

EVALUATION OF REHABILITATION PARAMETERS AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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ABSTRACT

Introduction: The purpose of this study is to find out the ideal number of pre and post-operative physical therapy sessions, the importance of age, the training after the reeducation visits, the optimal time of evaluation after surgery, and the impact of the period between the time of injury and surgery on the post-operative functional outcomes of the knee.

Materials and Methods: We have selected 50 patients among 539 individuals who have had ACL reconstruction surgeries (from six months and more) using the Kenneth Jones technic (KJ), aged between 18 and 50 years, and have gone through the same reeducation protocol. They had to complete the IKDC score to evaluate and analyze the outcomes across the 6 variables cited above.

Results and Discussion: The student's t-test has validated the results for the age ($P < 0.05$). As a matter fact, the age above 35 years is not an obstacle any more to have good functional outcomes in the knee. The results of the surgery in relation with the period of time between the date of injury and the surgery may negatively or positively affect the outcomes. Therefore, the optimal period is at 1 to 1,5 months after the injury. The number of post-operative sessions ($(P = 0.75) > 0.05$) as well as the number of post-reeducation training days ($(P = 0.44) > 0.05$) did not show significant impact on the functional outcomes of the knee.

Conclusion: The results of the surgery in relation with the number of visits following the operation have indicated a minimum of 15 sessions (79.3%) and a maximum of 20 to 25 sessions. Finally, there has not been a relevant relation between the date of evaluation and the functional outcomes of the knee.

KEY WORDS: Anterior cruciate ligament, KJ, IKDC, DITI, Lemaire.

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INTRODUCTION

The ACL reconstruction is one of the most com-

mon surgeries in the athletic field. Indeed, there have been more than 125000 operations every

year [1] with an incidence of 81/100 000 people [2]. This stems from the fact that this surgery has become more reliable and efficient and the reeducation protocols are now more adapted [3].

In spite of this advancement in this area and the increasing number of surgeries, there are still some issues that researchers are trying to identify in order to optimize the quality of this operation and its outcomes [4].

Professionals are working on shortening the off-field period, identifying the needed number of therapeutic sessions, and establishing the most adapted post-operative reeducation protocol [5,6,2]. For all these reasons, it is crucial to assess the outcomes of the surgery as well as the post-operative reeducation.

Our study was based on the evaluation of individuals who have had ACL reconstruction after a specific period of rehabilitation, using a reliable and valid outcome measure chosen based upon a review [7].

This study is interesting because of its universal approach. Whilst many studies have addressed and evaluated some parameters individually, such as the strength of the quadriceps muscle following rehabilitation and the comparison of post-treatment muscle performance between two different types of surgeries, we have moved on to analyze multiple variables at the same time using a questionnaire score for outcome measure.

Also, this retrospective study was facilitated by the availability of a big population of athletic individuals who have had ACL repair surgeries. Those athletes were assessed and evaluated in identical conditions and factors (same surgeon, same type of surgery, and same rehabilitation protocol).

We have assessed the knees of 50 amateur male athletes who have had ACL reconstruction using the KJ technic, with or without meniscal surgery (meniscectomy or meniscal repair). The individuals were aged between 18 and 39 years and came for evaluation after 1 to 5 years from the date of the surgery, and they were selected randomly. Also, these patients have received the same treatment and all used the same outcome measure for this study.

Several scales are actually used to evaluate the knee and quality of life in athletic patients after an injury and a surgery in the knee. Those outcome measures are important for the clinical diagnosis and the research area [8]. Thus, for this study, we have selected the most reliable and valid score based upon Hamza et al. review [7] to find answers for the following questions: what is the ideal number of physical therapy post-operative sessions to treat patients with ACL injuries? Do the post-operative visits enhance the post-surgery outcomes? Is there any relation between the age of the patients and the success of the surgery? Does the period between the injury and the surgery have any effects on the evaluation of the operated knee? What is the impact of the number of training days? And between the date of the surgery and the date of evaluation?

There is a controversial debate in the literature concerning these questions, and we have come to several hypotheses in this domain: There is a possibility to determine the best number of visits needed for rehabilitation, the therapeutic pre-operative sessions improve the results of post-surgical rehabilitation, people who are older than 35 years don't have an increased risk of surgery's failure, the period between the injury and the surgery does affect the functional outcomes in the knee, a bigger number of training days after the rehabilitation has a positive impact on the knee, and the time between the date of the surgery and the date of the evaluation does not influence the outcomes of the assessment.

