is a very strong internal ligament of the knee, whose injuries occur frequently in athletes (professional and recreational) and after which the recovery is very long and complicated. The aim of this study is to determine the effectiveness of a standardized rehabilitation program after anterior cruciate ligament reconstruction based on the time required for rehabilitation in athletes and recreational athletes.

*Methods*: Research is designed as prospective study. The research was conducted in Polyclinic FM Sarajevo over a period of 10 months, starting in June 2018 and ending in March 2019. The collection of data required for the study was carried out using a form prepared for the analysis of patients included in the study.

*Results*: Thirty-six people participated in the study, divided into two groups. In the first group, 52.8% belonged to recreational athletes, while in the second group, 47.2% belonged to athletes. At the end of the study, the flexion value in both studied groups was 120°. At the end of the study, the percentage of subjects with correct extension of the injured limb was 94.7% of recreational athletes and 64.7% of athletes. Of the total number of respondents included in this study, 33% were soccer players, 14% were basketball players, and 53% were recreational athletes.

*Conclusion:* Based on the research results, it was confirmed that early rehabilitation after the established rehabilitation treatment program is shorter in recreational athletes than in professional athletes.

**Keywords:** rehabilitation, anterior cruciate ligaments, athletes, recreational athletes

## INTRODUCTION

Current approaches to rehabilitation of anterior cruciate ligament (ACL) injuries emphasize the importance of immediate postinjury joint motion, early limb weight-bearing, immediate postinjury muscle strengthening exercises, closed kinetic chain exercises, early functional activity, and earlier return to sport (Ivančević., 2018). Anterior cruciate ligament injury is an injury that affects both sexes and populations of all ages. The anterior cruciate ligament (ACL) is a very strong internal ligament of the knee whose injurie are common in athletes (professional and recreational) and after

which recovery is very long and complicated (Slanac., 2017). Previous studies indicate that the risk of rupture of the anterior cruciate ligament is 1.4 to 9.5 times higher in women (Cimino et.al., 2010).

Anterior cruciate ligament injuries occur most frequently in athletes (basketball, handball, volleyball, and soccer). The reason for this is the complexity of the mentioned sports. They are acyclic sports with a complex structure, where the aggravating factor of the presence of opposing players is added to the multitude of different movements that the athlete must perform during the game (Jajić., 2008). In ACL injuries, mechanical instability of the joint occurs primarily (Saka., 2014). Neuromuscular reorganization in ACL injuries and reconstructions may be a predisposing factor for other clinical disorders such as muscle strength loss, atrophy, and altered function (Hasegawa et.al., 2011).

Tear of the anterior cruciate ligament of the knee affects the stability of the knee and causes numerous daily disturbances in sports or daily activities and leads to early degenerative changes in the knee. The treatment itself can be divided into conservative and surgical (Adams et.al., 2012).

The aim of surgery is anatomical reconstruction of the anterior cruciate ligament. In 90% of cases, surgical treatment succeeds in restoring the stability and kinematics of the knee (Ahldén et.al., 2009).

The preoperative rehabilitation phase is as important as the postoperative phase (Kotsifaki et.al., 2023). During the preoperative rehabilitation, it is necessary to assess the condition of the musculature and start strengthening the weakened muscle groups, which ensures a faster postoperative course. Contemporary acronyms encompass the rehabilitation continuum from immediate care (PEACE) to subsequent management (LOVE). PEACE and LOVE outline the importance of educating patients and addressing psychosocial factors to enhance recovery. While anti-inflammatories show benefits on pain and function, acronyms flag their potential harmful effects on optimal tissue repair (Dubois et.al., 2020).

Increasing muscle strength is especially important for athletes, allowing them to return to their athletic form more quickly. The postoperative period of rehabilitation includes the time after surgical reconstruction of the anterior cruciate ligament. The postoperative program aims to protect the anterior cruciate ligament and the patella, and to stretch the knee and achieve its full extension as early as possible. Postoperative rehabilitation lasts 3-5 months and begins the next day after surgery. According to the protocols prescribed by the Cincinnati Sports medicine and Orthopedic Rehabilitation Center for Anterior Cruciate Ligament, the postoperative rehabilitation course can be divided into weeks up to 12 weeks, and then the phases are followed for several months (Maletis et.al., 2015).

One of the most common complications after ACL reconstruction is loss of knee joint mobility, especially extension. This results in inadequate motor function during walking, weakness of the quadriceps muscles, and knee pain, leading to subsequent complications and limited performance of normal activities (Magnussen et.al., 2011).

The purpose of this research is to determine the effectiveness of a standardized rehabilitation program after anterior cruciate ligament reconstruction based on the duration of the rehabilitation program in professional and recreational athletes.

