EFFECT OF EXERCISES PROGRAM ON KNEE FUNCTIONAL OUTCOMES FOR PATIENTS AFTER ARTHROSCOPIC ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

[1] Mona Ibrahim ElsayedAbdElghany, [2] AmlEidAbd El- Monaemand [3]Amira Ahmed Hassanin

[1]Demonstrator ofMedical-Surgical Nursing, Faculty of Nursing,
[2]Lecturer of Medical-Surgical Nursing, Faculty of Nursing,[3]Professor ofMedical- SurgicalNursing, Faculty of Nursing-Mansoura University.
E-mail of corresponding author: mona_ibrahim11@yahoo.com

Abstract

Background: Rupture of the anterior cruciate ligament (ACL) is a common cause of knee instability, requiring ACL reconstructions with about one million completed worldwide annually. Successful (ACL) reconstruction requires physical rehabilitation to help patients return to an active lifestyle. This study **aimed to**evaluate the effect of exercises program on knee functional outcomes for patients after arthroscopic anterior cruciate ligament reconstruction. ***Study design:*** Quasi experimental research design was conducted in this research. ***Study sample:***Purposive sample of 60 adult patients of both sexes, who were diagnosed as a first-time primary unilateral anterior cruciate ligament injury and undergoing (ACL) reconstructionwere involved in the study and were divided randomly into two groups 30 patients for each group . ***Setting:*** The study was conducted at the knee arthroscopic surgery and stadium injuries unit at Mansoura University Hospital as well as the knee surgery outpatient clinic for patients follow up .***Tools of the study:*** Five tools were utilized in this study: Tool I: Patient's assessment structure interview sheet which consists of two parts: Part (1): Socio-demographic characteristics and health relevant data, Part (2): The patient's knowledge and practice assessment sheet.Tool II: Manual muscle testing (MMT) Scale of the knee muscles. Tool III: Anterior Knee Pain Scale (AKPS) ─ Kujala Scale‖. Tool (IV): Goniometric Range of Motion Measurement (ROM). Tool (V): The Knee Outcome Survey Activities of Daily Living Scale (KOS-ADLS).***Results:***The result revealed that post program implementation, study group had a reduction in pain and improvement in knee muscle strength and knee function more than the control group and a statistically significant improvement was found in the total mean score of (KOS-ADLS) of the patient in the study group (70.57 ± 3.87) compared to patient in the control group (40.86 ± 3.37). Moreover the total mean score of knee flexion was significantly improved in the study group (109.0 ± 8.35) than the control group (77.0 ± 10.14). Furthermore the total score of knee extension was significantly better in study group in comparison with the control group. ***Conclusions:***Exercises program after arthroscopic anterior cruciate ligament reconstruction had a significant positive effect on patient's knee functional outcomes.
Keywords: Anterior Cruciate Ligament Reconstruction, Arthroscopic, Exercisesprogram, Knee Functional Outcomes

Introduction:

The problems associated with the musculoskeletal system significantly influence on the productivity and activities of the patient [1,2].Few musculoskeletal conditions need to discuss, debate, and analyze such as injury to theACL[3].

One of the most common injured knee's ligaments is theACL. The injury of

ACL is a serious injury whichresults in the admission for surgery with the highest incidence found in young adults [4,5].An ACL injury has severe effect on the injured person includingthe time lost from the work, therapy costs and the risk of degenerative joint disease [6].

The long-term effects of an ACL injury can severely affect on the patient's quality of life [7].The tear of (ACL) is the causing of atrophy the knee. The modern study reveal that about 250,000 ACL injuries happen every year in the USAwith roughly 175,000 leading to reconstructions[8].

The post-operative rehabilitation is incredibly necessary and has significantly effects on the ability of the patient to do everyday activities and on the knee functional outcome [9]. The nurse becomes the basic element of the rehabilitation process [10].

Rehabilitation starts immediately following the surgery of ACLR including contracting the thigh muscles, walking with crutches, and liftingthe leg [11]. Post-discharge physiotherapy and exercise-based interventions promote re-training and functional improvement [12].Without rehabilitation, functional independence and activity levels may not be recovered[13].

The most common way of rehabilitation is exercise therapy and there are clinical effectiveness proves [14].The major purpose of exercise therapy is maximizing the range motion, improving the muscles strength, controlling the pain and normalizing the gait mechanics [15].

Aim of study:

This study aimed toevaluate the effect of exercises program on knee functional outcomes for patients after arthroscopic ACLR.

Research hypothesis:

•H1:patients who involved in exercises program (study group) will exhibit Muscles strength, ROM of affected knee better than those who do not (control group).

•H2: Study group will have less level of pain after implementing exercise program than control group.

•H3: Activities of daily living of study group will be improved after implementing exercise program than control group.

Operational definition

• **Effect:** Means the extent to which the proposed exercises program has achieved the desired outcome as measured by the study tools.

