Comparative Study between Duration of Injury and Muscle Response to Rehabilitation of Patients Undergoing Anterior Cruciate Ligament Surgery

Mona H. Ahmed[1], Zienab A. Mohamad[2], Hatem G. Said[3], Sahar A. Abd-El mohsen[4]

1. Head Nurse in Assiut university student′s hospital
2. Professor of Medical Surgical Nursing , Faculty of Nursing, Assiut University
3. Professor of orthopedic Surgery ,Faculty of Medicine, Assiut University
4. Lecturer of medical-surgical Nursing ,Faculty of Nursing, Assiut University.
Corresponding Author: Mona H. Ahmed

Abstract
Aim; *to compare between duration of anterior cruciate ligament injury and quadriceps muscle response to rehabilitation regarding size and strength for patients undergoing anterior cruciate ligament surgery.* ***Patients and methods;*** *Non-equivalent control group design was utilized to conduct this study, The study sample,60 adult patients with an anterior cruciate ligament injury, patients were divided into two equal groups (30 patients for each), group one their injury less than 3 months and group two their duration of injury more than 3 months.*
Tools; *four tools were utilized in this study; anterior cruciate ligament injured patient assessment sheet, the Short Form health survey (SF-12) scale sheet, the Modified Cincinnati Rating System Questionnaire scale sheet and exercise program.*
Results; *The mean age were (24.7), regarding measurement of the affected knee quadriceps muscle strength there was a highly statistically significant difference between patients in both group during all periods of follow up with P. (0.001**), but there were no statistically significant difference among both groups in the follow up except at 12 months with P. (0.04*), all the studied samples in both groups were having less disability in all periods of follow-up, regarding total score on the Modified Cincinnati Rating System Questionnaire there was no statistically significant difference between both groups but there were improvement among both groups in the follow up at 12 months.*
Conclusion; *An improvement was observed at 3 and 6 months follow up of patients with an anterior cruciate ligament injury of less than 3 months than those patients whose injury more than 3 months*.
Recommendation; *Providing patients with instructions for seeking medical advice for their sports injuries of great importance for early diagnosis and management of their injuries.*
Keywords: *Anterior cruciate ligament injury, muscle response rehabilitation*

I.   Introduction

The anterior cruciate ligament (ACL) is one of a pair of cruciate ligaments (the other being the posterior cruciate ligament) in the human knee. The two ligaments are also called cruciform ligaments, as they are settled in a crossed formation. In the quadruped stifle joint (parallel to the knee), based on its anatomical location, it is also raised to as the cranial cruciate ligament. The anterior cruciate ligament is one of the four focal ligaments of the knee, providing 85% of the restraining strength to anterior tibial displacement at 30 degrees and 90 degrees of knee flexion **(Ellison and Berg, 2012).**

Recovery time ranges between one and two years or longer, a week or so after the occurrence of the injury, the sportsperson is usually deceived by the fact that he/she is walking normally and not feeling much pain. This is dangerous as some athletes start restarting some of their activities, with an incorrect move or twist, could damage the bones. It is important for the injured athlete to know the importance of each step of an ACL injury to avoid complications and confirm a suitable recovery **(Kyung et al., 2010).**

Initial rehabilitation consists of range of motion exercises, often with the guidance of a physical therapist. Range of motion exercises are used to recover the flexibility of the ligament, avoid scar tissue from forming and decrease loss of muscle tone. In some cases, a continuous passive motion (CPM) device is used directly after surgery to help with flexibility. The favorite method of preventing muscle loss is isometric

---

exercises that put zero tension on the knee. Knee extension within two weeks is important with many rehab advices **(Sven et al., 2011)**.

The main goals of rehabilitation of the ACL-injured knee are to; improvement good functional stability, repair muscle weakness, reach the best possible functional level, and decline the risk for re-injury **(Savio et al., 2011)**.

Nurses play a dynamic role in the rehabilitation for patients who had ACL reconstruction surgery. Rehabilitation will include the use of crutches and, definitely, a knee brace range-of-motion exercises to recover full knee motion, muscle-strengthening and stability exercises. The nurse gives teaching about weight bearing limit, exercise restraints. Nurses' Initial goals are to decrease pain and swelling in knee, regain normal joint movement and make stronger the muscles round the knee and assess for signs of complications **(Sharonl, et al. 2007)**.