The methodology of assessment of physical therapy protocols: The population in this study had 539 patients who have had anterior cruciate ligament reconstruction. The inclusion criteria were the age (18-50 years), the ACL reconstruction surgery with JK technic associated or not with meniscal repair or meniscectomy, specific rehabilitation protocol and plan. However, the exclusion criteria encompassed the associated injuries and/or surgeries, more than one ACL reconstruction in the same knee, the combination of different types of ACL surgeries such as DIDT with Lemaire, other pathologies of the knee such as fractures and Bi-Cruciate, pathologies or diseases in the ankle

or hip, and non-operative ACL injuries.

In the last 20 years, there has been an increase in the number of outcome measures that are based on the perspectives of patients⁹. These scores that are in form of questionnaires are important for the clinical reasoning, yet they require certain validity and reliability [10]. Anyhow, we have previously done a literature review that pointed out the IKDC as the most reliable and valid score for assessment and evaluation. Therefore, the 50 Patients have completed this scale, which is a sample valid questionnaire that assesses the knee from a clinical, athletic, and functional perspective, and analyzes the patient's quality of life.

The pre-operative rehabilitation protocol was aimed at maintaining and sustaining the mobility and the muscular performance of the lower extremity (quadriceps, hamstrings, gluteus medius, hip adductors, gluteus maximus, and gastroc-soleus).

The post-operative rehabilitation protocol was planned for several weeks.

Week one's goals were a full range of extension motion in the knee, 90 degrees of flexion in the knee, isometric contraction of quadriceps, weight shifting exercises, and walking with two crutches.

Week two's goals were a full range of extension motion in the knee, 110 degrees of flexion in the knee, isometric and dynamic contraction of quadriceps and hamstrings, and walking with one crutch.

Week three's goals were knee flexion of 125 degrees, resistive bands exercise for quadriceps, hamstrings, and gluteus medius, walking without crutches, neuro-muscular reeducation, and bicycle.

After 6 weeks of surgery, we have included the single leg press and double leg press exercises on the shuttle. After 3 months, the patient would start running with progressive increasing speed and duration.

At 4 months of treatment, the patient is set up to a higher level with addition of compound movements, such as high steps, hops, rotations and pivoting. And, at 5 months the athlete starts training again with its team on the field to eventually go back to competition after 6 months of

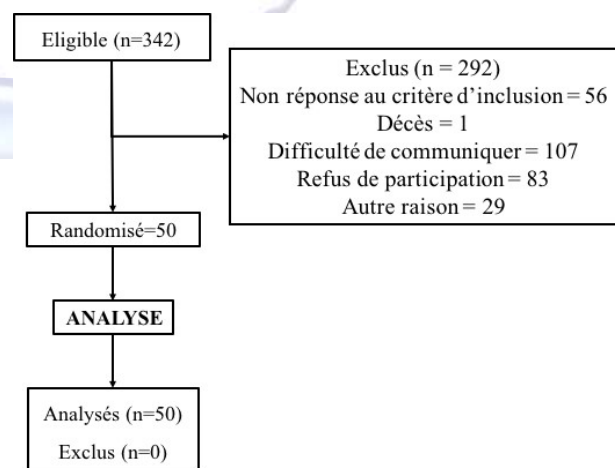
the date of surgery.

This protocol of treatment is adapted by Karaki H [12] and has been applied for several years in Hauteville-Iompnès in France at the public hospital center of Hauteville [11].

The variables studied in this study are the ideal number of visits which patients need after surgeries to reach optimal goals during rehabilitation, the benefits of pre-operative therapeutic sessions and their potential number, the relation between the age and the efficacy of ACL reconstruction, the effects of the period between the time of the injury of the anterior cruciate ligament and the time of the reconstructive surgery on the functional and general state of the knee, the timing of the evaluation after the surgery, and the practice of sport after 6 months.

Seeking to answer all these question, we considered our population of total of 539 patients who have had their surgeries done between 2005 and 2015, and went ahead and narrowed our selection to the individuals who were operated between 2010 and 2015. Therefore, it came down to 342 patients.