• **Knee Functional Outcomes:** Refers to the ability of patients to use their knees post injury in performing the activities of daily living without knee pain and with good muscle strength. Functional outcome measurement tools are specific tests and measures which are used to quantify overall function of a person. Functional evaluations were made using the KOS-ADL scale, kujala scale, MMT, ROM measurement applied before and after the surgical procedure.

Study Design:

Quasi – experimental research design was utilized in this study.

Setting:

The study was conducted at the knee surgery, arthroscopy and stadium injuries unit at Mansoura University Hospital.

Sample:

A purposive sample of 60 adult patients of both sexes, who were diagnosed as a first-time primary unilateral anterior cruciate ligament injury and will undergoing ACLR, were involved in the study. Patients randomly divided into two equal groups; the study group (Group I) involved patients who was received routine hospital care in addition to knee exercise program and Control group (Group II) who was received routine care of hospital only.

Inclusion criteria:

- Patients' age is between 20 and 60 years old and both sexs.
- Patients are conscious and able to communicate.
- Patient undergone an elective first-time primary unilateral arthroscopic ACLR.
- Willing to participate in the study and have the ability to learn.

Exclusion criteria:

- Patients with psychiatric problems.
- Cancer.
- Unable to give a consent.
- Revision arthroscopic ACLR.
- An acute injury to any part of the body that would disable them from safely completing the requirements of the study.

Tools:

The following five tools were used in this study to collect necessary data:

Tool I: Patient's Assessment Structure Interview sheet:

This tool was developed by researcher based on literature review to collect the required base line data and consisted of two parts;

Part1:Socio-demographic characteristics and health relevant data: This part was used to collect personal data of patients as : age, gender, marital status, educational level ,occupation,cause of ACL injury,other health diseases,previous knee surgery,…., etc

Part 2: Patient's knowledge and practice assessment sheet: This part was utilized to assess patient's knowledge concerningACL injury, ACLR and practice of rehabilitative exercises after ACLR.

Tool II:Manual muscle testing (MMT) Scale of the knee muscles: This scale was developed by **(Kendall, McCreary,& Provance,1993)**[16]and was used by the researcher for evaluating the strength of the knee muscles. This scale graduated from 0 to 5 grades.

Tool III: Anterior Knee Pain Scale (AKPS) "Kujala Scale": It was developed by **(Kujala et al., 1993)**[17]. It is a 13-item self-report questionnaire thatcenters around the subjective evaluation of 6 activities. These activities are: walking, running, jumping, climbing stairs, squatting, and sitting for a long time with knees bent. This scale gives insight additionally into limping, inability to weight bear through the affected limb, swelling, abnormal patellar tracking, muscle atrophy and ROM limitation, that lead to a global decrease in knee function and quality of life[18].The score ranges from 0 to 100 with higher scores performing better.

Tool (IV): Range of Motion Measurement (ROM): The researcher measured knee joint range of motion (flexion and extension) by a goniometer which was purchased by the researcher.

Tool (V): The Knee Outcome Survey Activities of Daily Living Scale (KOS-ADLS): This scale was developed by **Irrgang et al., 1998**[19] and was used by the researcher to evaluate patient's ADL. The ADLS is a 14 item scale which queries patients concerning how their knee symptoms have an effect on their capacity to perform general daily activities (6 items) and in addition how their knee condition influenceson their capacity to perform specific functional tasks (8 items). Each item is scored 0-5 with 5 indicating ‒no difficulty‖ and 0 representing ‒unable to perform‖. The highest possible score is 70. The scores of all items are summed, divided by 70, and then multiplied by 100 to give an overall ADLS percent rating.

Procedure:

1. The researcher obtained the required permissions from the Research Ethics Committee of Nursing faculty, Mansoura University.
2. A verbal and written consent were obtained from patients who participated in the study after clear

explanation of the aim and the nature of the study.

3. Tools tested for content validity by five specialists from medicine and nursing field. Faculty of nursing –Mansoura university (3 members), and faculty of medicine (2members), then the required modifications were done accordingly.

4. A pilot study was conducted on 6 (10%) patients, before data collection to test the clarity, feasibility, applicability, reliability. The tools was modified according to results of pilot study. Thesesix patients were excluded from the study.

•Filed work: The field of working included the following phases:

A)- preparatory phase .

B)- Implementation phase .

C)- Evaluation phase .

A)- Preparatory phase:

It was concerned with construction and preparation of different data collection tools.

Based on the information obtained from pilot study, in addition to literature, the researcher designed the exercise program in the form of booklet under the guidance of the supervisors. It includes information about the following items:

- Brief description of knee joint and ACL injury (definition,causes,degrees of injury, signs and symptoms, the line of treatment)
- Exercises for the first four weeks after ACLR
- Health instructions needed for ACLR operation.
- The instructional booklet was written in simple Arabic language with different illustrated colored pictures.