## METHODS

### *STUDY DESIGN AND PARTICIPANTS*

The study was designed as a prospective study. The study was conducted in Orthos Polyclinic (FM Polyclinic) Sarajevo over a period of 10 months from June 2018 to March 2019. The data required for the study were collected based on a form prepared for the analysis of patients included in the study. The criteria for inclusion in the study included subjects with rupture and reconstruction of the anterior cruciate ligament, regardless of sex, age, and etiology of the injury itself, who were treated with physiotherapy procedures from June 2018 to March 2019.

Thirty-six subjects who met the criteria for participation are included in the study. The respondents were divided into two groups: professional athletes and recreational athletes.

### *DATA GATHERING and VARIABLES*

The instrument used during the research is the Orthos Polyclinic Form (Polyclinic FM) for the analysis of the patients included in the studies. The first part is a general questionnaire consisting of 9 questions investigating sociodemographic characteristics, duration of sports participation, duration of training and presence of injuries. The second part consisted of a form to record anthropometric measurements of movements (flexion and extension) and circumference of the upper and lower legs. Validation of the question about sports participation was performed using Cronbach's alpha analysis ($\alpha = 0{,}8077$).

In both groups, range of motion was measured using a goniometer and body mass index (BMI) at the beginning, middle, and end of the rehabilitation process. Weight (kg) and height (cm) were measured, and body mass index (BMI) was calculated based on the following formula: weight/ $(\text{height}/100)^2$.

The research was approved by the Ethics Committee of the University of Sarajevo - Faculty of Health Studies, approval number 04-7-15/19 dated March 11, 2019. The research was conducted solely on a voluntary basis, and consent to participate in the research was obtained from each respondent. The identity of the

respondents was protected in accordance with ethical and data protection principles.

*STATISTICAL ANALYSIS*

The database was created using the Microsoft Office Excel 2013 program, and the data collected in the survey were entered into this program. After verifying the integrity of the data, statistical analysis was performed using the program IBM SPSS Statistics (v. 20.0 for Windows). The data are presented in the form of tables and graphs, using classical methods of descriptive statistics depending on the type of data and measurement scale. To describe the sample, we used appropriate methods of classical descriptive statistics depending on the type of data: arithmetic mean, standard deviation, median, interquartile range, absolute frequencies (N) and relative frequencies (%). Normality and distribution testing of continuous numerical variables was performed by inspection of histograms, quantile plots, and formal tests using the Kolmogorov-Smirnov test. Analysis of categorical variables was performed using the Pearson $\chi^2$ test or Fisher's exact probability test. Results are presented in contingency tables (numbers to three decimal places). The significance level was $p<0.05$.

If the distribution of the continuous variables is symmetric, the arithmetic mean and standard deviation are used to indicate the mean and the measures of dispersion, and parametric tests (ANOVA test, Dunnet test) are used to compare these variables. When the distribution of continuous variables is not symmetric, the median and interquartile range are used to show the mean and the measure of dispersion, and non-parametric tests (ANOVA-Bonforini test) are used to compare them. Results are presented in contingency tables (numbers with three decimal places). The significance level was $p<0.05$.

## RESULTS

The study included 36 respondents who met the criteria for participation in the study. Based on the criteria, respondents were divided into two groups. The first group included recreational athletes, a total of 19 (52.8%), and the second group included sportsmen, a total of 17 (47.2%) (Table 1).

Table 1. Presentation of the respondents according to the examined groups

| Examined groups | Number (N) | Percent (%) |
|---|---|---|
| Professional athletes | 17 | 47.2 |
| Recreational athletes | 19 | 52.8 |
| total | 36 | 100 |

The respondents from the group of recreational athletes had statistically significantly higher average body weight than the respondents from the group of athletes in all three measurements. At the first measurement, the average body weight of the recreational athletes was 78.36±11.64 kg and that of the athletes was 70.94±9.50 kg, F=4.327; p=0.045. In the second measurement, the average body weight of recreational athletes was 80.52±12.50 kg and that of athletes was 72.17±10.27 kg, F=4.721; p=0.037. In the third measurement, the average body weight of recreational athletes was 81±12.37 kg and that of athletes was 72.41±9.63 kg, F=5.304; p=0.028 (Table 2).