Fig. 1: Showing the consort diagram.



RESULTS AND DISCUSSIONS

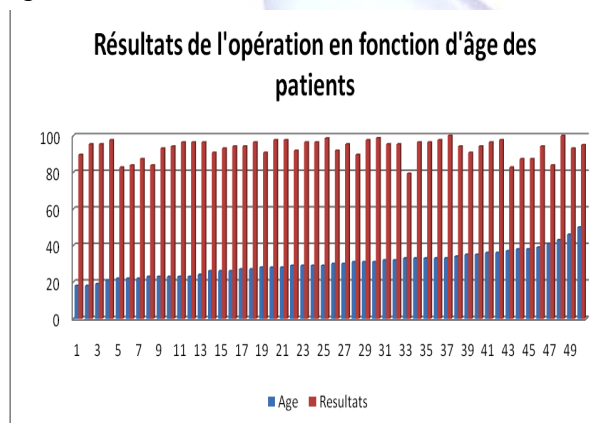
As we had mentioned above, we had planned to discuss the relation between six different variables and functional outcomes of 50 patients chosen randomly out of a population of 342 patients who have had their ACLs repaired.

Our analyses showed that three of those variables were statistically proven to have significant influences on the outcomes measured

via the IKDC score. Therefore, we will explore those variables and develop the results and compare them to other researchers' results.

Age and functional outcomes: The age and life expectancy are always increasing over time, which elevates the level of physical activities resulting in a higher risk and frequency of ACL injuries within this population of 40 years and older [13]. Therefore, authors have considered the act of operating on patients of 40 years old and older as a high risk practice [14], because of the aging anatomical state of the knee. Also, the possibility of restoring a good strength of the quadriceps muscle in those elder patients is almost an illusion and so difficult, giving that it is hard to maintain a strong muscle performance in young individuals under 35 years. Besides, elder patients are more likely to have complications such as arthrosis, infection, slow integumentary healing, and thromboembolic disorders [13]. On contrary, our results show that age does not negatively influence the results of the ACL surgery. And, this fact is confirmed in the following graph, the regression model, and the student's t-test.

Fig. 2: The results of the surgery in relation with patient's ages.



This graph demonstrates that for patients of 36 years old, 43 years old, 48 years old, and 50 year old which are all older than 35 years, the results of the surgery were respectively 96.5%, 97.7%, 100%, and 95% indicating good outcomes. On the other side, low results were registered for patients at age of 37 years old, 22 years old, and 33 years old with 82.7%, and 79.3% respectively. Therefore, we can't rule that it is contraindicated to operate on patients older than 35 years. One regression model analysis confirms these data.

Table 1: The results from Fisher's test for age.

F Value	Pr > F	R-Square
782.57	<.0001	0.9702

We have a p-value= [pr>F] <.0001< 0.005, and the linear model exists for a CI=95%. The R-Square = 0.9702 meaning that at 97.02% the results of the surgery are explained in this model.

So, the question about the influence of the age on the outcomes of the operation is answered by the final multiple regression model according to the variables coefficients and represented in this equation: Results=1.82 Age+1.78 Numb of post-operative sessions.

Table 2: The results of the student's t-test for age.

Variable	Coefficients	t Value	Pr > t
Age	1.82173	9.24	<.0001
Number of Post-Operative Sessions	1.78262	6.16	<.0001

This analysis model links the data of age and number of post-operative sessions and demonstrates a p-value=pr>|t| » < 0.05. So, the age and number of post-operative sessions are significant and have an influence on the outcomes of the surgery. These results are in match with previous research. Indeed, the ACL reconstruction surgery is becoming more frequent in active patients older than 40 years, and age does not represent a principle criterion anymore in decision making process related to deficient ACL treatment in aging population [13]. Brown et al. have highlighted in a systemic review that patients aged 40 years and older show satisfying results after an ACL surgery [15]. In fact, one comparison by Albet et al. between a group of individuals of 40 years old and up and a group of young individuals aged 25 years and younger after rehabilitation following an ACL reconstruction has found that the only difference is the presence of a chondral lesion in the elder patients. Yet, Lysholm scores were distinctively close [16]. In fact, we have taken into consideration that this lesion is very often with accidents and trauma. Therefore, our findings are in accordance with previous results, and having similar results among different groups of ages support the current findings.