B)- Implementation phase:

The researcher began the instruction of the program for every patient in the study group.

The program was conducted through four sessions; (1 session /day), each session took about 45- 60 minute for study group.

❖ **First session (on admission)**

- In this session the researcher contacted with each patient of the study group on admission to teach him/her knowledge around ACL injury and reconstruction that include (anatomy of knee,definition, causes,degrees of injury, signs and symptoms of ACL injury) .The arabic booklet was introduced to serve as a guide for them.

❖ **Second session (preoperative)**

- In this session the researcher prepare patients for surgery and assisstingthem to control pain and swelling after ACLR.
- The researcher contacted with each patient of the study group on the day before operation to teach him/her line of treatment of ACL injury ,the care for the knee and dressing and health instruction that be followed postoperatively .

❖ **Third session (postoperative)**

- This session comprised the recommended knee exercises during first two weeks postoperative such asheel prop,prone hang,wall slides, heel slides using demonstration and redemonstration.

❖ **Fourth session (on discharge)**

- The researcher contacted with each patient of the study group for teaching him phase II of recommended knee exercises (2-4) weeks postoperative using demonstration and redemonstration such as passive extension of the knee by using a rolled towel, active-assisted extension by using the opposite leg, passive flexion by gravity assistance, quadriceps isometric contractions as well as hamstring muscles exercises .

For study group the developed exercises begin with answering all patient questions

about the disease process, the line of treatment and importance of follow up, give the patient copy of the booklet and ask him to read it, or his /her relative to help him understand all data in the booklet. Patient asked to perform all of these form of exercise frequently and daily with an assistant of his relative. The patient was advised not to be over enthusiastic to avoid relapsing at the end.

After discharge , the researcher called each patient in the intervention group by telephone to be sure that he /she was following the given instruction, encouraging and reinforcing to follow the given instructions, continue and practice knee exercises.

Different teaching and learning methods were used during the sessions such as interactive lecture, demonstration &redemonstration, instructional media include pictures, printed handout and video programs.

The duration of program implementation was 9 months from the beginning of December 2016 to end of August 2017.

For study group the developed exercises begin with answering all patient questions about the disease process, the line of treatment and importance of follow up, give the patient copy of the booklet and ask him to read it, or his /her relative to help him understand all data in the booklet. Patient asked to perform all of these form of exercise frequently and daily with an assistant of his relative. The patient was advised not to be over enthusiastic to avoid relapsing at the end.

C)-Evaluation phase:
It was emphasizing on assessing the effect of the exercises program on knee functional outcomes. Each patient in the study group was interviewed individually for assessment as the following:
First assessment: Before beginning of exercise at knee surgery, arthroscopy and stadium injuries unit.

Second assessment: Two weeks after implementing the exercises at knee surgery outpatient clinics.
Third assessment: One month after exercise training at knee surgery outpatient clinics.
The same was done for a control group that assessed three times after admission (before operation),2 weeks after ACLR and lastly, one month after ACLR to assess routine hospital care . Comparison between control and study group's finding were done to evaluate the effect of exercises program.

Statistical analysis:
Data entry and statistical analysis were done using Statistical Package for Social Science "SPSS version 20". The quantitative data were viewed as numbers and percentages. To check the difference between two groups independent t-test was used. Tests of significance were performed to the study hypotheses i.e. Paired Samples Tests (P-value), and N Par tests (Wilcoxon Signed Ranks Test).Statistical significance was
considered at p-value <0.05 while, p-value of<0.001 indicates a high significant

Results:
Table (1): Frequency distribution of the studied sample according to socio-demographic characteristics. This table confirms that there is no statistically significant difference between the both groups regarding their socio-demographic characteristics. Maleswere more prevalent in both the studied sample, they constituted (86.7%) of the study group and (90%) of the control group. In relation to age, it can be noticed that (43.3%) of the study group and half of the control group (50%) aged from 30 to 40 years old. With regard to the marital status and the level of education, the highest percentage of both study and control group were married (56.7% and 73.3%) respectively. Furthermore; more than half of patients in

the study group and the control group (56.7%) were university educated. Regarding patient's occupation; the results of this table confirmed that mostly of both study and control group had physical effort job (43.3%) and (53.3 %) respectively.

Figure (1): Comparison between the the study and control groups regarding manual muscle strength throughout program phases.

It was evident from this figure that no significant group differences was found preoperatively in terms of manual muscle strength. On the other hand, there was a highly statistically significant difference between them postoperatively in regard to manual muscle strength at 2nd ,4th weeks after implementation of program where (p<0.001).

Figure (2) : Comparison between the study and control groups regarding total score of anterior knee pain scale (kujala scale) throughout the intervention phases. This figure clarified that there was a significantly higher total mean score of anterior knee pain scale among the study group than those among the control group throughout 2nd weeks and 4th weeks post program implementation where (p<0.001*).