Significance of the study

A delay in the timing of surgery and rehabilitation of > 3 months compared with performing the surgery and rehabilitation ≤ 3 months after the anterior cruciate ligament (ACL) injury leads to an increased risk of injuries or degenerative changes in the ACL-deficient knee. According to Assiut University hospital records 350 patients underwent ACL surgery in 2017.

Aim of the study:

To compare between duration of anterior cruciate ligament injury and quadriceps muscle response to rehabilitation regarding size and strength for patients undergoing anterior cruciate ligament surgery.

Hypothesis:

Improvement in muscle response of patients whose ACL injury less than 3 months will be better than those patients whose ACL injury more than 3 months.

II. Patients and Methods:

Research design; Non-equivalent control group design was utilized in this study.

Setting; this study was conducted in the department of orthopedic surgery and out-patient arthroscopy clinic at Assiut University hospital.

Patients; A sample of 60 adult patients with an ACL injury were included in the study, both gender, having an ACL injury; their age ranges from 18 to 50 years, patients were assessed from time of admission in the department (pre operatively) and 3 months, 6 months and 12 months (post operatively) follow up in the out-patient arthroscopy clinic, patients were divided into two equal groups (30 patients for each), group one their injury less than 3 months and group two their duration of injury more than 3 months.

Exclusion Criteria:
1. Patients with radiographic evidence of osteoarthritis (grade 3 or 4 osteoarthritis according to the Kellegren and Lawrence system) or inflammatory arthritis at the time of injury or first-time clinical evaluation.
2. Patients who sustained intra-cerebral/spinal cord injury at the time of initial presentation.

Sample size calculation:

G power program 3.1.3 was used to calculate sample size in order to detect a-significant difference in mean of (S.F. 12) between two groups under the study hypothized; effect size 0.7, power 80%, ∞ error 0.05, allocation ratio 1:1 and 26 patients were included in each group with total sample size 52 patients.
- Sample size was increased 4 patients in each group.
- 80 patients were included in this study, 20 dropouts because some patients were not living in Assiut city and it was difsficult for them to come and some of them were not cooperative with the study, the final sample size was estimated on 60 patients.

Tools; four tools were used in this study and were developed by the researcher to collect the necessary data for this study.

Tool I: Anterior cruciate ligament injured patient assessment sheet; this tool was developed to collect the following data; it was divided into three parts:

Part 1: Demographic patient characteristics:
This part was developed to assess patient's characteristics as name, age, gender, level of education, occupation, time of ACL injury, and surgery day.

Part 2: Measurement of mid-thigh circumference:
This part was developed for measurement of the patient's mid-thigh circumference which was taken with a tape measure 10 cm above the superior pole of the patella, with the patient in a standing position and both feet flat on the floor.

Part 3: Measurement of quadriceps muscle strength:
This part was developed for measurement of the patient's quadriceps muscle strength. This was done by using the digital strength measuring device (Beurer Gmbh), while the patient is sitting and a belt is attached for measurement of isometric knee extension strength, a sensor pad is attached to the front of the distal lower extremity by rope 35cm in the other side of the machine with a hard object, the patient is asked to push frontally as he can, the power of pushing was translated by number.

Beurer Gmbh

Tool II: Quality of life assessment using the Short Form health survey (SF-12) scale sheet (Ware and John 1995):
This tool was developed to measure physical and mental health status in relation to eight health concepts and consists of 12 questions regarding physical functioning, role limitations due to physical health, bodily pain, general health perceptions, vitality (energy/fatigue), social functioning, role limitations due to emotional health, general mental health (psychological distress/wellbeing).

Scoring system:
The SF-12 has eight scaled scores; the scores are weighted sums of the questions in each section. Scores range from 0 – 100, lower scores = more disability, higher scores = less disability

Tool III: Assessment of patient's physical status using the Modified Cincinnati Rating System Questionnaire scale (Barber, et al., 2003):
This tool was developed to give information about how patient's knee pain had affected his/her ability to manage in everyday life, this includes 8 sections: pain intensity, swelling, giving way, overall activity level, walking, stair climbing, running activity, jumping or twisting.