Injury-Surgery period and functional results:

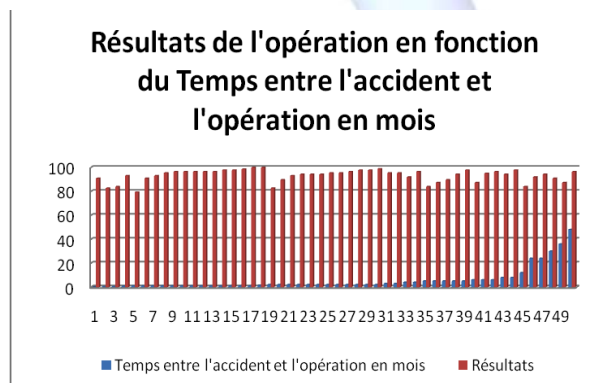
The period between the date of injury and the

date of surgery is still controversial in the literature [17]. In fact, Frobell et al define early surgery as a delayed operation (done after 10 weeks of injury) [18]. Other authors have not yet determined the numbers for the delayed surgery. But, they have considered in their studies that between 5.5 and 19 months, the results become convenient [19]. Bottoni et al. have concluded that the best clinical outcomes could be reached after an immediate surgery of an injured ACL using the autograft hamstrings [17]. Yet, there is no difference regarding the mobility. Hence, the findings of one systematic review by Smith represent that there is no clinical post-operative difference between early (less than 3 weeks) and delayed (more than 6 weeks) reconstitution of ACL [20].

Mary et al. have found a relation between the surgery during the first month after injury and the post-operative arthrofibrosis. Similarly, they have established a relation between the surgery after 4 weeks of the lesion of an irritated knee and the post-operative arthrofibrosis. Thus, findings in this study confirm that the state of the knee prior to the surgery is a relevant factor for the period of time between the injury and surgery [21].

Correspondingly, concerning the following question: if the accident or trauma occurs on X day, is it ideal to have surgery as soon as possible or to wait?

Fig. 3: The results of the surgery in relation to the time between injury and surgery in a month.



The graph above shows the variation of the surgery's outcomes in relation with the time between the accident and the operation. We can see that at 0.25 and 0.5 months, the results of the surgery were 90.8%, 82.7%, and 83.9% respectively. Then, the results start increasing after 0.75 months and keep rising to reach 100%

after 1 and 1.5 months and maintain a good level through the second and third month. However, we have noticed that from the 4th month the results start declining and specially at the 5th, 6th, 12th and 36th months to register values of 83.9% and 87.3%. therefore, we can mark that a patient should not undergo the surgery right after the injury. The ideal setting is to wait 0.75 month, or 1 month, or 1.5 month as the results of the surgery are excellent during this period. Nevertheless, a patient should not wait too long either and go past the 4 months. In fact, these findings are totally reasonable and logic, because with an ACL accident and injury, the inflammatory process is remarkable and the edema, intra-articular bleeding, muscular spasms, and articular blockage are often important. Thus, a patient should wait for these signs and symptoms to clear away. Nonetheless, the patient can't hold off the surgery for a long time, as the muscular, articular, and proprioceptive deficits and weakness may take place quickly.

Pre and Post-Operative sessions in relation to functional outcomes: One systemic review on the effects of pre-operative rehabilitation in individuals with anterior cruciate ligament rupture has shown a changing and improvement for the intervention group vs the control group regarding the muscular strength, function, and quality of life after treatment [22]. Kim et al have noted that a pre-operative muscular deficit that is more than 20% in the quadriceps may result in a persistent muscular deficit for 2 years [23]. On the other side, according to Eitzen et al. the indicator of pre-operative muscle strengthening of the quadriceps is significant for the knee function 2 years post-surgery [24]. However, although the listed studies and many other recent research have focused on importance of pre-operative sessions in relation to post-surgical outcome in short and long term [23,25,26], we did not find any relevant correlation between those two variables in our analysis. So, the answer for the question about the influence of pre-operative visits on the post-surgical results is negative.

In fact, the $p\text{-value}=0.75>0.05$ indicates a non-significant difference between the two groups, which means there is no benefit for those who do pre-operative over the people who don't

regarding the results of the surgery.