Table (2) : Comparison between the studied groups according to knee range of motion measurement through the study period.

The result of this table shows that there was a statistically significant difference between the both groups regarding their knee extension measurement preoperatively in pre implementation phase of the program , postoperatively at 2nd and 4th weeks after implementation of the program where (p<0.001).As regard knee flexion measurement, no statistical significant difference was noticed between the study and the control group preoperatively in pre implementation phase of the program. While there was a highly statistically significant difference between them at 2nd and 4th weekspostoperatively after implementation of the program.

Figure (3): Comparison between the study and control groups according to total mean score of the (KOS-ADLS) throughout the intervention phases.

This figure provides evidence that post implementing the proposed program at the 2nd and 4th weeks

Postoperatively, the total mean score of activities of daily living of patients with ACLR were statistically significantly higher among study group in comparison to the control group.

Table (1): Frequency distribution of the studied sample according to socio-demographic characteristics.

| Socio demographic characteristics	Study group (n = 30)		Control group (n = 30)		χ2	p
	No.	%	No.	%		
Age (years)						
20 – <30 year	11	36.7	11	36.7	1.949	0.377
30 – <40 year	13	43.3	15	50.0		
40 – <50 year	6	20.0	4	13.3		
Sex						
Male	26	86.7	27	90.0	0.162	FEp= 1.000
Female	4	13.3	3	10.0		
Marital status						
Single	11	36.7	7	23.3	1.918	MCp= 0.441
Married	17	56.7	22	73.3		
Divorced	2	6.7	1	3.3		
Level of education						
Illiterate	2	6.7	0	0.0	2.966	0.427
Primary or preparatory	1	3.3	0	0.0		
Average qualification education	10	33.3	13	43.3		
University education	17	56.7	17	56.7		
Occupation						
Doesn't work	7	23.3	3	10.0	1.958	0.376
Work does not require physical effort	10	33.3	11	36.7		
Work require physical effort	13	43.3	16	53.3		
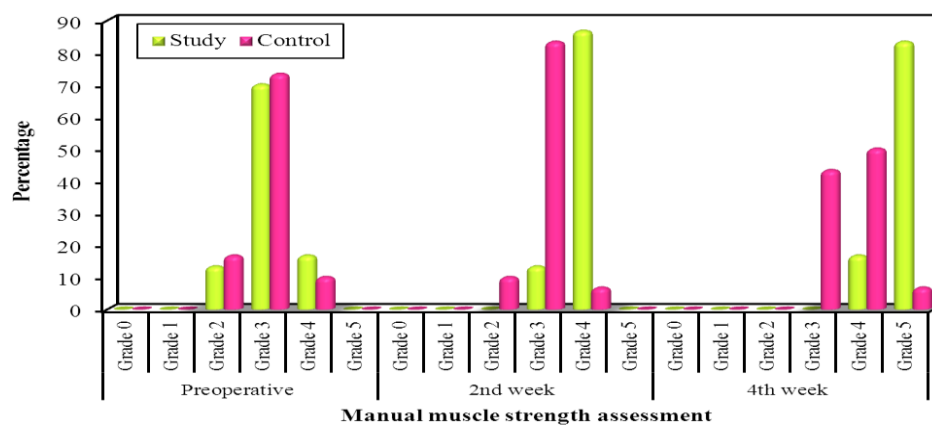
Figure (1): Comparison between the two studied groups according to manual muscle strength assessment sheet of the affected kneethroughout program phases
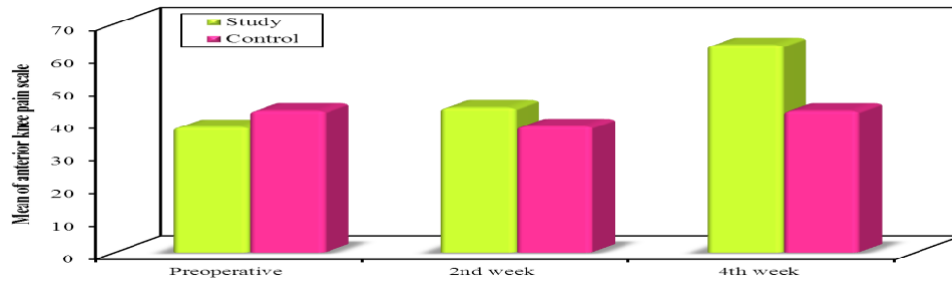
191

Figure (2): Comparison between the two studied groups concerning total score of anterior knee pain scale (kujala scale) throughout the intervention phases.

Table (2): Comparison between the two studied groups regarding knee range of motion measurement assessment sheet through the study period.