Table 2. Comparison of average values of body weight during all three measurements

| | Body weight | N | X | SD | SE | Min | Max |
|---|---|---|---|---|---|---|---|
| I MEASUREMENT | Recreational | 19 | 78.36 | 11.64 | 2.67 | 56.0 | 105.0 |
| | Professional | 17 | 70.94 | 9.50 | 2.30 | 55.0 | 95.00 |
| | | | | | | F=4.327; p=0.045 | |
| II MEASUREMENT | Recreational | 19 | 80.52 | 12.50 | 2.86 | 56.0 | 107.0 |
| | Professional | 17 | 72.17 | 10.27 | 2.49 | 55.0 | 100.0 |
| | | | | | | F=4.721; p=0.037 | |
| III MEASUREMENT | Recreational | 19 | 81.00 | 12.37 | 2.83 | 55.0 | 105.0 |
| | Professional | 17 | 72.41 | 9.63 | 2.33 | 56.0 | 97.00 |
| | | | | | | F=5.304; p=0.028 | |

Application of the ANOVA test to the degree of flexion of the injured/operated leg in all three measurements showed that the degree of flexion before surgery was not statistically significantly different between recreational athletes and athletes (p=0.0736).

After the second measurement, the flexion values were close to physiological values, but the degree of flexion of the operated leg was higher in subjects from the recreational group (p=0.001). At the end of the study, no statistically significant difference was found in the degree of flexion of the operated leg in the two studied groups, and the flexion was within the physiological values (p=1.000) (Table 3).

Table 3. Comparison of average flexion values during all three measurements

| Flexion of the injured/ operated leg | | N | X | SD | SEM | Min | Max |
|---|---|---|---|---|---|---|---|
| I MEASUREMENT | Recreational | 19 | 59.47º | 15.08 | 3.46 | 30.00 | 90.00 |
| | Professional | 17 | 61.17º | 14.95 | 3.62 | 40.00 | 90.00 |
| | | | | | | F=1.115; p=0.736 | |
| II MEASUREMENT | Recreational | 19 | 117.89º | 4.18 | .96 | 110.0 | 120.0 |
| | Professional | 17 | 111.76º | 5.28 | 1.28 | 100.0 | 120.0 |
| | | | | | | F=15.027; p=0.000 | |
| III MEASUREMENT | Recreational | 19 | 120.00º | .00 | .00 | 120.0 | 120.0 |
| | Professional | 17 | 120.00º | .00 | .00 | 120.0 | 120.0 |
| | | | | | | p=1.000 | |

At the beginning of the study, 5.3% of the recreational athletes and 41.2% of the athletes had a pathological deflection of -20° in the extension of the injured leg. Of the total number of recreational athletes, 42.1% had a pathological deviation of -10° in extension at baseline, whereas this percentage was 29.4% in the athlete group.

At baseline, a total of 36.8% of recreational athletes and 29.4% of athletes had a pathologic deviation of -5°. No athlete had corrected extensor findings of the injured leg at baseline, while this percentage was

15.8% in the recreational athlete group. After the second measurement, the percentage of respondents with correct extension of the injured limb was 89.5% of recreational athletes and 29.4% of sportsmen.

Of the total number of recreational athletes, 5.3% showed a pathological deviation of -10° in extension at the second measurement, while this percentage was 17.6% in the group of athletes. At the second measurement, a total of 5.3% of recreational athletes and 52.9% of athletes showed a pathological deviation of -5°. At the end of the study, the percentage of respondents with correct extension of the injured limb was 94.7% of recreational athletes and 64.7% of athletes (Table 4).

Table 4. The frequency of pathological extension of the injured limb during the research

| Extension of the operated /Injured leg | | | Groups | | Total |
|---|---|---|---|---|---|
| | | | Recreational | Professional | |
| I MEASUREMENT | - | Count | 1 | 7 | 8 |
| | 20,00 | % | 5.3% | 41.2% | 22.2% |
| | - | Number | 8 | 5 | 13 |
| | 10,00 | % | 42.1% | 29.4% | 36.1% |
| | -5,00 | Number | 7 | 5 | 12 |
| | | % | 36.8% | 29.4% | 33.3% |
| | ,00 | Number | 3 | 0 | 3 |
| | | % | 15.8% | 0.0% | 8.3% |
| | | | | | $x^2$=6.902; P=0.009 |
| II MEASUREMENT | - | Number | 1 | 3 | 4 |
| | 10,00 | % | 5.3% | 17.6% | 11.1% |
| | -5,00 | Number | 1 | 9 | 10 |
| | | % | 5.3% | 52.9% | 27.8% |
| | ,00 | Number | 17 | 5 | 22 |
| | | % | 89,5% | 29,4% | 61,1% |
| | | | | | $x^2$=9.695; p=0.002 |
| III MEASUREMENT | -5,00 | Number | 1 | 6 | 7 |
| | | % | 5,3% | 35,3% | 19,4% |
| | ,00 | Number | 18 | 11 | 29 |
| | | % | 94,7% | 64,7% | 80,6% |
| | | | | | $x^2$=5.022; p=0.030 |

Of the total number of respondents included in this study, 12 (33%) were soccer players and 5 (14%) were basketball players, while 19 (53%) of the respondents were recreational athletes (Table 5).