Scoring system:
Functional assessment score = SUM (points for all 8 activities) : <30 poor; 30-54 fair; 55-79 good; >80 excellent.

Tool IV: Exercise program for patients with an ACL injury.
This tool was developed to teach the patients the rehabilitation exercises which were given in a simple Arabic booklet to the patients and then those patients were followed up to assess the effect of the recovery on their condition comparatively with their injury duration, and to see which group would have a good quadriceps muscle response, it consists of 5 phases: week 1-2 after the operation, week 2-6 after the operation, weeks 6-12 after the operation, preparation for return to sport 3-6 months, and return to sport at 6-9 months.

Methods
1) Content validity was established by panel of 5 expertises from medical and surgical nursing staff who reviewed the tools for clarity, relevance, comprehensiveness, understanding, applicability and easiness, minor modifications were required.

2) Content reliability was estimated by Alpha Cronbach's test and its result was R=0.68.
3) A pilot study was carried out in December 2016 to test the feasibility and practicability of the study tools on 10% of the sample. It also provided an estimate of time needed to fill out the tools.
4) Data were collected from orthopedic surgery and out-patient arthroscopy clinic at Assiut University hospital during the period from December /2016 to April /2018. The tools were filled out through interviewing each patient individually.

Ethical consideration
* there was no risk for patients participating in the study , patients was assured confidentiality and anonymity and their right to withdraw from the study without any rational at any time during the study after attaining their informed consent for participation in the study.

Statistical analysis:
Data collected were analyzed by computer program SPSS" version.17" Chicago. USA. Data expressed as "mean □ standard deviation" "number, percentage". Using T test to determine significance for numeric variables. Using Chi. square test to determine significance for non-parametric variables. Using Pearson correlation for numeric variables in the same group.
 n.s P > 0.05 no significance.
 **P < 0.01 moderate significance.
*** P < 0.001 highly significance.

Limitation of the study:
It was difficult to follow up some of patients because they were not living in Assiut city and it was difficult for them to come, some of patients were not cooperative with the study.

III. Results
Table (1):- Frequency distribution of patient was according to their Socio-demographic characteristics:-

Personal data	ACL injury < 3 months N=30		ACL injury > 3 months N=30		Total N=60
	N.	**%**	**N.**	**%**	**N. %**
Age group 18yrs to 50yrs	**Means±SD** 24.75± 5.559				
Level of education					
Secondary school	9	30%	9	30%	18 (30.0%)
University	21	70%	21	70%	42 (70.0%)
Occupation					
Student	15	50%	22	36.7%	37 (61.7%)
Worker	10	33.3%	5	8.3%	15 (25.0%)
Private	2	6.7%	2	3.3%	4 (6.7%)
Farmer	3	10%	1	1.7	4 (6.7%)

Table (1), this table demonstrates that; the mean age was (24.75± 5.559), regarding level of education; (70%) of patients in both groups were highly educated and the majority of them (61.7%) were students.

Table (2): Comparison between the studied samples regarding measurement of the affected knee mid-thigh circumference during all periods of follow-up:-

	Pre. Op.	3 m.	6 m.	12 m.
ACL injury < 3 months	41.13±1.65	40.20±1.42	39.83±1.39	39.86±1.43
ACL injury > 3 months	41.46±2.66	40.83±2.91	40.53±2.77	40.53±2.77
P.value	0.56	0.28	0.22	0.24

Table (2): This table demonstrates that, there was no statistically significant difference among both groups in any of the follow-up periods.

Table (3): Comparison between the studied samples regarding measurement of the affected knee quadriceps muscle strength during all periods of follow-up:-

	Pre. Op.	3 m.	6 m.	12 m.	P.value1
ACL injury < 3 months	12.16±3.12	16.04±2.08	17.76±1.77	19.66±1.71	0.001**
ACL injury > 3 months	12.00±3.15	15.48±2.74	17.45±1.72	18.75±1.77	0.001**
P.value2	0.85	0.37	0.49	0.04*	

P.value1: Comparison between each group regarding measurement of the affected knee quadriceps muscle strength during all periods of follows-up.

P.value2: Comparison between ACL injury < 3 month and ACL injury > 3 months regarding measurement of the affected knee quadriceps muscle strength during all periods of follow-up.