Knee Range of Motion Measurement	Study (n = 30)			Control (n = 30)			P4	P5	P6
	Preoperative	Postoperative		Preoperative	Postoperative				
		2nd week	4th week		2nd week	4th week			
Knee Flexion									
Min. – Max.	45.0 – 75.0	80.0 – 95.0	90.0 – 120.0	45.0 – 80.0	60.0 – 85.0	60.0 – 95.0	0.887	<0.001*	<0.001*
Mean ± SD.	62.67 ± 8.07	89.0 ± 3.57	109.0 ± 8.35	63.0 ± 9.88	72.0 ± 7.94	77.0 ± 10.14			
Sig. bet. Periods	$p_1<0.001^*$,$p_2<0.001^*$,$p_3<0.001^*$			$p_1<0.001^*$,$p_2<0.001^*$,$p_3<0.001^*$					
Knee Extension									
Min. – Max.	10.0 – 20.0	5.0 – 15.0	0.0 – 15.0	15.0 – 25.0	13.0 – 20.0	10.0 – 20.0	<0.001*	<0.001*	<0.001*
Mean ± SD.	15.07 ± 2.39	7.83 ± 7.83	4.33 ± 4.84	20.33 ± 3.29	17.30 ± 2.48	15.77 ± 2.93			
Sig. bet. Periods	$p_1<0.001^*$,$p_2<0.001^*$,$p_3<0.001^*$			$p_1<0.001^*$,$p_2<0.001^*$,$p_3=0.001^*$					

p_1: comparing between pre and 2nd week postoperative in each group
p_2: comparing between pre and 4th week postoperative in each group
p_3: comparing between 2nd week and 4th week postoperative in each group
p_4: comparing between the two studied groups at preoperative
p_5: comparing between the two studied groups at 2nd week postoperative
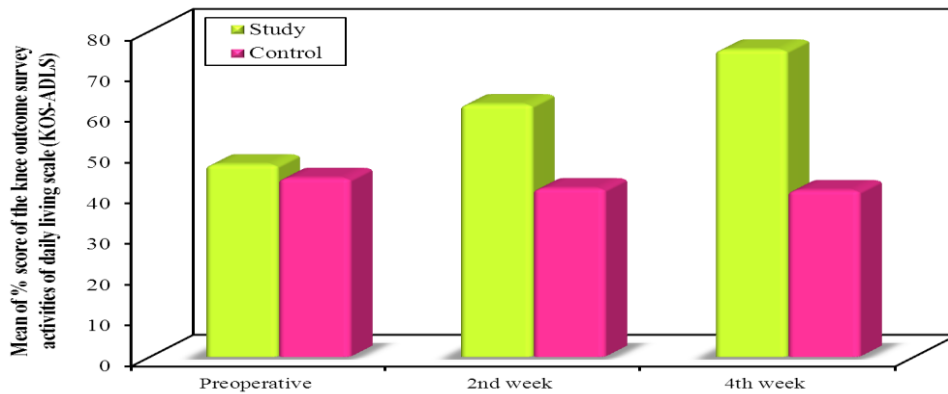p_6: comparing between the two studied groups at 4th week postoperative

Figure (3): Comparing between the two studied groups regarding total mean score of the (KOS-ADLS) throughout the intervention phases.

Discussion:

Anterior cruciate ligament reconstruction is a common surgical procedure. Allograft and autograft were utilized for reconstruction [20], that often result in persistent deficiency of hamstring muscle-

strength and diminished knee function [21]. Following an ACL reconstruction, there are various short term and long-term implications that will eventually influence the health of the knee as well as the overall quality of life for the patient [22,23]. Exercise prescription is a fundamental part of physiotherapy care and an important element in an ACL rehabilitation programme of care [24].

In the present study males were more prevalent than females.This agree with **Di Vico, et al., (2017)** [25]. In the opposite direction **Paterno et al., (2017)** [26] who stated that most of their studied sample were female.

In relation to age, the current study represented that the highest percentage of both groups aged from 30_40 years .This finding is in agreement with **Cheecharern, (2018)** [27].On the other hand, this result is in disagreement with **Okoroha et al., (2016)** [28] who reported that the mean age of patients undergoing ACL reconstruction was 19.7 years.

As regard marital status more than half of patients in the studied groups were married .These subjects' marital status was similar to **Christensen, Miller, Burns, & West, (2017)** [29]. In contrast, it disagrees with **Magnussen et al., (2016)** [30] who illustrated that most of their studied sample were single.

With reference to educational level, the finding of the study represented that most of both groups were university educated. This agree with **Filbay, Ackerman, Russell, &Crossley, (2017)** [7]. In contrast, it disagrees with **El-Kafafy& El-Hadary (2012)** [32].

This study revealed that mostly of two studied groups were working job needed physical effort .This agree with **El-Kafafy and El-Hadary (2012)** [32]who illustrated that the most subjects were farmer/manual work .This result doesn't correspond with **Kanamoto et al., (2015)** [33]who reported that the majority of participants were students not worker.