Table 3: The results of student’s t-test for the pre-operative session.

Indicator	Groups	Test T	p-value
Results of the operation	Does the pre-operative sessions	0.58	0.75
	Don't do the pre-operative sessions		

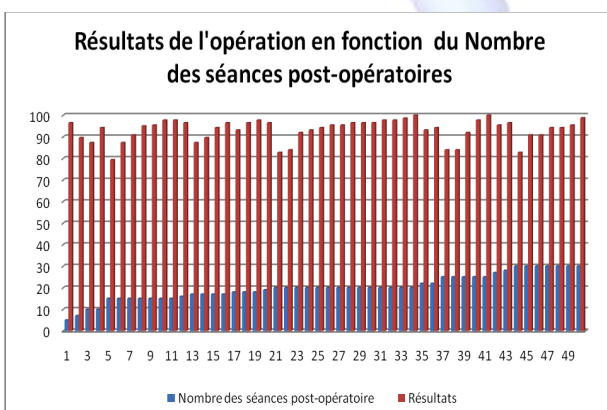
Concerning the ideal number of visits needed after the surgery, multiple studies have determined the necessary number of sessions for rehabilitation after anterior cruciate ligament reconstruction operation. Derscheid et al. have mentioned an average of 39 physical therapy visits needed, while Treacy et al. have reported a number of 60 sessions²⁷.

Another study has marked that the patient needs 15 physical therapy visits during the first 6 weeks post-surgery [28]. Also, many studies pointed out the importance of the physical therapists’ supervision and follow up on the home exercise programs rather than decreasing the number of total visits.

Correspondingly, De Carlo et al. have concluded that the patients who have had an early rehabilitation that includes full range of knee extension, support, and functional training, don’t need a big number of physical therapy visits. Rather, they only need a supervision with their rehabilitation program and muscular strengthening [29].

In our opinion, an initial analysis demonstrates that the optimal number of post-surgical physical therapy visits would be somewhere between 20 and 25 visits.

Fig. 4: The results of the surgery in relation to the number of post-operative sessions.



This graph shows that the lowest surgical result is 79.3% for 15 visits, while the highest result is 100% when the number of visits is 20

and 25. Therefore, the ideal number of post- surgical visits is 20-25 sessions due to the high quality results that are very close from normality 100%.

The regression model confirms those findings and correlates the age data to the number of post-operative sessions. The $p\text{-value} = p > |t| < 0.05$ indicates that the age and the number of post-operative visits together are significant and have an influence on the surgical outcomes. This correlation can be presented in this equation: $\text{Results} = 1.82 \text{ Age} + 1.78 \text{ Number of post-operative session}$.

Table 4: The results of student’s t-test for the number of post-operative sessions.

Variable	Coefficients	t Value	Pr > t
Age	1.82173	9.24	<.0001
Number of post-operative sessions	1.78262	6.16	<.0001

Nevertheless, we think that limiting the number of visits will contribute to an increase in the number of training days as a compensation, which will maintain the same functional outcomes. Therefore, this is not a recommended practice for professional therapists. In fact, the number of training days after treatment discharge has no impact on the outcomes of the surgery, giving that $p\text{-value} = 0.44 > 0.05$ solely and even coupled with the number of post-operative visits. Therefore, it is recommended to increase the number of post-operative therapeutic sessions and cut down on the number of training days after the rehabilitation, because only the number of post-operative influences the results of the surgery.

Date of the evaluation and functional results:

In reality, the date of the evaluation represents the number of months between the date of the surgery and the time of the evaluation. We were seeking to know if the post-operative period is an important element for the functional outcomes in the knee. We have hypothesized that the more the period extends the better are the results patients would get after surgery. However, this didn’t turn to be so true as the analysis showed that there is no significant relation between the post-operative duration and the functional outcomes in the knee.

CONCLUSION

Finally, this study has relied on the IKDC scale to evaluate and assess 50 operated knees for anterior cruciate ligament reconstruction to answer some debatable questions concerning the optimal number of post-operative sessions, the efficiency of therapeutic pre-operative visits, the relation between the age of the patients and the success of the operation, the importance of training after physical therapy sessions, and the delay between the injury and the surgery.