Table 5. Division of respondents in relation to subgroups

| Subgroup of the respondents | Number N | Percent (%) |
|---|---|---|
| Soccer players | 12 | 33 |
| Basketball players | 5 | 14 |
| Recreational athletes | 19 | 53 |
| Total | 36 | 100 |

# DISCUSSION

The study included 36 respondents who met the criteria for participation in the study. Based on the criteria, the respondents were divided into two groups. The first group included 19 (52.8%) recreational athletes and the second group included a total of 17 (47.2%) athletes.

In our work, subjects from the recreational athlete group had a statistically significant higher average body weight than subjects from the athletic group on all three measurements. At the first measurement, the average body weight of the recreational athletes was 78.36±11.64 kg and that of the athletes was 70.94±9.50 kg, F=4.327; p=0.045. At the second measurement, the average body weight of recreational athletes was 80.52±12.50 kg and that of athletes was 72.17±10.27 kg, F=4.721; p=0.037. At the third measurement, the average body weight of recreational athletes was 81±12.37 kg and that of athletes was 72.41±9.63 kg, F=5.304; p=0.028.

An interesting study was conducted by a team of orthopedic surgeons from a clinic in Bologna, who investigated the influence of body weight on the rupture of the cruciate ligament after a certain period of time. They reported that in 186 subjects from both test groups, after two years, up to 25 percent of ACL ruptures occurred in the under-25 group, which called into question the quality of diet and lifestyle of these groups, as well as the quality of work in sports clubs after their return to the playing field (Siebold et.al., 2014).

In the study by Shi et. Al., male skiers (17.13%) had a higher proportion of multiple knee ligament injuries than females (6.40%). Combined anterior cruciate ligament (ACL) and medial collateral ligament (MCL) injuries were the most common injuries in both females and males, with anterior cruciate ligament injury being more common in females (79.20%) than males (56.35%). The percentage of female skiers (17.6%) with a high activity level was significantly lower than the percentage of males (30.9%). Female skiers had lower height, body weight, and body mass index than male skiers ($P < 0.001$) (Shi et.al., 2020).

In research by Lee et. al., and associates examining obesity and muscle strength recovery after anterior cruciate ligament reconstruction in pediatric patients, the research group consisted of 330 patients, of whom 198 (60%) and 231 (70%) met criteria for quadriceps and hamstrings recovery at final examination (mean: 7.0±3.2 months). Hamstring recovery took significantly longer in the overweight group (mean: 5.7±2.2 months) than in the normal weight group (mean: 5.1±2.1 months; $p = 0.025$). Quadriceps muscle recovery was not significantly slower in the overweight group (mean: 6.5±2.6 months) than in the normal weight group (mean: 5.9±2.1 months; $p = 0.173$) (Lee et.al., 2018).

Kowalchuk et. al., found that obese patients (BMI greater than 30 kg/m$^2$) had a 0.4 times higher chance of success after reconstruction than subjects with normal BMI (Kowalchuk et.al., 2018).

The results of the study conducted by Logerstedt (2013) suggest that preoperative quadriceps strength predicts IKDC2000 (International Knee Documentation Committee 2000) scores 6 months after ACL reconstruction. This is further evidence that

preoperative quadriceps strength may influence knee function after surgery (Logerstedt et.al., 2013).
Emami Meybodi et.al., concluded that knee flexion strength decreases after surgery and that the magnitude of this decrease increases at higher knee flexion angles. Physiotherapy of the operated knee gradually improves the knee flexion strength and approaches the preoperative value. The value of knee flexion strength may be equal to the preoperative value one year after surgery at angles of 20 and 45˚. However, at angles of 90˚ and 110˚, the mean knee flexion force was still lower than the corresponding preoperative value one year after surgery. This difference was statistically significant ($p = 0.000$ at 90˚, $p = 0.000$ at 110˚) (Emami Meybodi et.al., 2013).
The results of the study by Maeda et. al., showed that 56% of patients returned to their preinjury activity level, while 71% had a difference in anterior laxity of 3 mm or less when the affected knee was compared to the contralateral uninjured knee. Quadriceps muscle strength was 90% compared with the contralateral healthy limb, and knee muscle strength was equivalent to that of the contralateral limb (Maeda et.al., 1996).

## CONCLUSION

Based on the research results, it was confirmed that early rehabilitation after the established rehabilitation treatment program is shorter in recreational athletes than in professional athletes.

### Conflict of Interest

The authors do not have any conflicts of interest to disclose. All co-authors have reviewed and concurred with the manuscript's content, and no financial interests need to be reported.

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