Concerning effectiveness of exercises program on study group regarding knee function and pain by anterior knee pain scale (Kujala scale). Post-operative Kujala scale regarding all subscales was significantly better in the study group.

These findings were supported by **Hamada, Draz, Koura, & Saab, (2017)** [34] who found that there were significant increase in Kujalascale in the post 4 weeks treatment condition compared with the pre-treatment. In contrast,it disagrees with **Heijne& Werner, (2010)** [35] who said that there were no significant group differences in terms of AKP preoperatively or at any of the follow-ups except for the 2-year follow-up.

When assessing knee range of motion among the study group, our study revealed that there is improvement in post-operative knee flexion angle at 2nd weeks and 4^{th}weeks post intervention was significantly better in the study group. As revealed in this study, there was a positive significant difference between the both groups after 2 weeks and 4 weeks of intervention regarding knee extension angle .

These findings are congruent with**Uçar et al., (2014)** [36] and **Panchal, Bedekar, Sancheti, &Shyam, (2017)** [37] . Regarding manual muscle strength, this study showed that a high statistical significant difference was observed between the both groupsconcerning post-operative manual muscle strength after 2 weeks and 4 weeks of intervention.

These results were supported by **Konishi et al., (2012)** [38] who reported improved extensor muscle strength after closed kinetic channel exercise. In addition to **Lee et al., (2016)** [39] However, these results contradict the results of **Gokeler et al.,(2014)** [40].

With reference knee outcomes survey activity of daily living (KOS-ADLS), the result of this study revealed that a highly statistically significant difference was found between the studiedgroupsas regard to their total score of (KOS-ADLS) postoperatively at 2nd and 4th weeks after implementation of the program where (p<0.001).

These results were supported by **Christensen, Miller, Burns, & West, (2017)** [29] .In addition to **Gerber et al., (2007)** [41].

Conclusion:

Exercises program following arthroscopic ACLR has a significant positive effect on patient's knee functional outcomes.

Recommendation:

Based on the results of the current study, the following recommendations are suggested:

- Functional abilities of patientswith ACLRshould be assessed by nurses constantly and progressively.
- All patients undergoingACLR and their relatives should receive sufficientknowledge and skills concerning the rehabilitation process.
- Development of patient-education and rehabilitation unit connected to the orthopedic departments where the patients can realize easy simple attractive colored illustrated posters and booklets concerning ACL rehabilitation and providing a simple instrument for basic exercises.
- Illustrated colored booklet about ACLR rehabilitation modalities should be distributed for all ACL injured patients from admission to encourage patient's learning.
- Replication of the study on a larger probability sample selected from various geographical areas in Egypt is recommended and expanding length of intervention and assessment are needed.

References:

1. **Santy-Tomlinson, J., Clarke, S., & Davis, P. (2014).** The complications of musculoskeletal conditions and trauma. Orthopaedic and Trauma Nursing: An evidence-based approach to musculoskeletal care, 96.

2. **Phillips, T. D., & Shoemaker, M. J. (2017).** Early Access to Physical Therapy and Specialty Care Management for American Workers With Musculoskeletal Injuries. Journal of Occupational and Environmental Medicine, 59(4), 402-411.

3. **Salzler, M., Nwachukwu, B. U., Rosas, S., Nguyen, C., Law, T. Y., Eberle, T., & McCormick, F. (2015).** State-of-the-art anterior cruciate ligament tears: A primer for primary care physicians. The Physician and sports medicine, 43(2), 169-177.

4. **Kiapour, A. M., & Murray, M. M. (2014).** Basic science of anterior cruciate ligament injury and repair. Bone and Joint Research, 3(2), 20-31.

5. **Samitier, G., Marcano, A. I., Alentorn-Geli, E., Cugat, R., Farmer, K. W., & Moser, M. W. (2015).** Failure of anterior cruciate ligament reconstruction. Archives of bone and joint surgery, 3(4), 220.

6. **Arora, D. (2017).** The Impact of Delay to Anterior Cruciate Ligament Reconstruction on Patient-Reported Outcomes and Concurrent Knee Injuries (Doctoral dissertation).

7. **Filbay, S. R., Ackerman, I. N., Russell, T. G., Macri, E. M.,**

&Crossley, K. M. (2014). Health-related quality of life after anterior cruciate ligament reconstruction: a systematic review. The American journal of sports medicine, 42(5), 1247-1255.

8. Nadarajah, V., Roach, R., Ganta, A., Alaia, M. J., & Shah, M. R. (2017). Primary anterior cruciate ligament reconstruction: perioperative considerations and complications. The Physician and Sports medicine, 45(2), 165-177.

9. Gokeler, A., Dingenen, B., Mouton, C., &Seil, R. (2017). Clinical course and recommendations for patients after anterior cruciate ligament injury and subsequent reconstruction: A narrative review. EFORT Open Reviews, 2(10), 410-420.