Table (3): This table demonstrates that, there was a highly statistically significant difference between patients with an ACL injury < 3 months during all periods of follow up and also between patients with an ACL injury > 3 months during all periods of follow up regarding measurement of the affected knee quadriceps muscle strength with P. (0.001**), but there were no statistically significant difference among both groups in the follow up except at 12 months with P. (0.04*).

Table (4):- Frequency distribution of patients regarding their disability status using (SF-12) scale:
Table (4): This table demonstrates that, all the studied samples in both groups were having less disability in all periods of follow-up.

Variables	Pre. Op.		3 m.		6m.		12m.	
	N.	%	N.	%	N.	%	N.	%
ACL injury < 3 months								
Poor <30	15	50%	8	26.7%	0	0.0	0	0.0
Fair30-54	15	50%	22	73.3%	4	13.3%	0	0.0
Good 55-79	0	0.0	0	0.0	26	86.7%	0	0.0
Excellent >80	0	0.0	0	0.0	0	0.0	30	100%
ACL injury > 3 months								
Poor <30	13	43.3%	12	40%	0	0.0	0	0.0
Fair30-54	17	56.7%	18	60%	9	30%	0	0.0
Good 55-79	0	0.0	0	0.0	21	70%	0	0.0
Excellent >80	0	0.0	0	0.0	0	0.0	30	100%
P.value.	0.398		.206		.105		------------	

Table (5):- Comparison between   ACL injury < 3 months and ACL injury > 3 months regarding total score of the Modified Cincinnati Rating System Questionnaire:-
** Statistically significant difference (p<0.01)

Variables	Pre. Op.		3 mo.		6mo.		12mo.	
	N.	%	N.	%	N.	%	N.	%
ACL injury < 3 months								
More disability	0	0.0	1	3.3%	0	0.0	0	0.0
Less disability	30	100%	29	96.7%	30	100%	30	100%
ACL injury > 3 months								
More disability	0	0.0	0	0.0	0	0.0	0	0.0
Less disability	30	100%	30	100%	30	100%	30	100%
P.value.	-------		.500		-----------		------------	

Table (5):- This table demonstrates that, there was no statistically significant difference between both groups regarding their total score on the Modified Cincinnati Rating System Questionnaire.

IV. Discussion
The mean age were (24.7) of patients in both groups ACL injury is more common in this age group because of their more active lifestyle as well as higher participation in sports. This outcome agree with **(Mohammed, 2016)** who found that ACL is most prevalent in patients with a mean age of (28.2) years. While

the result of this study upsets with **(Hussien, 2013)** who found that the mean age of patients was 47 years and also disagree with **(Collins et al., 2013)** who reported that the age of contributors ranged from 16 to 52 years.

The common of patients in both groups were highly educated. Our study agrees with **(Mohammed, 2016)** who found that the majority of patients were highly educated, and differs with the study results of **(Salem et al., 2012)** which showed that the majority of patients were secondary educated.

Regarding occupation, the majority of patients were students. This result disagrees with **(Salem et al., 2012)** who found that patients were about similarly to have a manual or sedentary occupation.

The present study revealed that there was no statistically significant difference among both groups in any of the follow-up periods, regarding quadriceps weakness, our study result comes in disagreement with **(Rittweger et al., 2011)** in their study entitled "Persisting side-to-side differences in muscle strength and tendon stiffness after anterior cruciate ligament reconstruction", done on 100 patients at Institute for Biomedical Research into Human Movement and Health, Manchester Metropolitan University, Manchester, UK. which emphasized that there were significant side-to-side differences in quadriceps muscle strength between the study and control groups.

There was a highly statistically significant difference between patients with an ACL injury < 3 months during all periods of follow up and also between patients with an ACL injury > 3 months during all periods of follow up regarding measurement of the affected knee quadriceps muscle strength with P.valuealue (0.001**), but there was no statistically significant differences among both groups except at 12 months with P.valuealue (0.04*). This result disagree with **(George et al., 2012)** in their study as they declared that the quadriceps muscle of the uninvolved knee was always significantly stronger than that of the involved knee at all three test speed.