Our results prove that the age is not related to the success or failure of the operation whatsoever, and that the ideal timing for undergoing the surgery should take into account the progress of the inflammatory reactions occurring right following the injury and the post-operative complications that could debut after 4 months.

This study suggests that the ideal number of physical therapy visits after the surgery varies between 20 and 25 sessions. Nevertheless, the number of training days after the rehabilitation as well as the date of the evaluation (after 6 months of the operation) have no impact or effects on the functional outcomes of the knee.

The same, the functional outcomes in the knee are not influenced by the pre-operative sessions as those visits can only improve and enhance the articular and muscular components of the knee before and after the surgery.

At the end, despite that the findings established by this methodology help improving the quality of the rehabilitation and clinical practice, more research and experimental protocols are needed in this area to confirm and support these results.

Conflicts of interest: None

REFERENCES

- [1]. Logerstedt D, Stasi SD, Grindem H, Lynch A, Eitzen I, Engebretsen L, et al. Self-reported Knee Function Can Identify Athletes Who Fail Return to Activity Criteria up to 1 Year after Anterior Cruciate Ligament Reconstruction. A Delaware-Oslo ACL Cohort Study. *J Orthop Sports Phys Ther.* 2014 Dec;44(12):914–23.
- [2]. Christensen JC, Goldfine LR, Barker T, Collingridge DS. What can the first 2 months tell us about outcomes after anterior cruciate ligament reconstruction? *J Athl Train.* 2015 May;50(5):508–15.
- [3]. Heijne A, Werner S. A 2-year follow-up of rehabilitation after ACL reconstruction using patellar tendon or hamstring tendon grafts: a prospective randomised outcome study. *Knee Surg Sports Traumatol Arthrosc Off J ESSKA.* 2010 Jun;18(6):805–13.
- [4]. Spindler KP, Huston LJ, Wright RW, Kaeding CC, Marx RG, Amendola A, et al. The Prognosis and Predictors of Sports Function and Activity at Minimum Six Years after ACLR: A Population Cohort Study. *Am J Sports Med.* 2011 Feb;39(2):348–59.
- [5]. Hsiao S-F, Chou P-H, Hsu H-C, Lue Y-J. Changes of muscle mechanics associated with anterior cruciate ligament deficiency and reconstruction. *J Strength Cond Res.* 2014 Feb;28(2):390–400.
- [6]. Ardern CL, Webster KE, Taylor NF, Feller JA. Return to sport following anterior cruciate ligament reconstruction surgery: a systematic review and meta-analysis of the state of play. *Br J Sports Med.* 2011 Jun;45(7):596–606.
- [7]. Atwi H, Mansour A, Hassan KH, Karaki H. which outcome measures to use to evaluate the results of anterior cruciate ligament reconstruction surgery. *WJPPS.* 2017 Feb;6(3): 1090-1112.
- [8]. COLLINS NJ, MISRA D, FELSON DT, CROSSLEY KM, ROOS EM. Measures of Knee Function. *Arthritis Care Res.* 2011 Nov;63(0 11):S208–28.
- [9]. Wang D, Jones MH, Khair MM, Miniaci A. Patient-reported outcome measures for the knee. *J Knee Surg.* 2010 Sep;23(3):137–51.
- [10]. Higgins LD, Taylor MK, Park D, Ghodadra N, Marchant M, Pietrobon R, et al. Reliability and validity of the International Knee Documentation Committee (IKDC) Subjective Knee Form. *Jt Bone Spine Rev Rhum.* 2007 Dec;74(6):594–9.
- [11]. Quelard B. et Rachet O. Rééducation et réadaptation au sport après greffe du ligament croisé antérieur chez le rugbyman, in *Pathologie du rugbyman, Sauramps médical 2004, Lyon, pp. 225-241.*
- [12]. Karaki H. Le renforcement musculaire après réparation du ligament croisé antérieur - Principes et modalités, *Pertinence, N 1, pp. 117-127, Éditions de l'université Antonine, 2009, Beyrouth.*
- [13]. Legnani C, Terzaghi C, Borgo E, Ventura A. Management of anterior cruciate ligament rupture in patients aged 40 years and older. *J Orthop Traumatol Off J Ital Soc Orthop Traumatol.* 2011 Dec;12(4):177–84.
- [14]. Buss DD, Min R, Skyhar M, Galinat B, Warren RF, Wickiewicz TL. Nonoperative treatment of acute anterior cruciate ligament injuries in a selected group of patients. *Am J Sports Med.* 1995 Mar-Apr;23(2):160-5.
- [15]. Brown CA, McAdams TR, Harris AHS, Maffulli N, Safran MR. ACL Reconstruction in Patients Aged 40 Years and Older A Systematic Review and Introduction of a New Methodology Score for ACL Studies. *Am J Sports Med.* 2013 Apr 2;0363546513481947.
- [16]. Gee AO, Kinsella SD, Lee G-C, Sennett B, Tjoumakaris FP. ACL Reconstruction in Patients Over 40 Years of Age: A Case Control Study (SS-60). *Arthroscopy.* 2011 May 1;27(5):e62.