10. Peterson, L., &Renstrom, P. A. (2016). Sports Injuries: Prevention, Treatment and Rehabilitation. CRC Press.

11. Hart, J. M. (2015). Sports Rehabilitation, An Issue of Clinics in Sports Medicine, E-Book (Vol. 34, No. 2). Elsevier Health Sciences.

12. Artz, N., Elvers, K. T., Lowe, C. M., Sackley, C., Jepson, P., &Beswick, A. D. (2015). Effectiveness of physiotherapy exercise following total knee replacement: systematic review and meta-analysis. BMC musculoskeletal disorders, 16(1), 15.

13. Grindem, H., Eitzen, I., Engebretsen, L., Snyder-Mackler, L., &Risberg, M. A. (2014). Nonsurgical or surgical treatment of ACL injuries: knee function, sports participation, and knee reinjury: the Delaware-Oslo ACL Cohort Study. The Journal of bone and joint surgery. American volume, 96(15), 1233.

14. Frontera, W. R., Silver, J. K., & Rizzo, T. D. (2014). Essentials of Physical Medicine and Rehabilitation E-Book. Elsevier Health Sciences.

15. Joreitz, R., Lynch, A., Rabuck, S., Lynch, B., Davin, S., &Irrgang, J. (2016). Patient-specific and surgery-specific factors that affect return to sport after ACL reconstruction. International journal of sports physical therapy, 11(2), 264.

16. Kendall, F.P., McCreary, E.K., &Provance, P.G.(1993). Muscles testing and function. Baltimore, MD: Williams &Wilkins ; p. 179-9014.

17. Kujala, U.M., Jaakkola, L.H., Koskinen, S.K., Taimela, S., Hurme, M., Nelimarkka, O.(1993). Scoring of patellofemoral disorders. Arthroscopy: the journal of arthroscopic & related surgery: official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 1993; 9(2):159–63.Epub 1993/01/01. PMID: 8461073.

18. Kon, E., Altadonna, G., Filardo, G., Di Matteo, B., &Marcacci, M. (2014). Knee Scoring Systems. In European Surgical Orthopaedics and Traumatology (pp. 3371-3388). Springer Berlin Heidelberg.

19. Irrgang JJ, Snyder-Mackler L, Wainner RS, Fu FH, Harner CD. (1998).Development of a patient-reported measure of function of the knee. Journal of Bone & Joint Surgery - American Volume 1998; 80 A(8):1132-1145.

20. Wahed, S. B., Boughton, P., Wahed, T. B., Hossain, M. S., Haque, E., &Ruys, A. (2016) .A Systematic Review for Anterior Cruciate Ligament Reconstruction. J AnesthSurg 3(1): 119-127

21. Bregenhof, B., Jørgensen, U., Aagaard, P., Nissen, N., Creaby, M. W., Thorlund, J. B., ...&Holsgaard-Larsen, A. (2018). The effect of targeted exercise on knee-muscle function in patients with persistent hamstring deficiency following ACL

reconstruction–study protocol for a randomized controlled trial. Trials, 19(1), 75.

22. **Risberg, M. A., Oiestad, B. E., Gunderson, R., Aune, A. K., Engebretsen, L., Culvenor, A., & Holm, I. (2016).** Changes in knee osteoarthritis, symptoms, and function after anterior cruciate ligament reconstruction: a 20-year prospective follow-up study. The American journal of sports medicine, 44(5), 1215-1224.

23. **Davies, G. J., McCarty, E., Provencher, M., &Manske, R. C. (2017).** ACL return to sport guidelines and criteria. Current reviews in musculoskeletal medicine, 10(3), 307-314.

24. **Essery, R., Geraghty, A. W., Kirby, S., & Yardley, L. (2017).** Predictors of adherence to home-based physical therapies: a systematic review. Disability and rehabilitation, 39(6), 519-534.

25. **Fakhro, M. A., Wehbe, N., & Hassan, K. H. (2016).** Objective Criteria Associated with Unrestricted Return to SportsActivitiesAfterAnterior Cruciate Ligament Reconstruction. Int J Physiother Res, 4(2), 1459-67.

26. **Di Vico, G., Di Donato, S. L., Balato, G., Correra, G., D'Addona, A., Maffulli, N., & Rosa, D. (2017).** Correlation between time from injury to surgery and the prevalence of ramp and hidden lesions during anterior cruciate ligament reconstruction. A new diagnostic algorithm. Muscles, ligaments and tendons journal, 7(3), 491.