Moreover, **(Eitzen et al. 2009)** had reported that pre-operative quadriceps muscle strength deficits had significant negative effects on the long-term functional outcomes of ACL reconstruction. This result disagree with **(Wasilewski et al. 2013)** who reported that there was no significant difference in quadriceps power with timing of ACL reconstruction, and **(Halinen et al. 2009)** who declared that deficits in quadriceps power have been previously cited as persisting at 1-year post-ACL reconstruction.

The results of the present study revealed that there was no statistically significant differences among both groups regarding quality of life using (SF-12) scale pre-operatively and at all post-operative follow up periods, this finding disagrees with **(Philipp et al., 2017)** who found highly statistically significant differences at 3, 6, 12 and 24 months compared to preoperatively using (SF-12) scale .

There was no statistically significant difference between both groups regarding assessment of their physical status preoperatively using Modified Cincinnati Rating System Questionnaire. This result disagrees with **(Seiji Kubo et al. 2012)** who found in their study that patient's pre-operative score on the Modified Cincinnati Rating System Questionnaire were having a moderately strong positive correlation.

There was a highly statistically significant difference between both groups regarding their physical status in both groups at 3 months post- operatively using the Modified Cincinnati Rating System Questionnaire scale as pain intensity, giving way, overall activity, walking, and running activity,. **(Vijayan 2011)** in their study using the Modified Cincinnati Rating System Questionnaire at 3 mo. post- operatively 20 cases; found that 10 cases had inconstant and slight pain during severe exertion (50%),18 cases had no giving way (90%), 5 cases had slightly impaired stair climbing (25%), 1 case had marked pain during severe exertion, 1 case had marked pain on or after walking more than 2 km (5%,) & 1 case had constant pain (5%) at 22 months follow up. This result comes in agreement with **(Risberg and Inger 2009)** who found significant improvement in knee function and reduced pain during activity for the patients who performed neuromuscular exercise program at the 6 months follow up after ACL reconstruction surgery.

There was no statistically significant difference between both groups regarding their total score on the Modified Cincinnati Rating System Questionnaire pre-operatively and at all of the follow up periods but there was an improvement on 12 months of the follow up in both groups, This result disagree with **(Boden et al. 2009)** who reported that there was a moderately strong positive correlation between pre and post-operative scores.

V. Conclusion and Recommendations

Conclusion:
* An improvement was observed at 3&6 months follow up of patients with an ACL injury of less than 3 months than those patients whose injury more than 3 months.

Recommendations
* Orientation programs on mass media (TVs & radio) on importance of early medical consultation and early surgery to improve their condition.

- As the study sample consisted of (61.7%) students; providing university students with instructions for seeking medical advice for their sports injuries is of great importance for early diagnosis and management of their injuries.

References

[1]. **Barber, W. Bentley, G. Biant, L. Carrington, R. Akmal, M. and Goldberg, A. (2003):** Cincinnati Rating System Scale. http://www.orthopaedicscores.com.

[2]. **Boden, Moyar, Berz and Sapega (2009):** Arthroscopic Assisted ACL Reconstruction – 26 months follow-up study. ed(2). P. (183).

[3]. **Collins, J. Katz, J. Donnell-Fink, L. Martin, S. and Losina, E. (2013):** Cumulative incidence of ACL reconstruction after ACL injury in adults, role of age, sex, and race, 2nd edition chapter 5,USA: Clinical Orthopedic.

[4]. **Eitzen, I. Holm, I. And Risberg, M.A. (2009):** Preoperative quadriceps strength is a significant predictor of knee function two years after anterior cruciate ligament reconstruction. British Journal of Sports Medicine, 05, vol. 43, no. 5, P.p. (371-376).

[5]. **Ellison A. and Berg E. (2012):** anatomy, and function of the anterior cruciate ligament. Orthop Clin North Am; ed (16), P.p. (1-3).

[6]. **George, A. Arangio, Facs, C.C. Kalady, B.A. and lames, F. R. (2012):** Thigh Muscle Size and Strength After Anterior Cruciate Ligament Reconstruction and rehabilitation.

[7]. **Halinen, J. Lindahl, J. and Hirvensalo, E. (2009)**: Range of motion and quadriceps muscle power after early surgical treatment of acute combined anterior cruciate and grade-III medial collateral ligament injuries. A prospective randomized study. J Bone Joint Surg vol. 91, P.p. (1305–1312).