- [17]. Bottoni CR, Liddell TR, Trainor TJ, Freccero DM, Lindell KK. Postoperative range of motion following anterior cruciate ligament reconstruction using autograft hamstrings: a prospective, randomized clinical trial of early versus delayed reconstructions. *Am J Sports Med.* 2008 Apr;36(4):656–62.
- [18]. Frobell RB, Roos EM, Roos HP, Ranstam J, Lohmander LS. A randomized trial of treatment for acute anterior cruciate ligament tears. *N Engl J Med.* 2010 Jul 22;363(4):331–
- [19]. Evans S, Shaginaw J, Bartolozzi A. ACL RECONSTRUCTION IT'S ALL ABOUT TIMING. *Int J Sports Phys Ther.* 2014 Apr;9(2):268–73.
- [20]. Smith TO, Davies L, Hing CB. Early versus delayed surgery for anterior cruciate ligament reconstruction: a systematic review and meta-analysis. *Knee Surg Sports Traumatol Arthrosc Off J ESSKA.* 2010 Mar;18(3):304–11.
- [21]. Mayr HO, Weig TG, Plitz W. Arthrofibrosis following ACL reconstruction—reasons and outcome. *Arch Orthop Trauma Surg.* 2004 Oct;124(8):518–22.
- [22]. Alshewaiir S, Yeowell G, Fatoye F. The effectiveness of pre-operative exercise physiotherapy rehabilitation on the outcomes of treatment following anterior cruciate ligament injury: A systematic review. *Clin Rehabil.* 2016 Feb 15;
- [23]. Kim DK, Hwang JH, Park WH. Effects of 4 weeks pre-operative exercise on knee extensor strength after anterior cruciate ligament reconstruction. *J Phys Ther Sci.* 2015 Sep;27(9):2693–6.
- [24]. Eitzen I, Holm I, Risberg MA. Preoperative quadriceps strength is a significant predictor of knee function two years after anterior cruciate ligament reconstruction. *Br J Sports Med.* 2009 May; 43(5):371–6.
- [25]. Eitzen I, Moksnes H, Snyder-Mackler L, Risberg MA. A progressive 5-week exercise therapy program leads to significant improvement in knee function early after anterior cruciate ligament injury. *J Orthop Sports Phys Ther.* 2010 Nov;40(11):705–21.
- [26]. Keays SL, Bullock-Saxton JE, Newcombe P, Bullock MI. The effectiveness of a pre-operative home-based physiotherapy programme for chronic anterior cruciate ligament deficiency. *Physiother Res Int J Res Clin Phys Ther.* 2006 Dec;11(4):204–18.
- [27]. Feller JA, Webster KE, Taylor NF, Payne R, Pizzari T. Effect of physiotherapy attendance on outcome after anterior cruciate ligament reconstruction: a pilot study. *Br J Sports Med.* 2004 Feb 1;38(1):74–7.
- [28]. Darain H, Alkitani A, Yates C, Bailey A, Roberts S, Coutts F, et al. Antecedent anterior cruciate ligament reconstruction surgery and optimal duration of supervised physiotherapy. *J Back Musculoskeletal Rehabil.* 2015;28(4):877–82.
- [29]. De Carlo MS, Sell KE. The effects of the number and frequency of physical therapy treatments on selected outcomes of treatment in patients with anterior cruciate ligament reconstruction. *J Orthop Sports Phys Ther.* 1997 Dec;26(6):332–9.

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