27. **Paterno, M. V., Huang, B., Thomas, S., Hewett, T. E., & Schmitt, L. C. (2017).** Clinical Factors That Predict a Second ACL Injury after ACL Reconstruction and Return to Sport: Preliminary Development of a Clinical Decision Algorithm. Orthopaedic journal of sports medicine, 5(12), 2325967117745279

28. **Cheecharern, S. (2018).** Return to sport and knee functional scores after anterior cruciate ligament reconstruction: 2 to 10 years' follow-up. Asia-Pacific Journal of Sports Medicine, Arthroscopy, Rehabilitation and Technology

29. **Okoroha, K. R., Keller, R. A., Jung, E. K., Khalil, L., Marshall, N., Kolowich, P. A., &Moutzouros, V. (2016).** Pain Assessment after Anterior Cruciate Ligament Reconstruction: Bone–Patellar Tendon–Bone versus Hamstring Tendon Autograft. Orthopaedic journal of sports medicine, 4(12), 2325967116674924.

30. **Christensen, J. C., Miller, C. J., Burns, R. D., & West, H. S. (2017).** Effect of Physical Therapy Visits on Clinical Outcomes Following Anterior Cruciate Ligament Reconstruction With and WithoutConcurrent Meniscal Repair. Journal of sport rehabilitation, 1-29.

31. **Magnussen, R. A., Reinke, E. K., Huston, L. J., MOON Group, Hewett, T. E., &Spindler, K. P. (2016).** Effect of high-grade preoperative knee laxity on anterior cruciate ligament reconstruction outcomes. The American journal of sports medicine, 44(12), 3077-3082.

32. **Filbay, S. R., Ackerman, I. N., Russell, T. G., &Crossley, K. M. (2017).** Return to sport matters—longer-term quality of life after ACL reconstruction in people with knee difficulties. Scandinavian journal of medicine & science in sports, 27(5), 514-524.

33. **El-Kafafy, H. H., & El-Hadary, S. M. (2012).** Effect of Nursing Rehabilitation Program on knee function and functional status among

patients after Anterior Cruciate Ligament (ACL) Reconstruction at El-Manial University Hospital. Journal of American Science, 8(12).

34. **Kanamoto, T., Tanaka, Y., Yonetani, Y., Kita, K., Amano, H., Kusano, M., ...&Horibe, S. (2015).** Anterior knee symptoms after double-bundle ACL reconstruction with hamstring tendon autografts: an ultrasonographic and power Doppler investigation. Knee Surgery, Sports Traumatology, Arthroscopy, 23(11), 3324-3329.

35. **Hamada, H. A., Draz, A. H., Koura, G. M., & Saab, I. M. (2017).** Carryover effect of hip and knee exercises program on functional performance in individuals with patellofemoral pain syndrome. Journal of physical therapy science, 29(8), 1341-1347.

36. **Lee, M., Sung, D. J., Lee, J., Oh, I., Kim, S., Kim, S., & Kim, J. (2016).** Enhanced knee joint function due to accelerated rehabilitation exercise after anterior cruciate ligament reconstruction surgery in Korean male high school soccer players. Journal of exercise rehabilitation, 12(1), 29.

37. **Heijne, A., & Werner, S. (2010).** A 2-year follow-up of rehabilitation after ACL reconstruction using patellar tendon or hamstring tendon grafts: a prospective randomised outcome study. Knee Surgery, Sports Traumatology, Arthroscopy, 18(6), 805-813.

38. **Uçar, M., Koca, I., Eroglu, M., Eroglu, S., Sarp, U., Arik, H. O., &Yetisgin, A. (2014).** Evaluation of open and closed kinetic chain exercises in rehabilitation following anterior cruciate ligament reconstruction. Journal of physical therapy science, 26(12), 1875-1878.

39. **Panchal, P., Bedekar, N., Sancheti, P., &Shyam, A. (2017).** Effects of Lumbar Core Stability Exercise Programme on Knee Pain, Range of Motion, and Function Post Anterior Cruciate Ligament Reconstruction:. Journal of Orthopaedics, Trauma and Rehabilitation, 23, 39-44.

40. **Konishi, Y., Oda, T., Tsukazaki, S., Kinugasa, R., &Fukubayashi, T. (2012).** Relationship between quadriceps femoris muscle volume and muscle torque at least 18 months after anterior cruciate ligament reconstruction. Scandinavian journal of medicine & science in sports, 22(6), 791-796.

41. **Gokeler, A., Bisschop, M., Benjaminse, A., Myer, G. D., Eppinga, P., &Otten, E. (2014).** Quadriceps function following ACL reconstruction and rehabilitation: implications for optimisation of current practices. Knee Surgery, Sports Traumatology, Arthroscopy, 22(5), 1163-1174.

42. **Gerber, J. P., Marcus, R. L., Dibble, L. E., Greis, P. E., Burks, R. T., &Lastayo, P. C. (2007).** Safety, feasibility, and efficacy of negative work exercise via eccentric muscle activity following anterior cruciate ligament reconstruction. Journal of orthopaedic& sports physical therapy, 37(1), 10-18.