[8]. **Hussien, S. (2013):** Effect of Developing Nursing care standards for patient with anterior cruciate ligament surgery at Assiut university hospital, Unpublished Doctor thesis of Medical and Surgical Nursing, Faculty of Nursing, Assiut university.

[9]. **Kyung, M. K. Ted, C. Jay, H. and SuSan, S. (2010):** Effects of Neuromuscular Electrical Stimulation after Anterior Cruciate Ligament Reconstruction on Quadriceps Strength, Function, and Patient-Oriented Outcomes: A Systematic Review. JOSPT, ed (7), P.p. (383-391).

[10]. **Marcacci, M. Zaffagnini, S. Iacono, F. Pia Neri, M. and Petitto, A. (2013):** Early versus late reconstruction for anterior cruciate ligament rupture. Results after five years of follow-up. Am J Sport Med vol.23, P.p. (690–693).

[11]. **Mohammed, S. (2016):** Impact Of Nursing Rehabilitation Program On Outcome Of Patients Undergoing Arthroscopy For Anterior Cruciate Ligament Injury.iosrjournals, Volume 5, No.(2), Pp.(29-38).

[12]. **Philipp, M. Thomas, H. Matthias, J.F. Johannes, E. Plath, Stefan H. Andreas, B.I. and Tim, S. (2017):** Patient satisfaction with health is substantially improved following ACL reconstruction European Society of Sports Traumatology, Knee Surgery, Arthroscopy (ESSKA).

[13]. **Risberg, A.S. and Inger, H.A. (2009):** The Long-term Effect of 2 years Postoperative Rehabilitation Programs After Anterior Cruciate Ligament Reconstruction.

[14]. **Risberg, M.A., Inger, H.O. Grethe, M.K. and Lars (2011):** Neuromuscular Training Versus Strength Training During First 6 Months After Anterior Cruciate Ligament Reconstruction: A Randomized ClinicaL Trial .

[15]. **Rittweger, J. Reeves, N.D. Narici, M.V. Belavý, D.L. Maganaris, C.N. and Maffulli, N. (2011):** Persisting side-to-side differences in muscle strength and tendon stiffness after anterior cruciate ligament reconstruction. Journal of Clinical Physiology and Function Imaging. Manchester, UK, 31(1). Pp.73-79 ,

[16]. **Salem, S. Sharaf, S. Mostafa, M. and Abd- Elhaliem, M. (2012):** Impact of a Designed Nursing Rehabilitation Program on incidence of complication and length of hospital stay After Anterior Cruciate Ligament (ACL) Reconstruction El-Manial University Hospital. Am J Sport Med vol.(18), Pp. (43–45).

[17]. **Savio, L.Y. Richard, E. D. John, D. W. and Marsie, A. J. (2011):** Biomechanics of Knee Ligaments. The American Journal of Sports medicine ed (27), P. (533).

[18]. **Seiji, K. Hirotugu, M. Shinichi, Y. Kiyonari, M. and Masahiro, K. (2012):** Reliability and usefulness of a new in vivo measurement system of the Pivot Shift. Vol. 45, P.p. (54-58).

[19]. **Sharonl, k. Heitkemper, L. Patricia, S. and Linda, N. (2007):** medical surgical nursing, Role of Nurse in Rehabilitation, 8th ed., Sunders Elsevier, USA 7th ed ,ch (15), p(2430).

[20]. **Sven, F. John, N. Conor, M. and Hans, H. P. (2011):** The Effectiveness of Supplementing a Standard Rehabilitation Program With Superimposed Neuromuscular Electrical Stimulation After Anterior Cruciate Ligament Reconstruction: A Prospective, Randomized, Single-Blind Study. Am J Sports Med February, P. (22).

[21]. **Vijayan, B. (2011):** Early functional outcome of anterior cruciate ligament injuries managed by arthroscopic four strand hamstring autograft, P.(45-50).

[22]. **Ware, J.E. and John, E. (1995):** SF-12 Physical and Mental Health Summary Scales. The Health Institute, New England Medical Center, 2nd(ed), pp (21-23).

[23]. **Wasilewski, S.A. Covall, D.J. and Cohen, S. (2013)** Effect of surgical timing on recovery and associated injuries after anterior cruciate ligament reconstruction. Am J Sport Med, vol. 21, P.p. (338–342).