Effectiveness of a Recommended Program for Muscular Strength exercises and Range of Motion on knee flexors and extensors muscles on athletes with ACL

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Abstract: The current study aims to identify the effectiveness of a designed rehabilitation training program on muscular strength exercises and range of motion (ROM) on athletes with anterior cruciate ligament (ACL) injury. The procedure was on experimental bases (one-group design) with pre-test, during, and post-tests for knee flexors and extensors muscles. The dynamometer was used for isokinetic testing of muscular strength and ROM following the same protocol for all participants and measurements. The entire measurements were performed in the "Sports Medicine and Health Awareness Center" (SMHAC) affiliated with the Public Authority for Sport in The State of Kuwait. The program lasted for (8) weeks with (3) sessions per week making a total of (24) rehabilitation sessions. Fourteen male football players from different sports club aged between 19 and 22 years with ACL injury were chosen to participate in this study. The results show statistically significant differences among the three measurements (pre-test/during-test/post-test) on isokinetic muscular strength for right leg flexion and extension at both tests (60°/sec) and (180°/sec) and also, for the left leg flexion and extension at both (60°/sec) and (180°/sec). This indicate that the recommended exercises program had a positive effect on rehabilitating knee joint flexors and extensors muscles and helped improving knee range of motion in post-operative treatment of ACL. It is recommended that the rehabilitation program with strength and ROM exercises should be used for rehabilitating athletes with ACL injuries.

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1. Introduction:

Participation in sport plays a big part in people live and has many benefits in improving health and fitness, while exercise training for athletes improves performance by developing skills, experience and fitness (Grisogone V. 1996). However, exercise scientists have classified fitness in the following components; strength, power, agility, balance, flexibility, local muscle endurance, cardiovascular endurance, strength, and coordination (Tancred, 1995), (Davis, 2000). With the benefits of participation in sport activities, injury is among the main obstacles that can cause for some athletes problems and injury which may decrease the technical and physical level of an athlete. Injury occurs as a result of multiple factors at a given time (Lysens et al., 1991) and limits athletes' participation for several days or weeks and refrain him from training and competing (Farrag, M. 2004: 15), (Volpi et al., 2016). In most sports, the lower extremity is the most body region often injured (Wong p & Hong Y. 2005), (Ekstrand et al., 2011).

Injury rates increase with the increase of sports competitions and its intensity. It poses significant pressure on joints, muscles, ligaments, and tendons (Schmikli et al., 2011), (Riad, O. 1999: 5-6). Sports governing bodies all over the world try to provide a healthy training environment and integrated medical care system, and without a good medical care system athletes will suffer from limited participation in either training and/or competition (Farrag, M. 2004: 127), (Keller et al., 2016).

The knee joint is located between the longest two bones of the body; femur and tibia and surrounded with strong muscles and ligaments (Rushdy, M. 1999: 226), (van Eck et al., 2015). The quadriceps and hamstrings muscles control the knee movement in extension and flexion positions. The hamstring muscle spam the hip to the knee maintains and coordinate the two joints movement and the quadriceps muscle play an important role in jumping and kicking a football (Agre CY, 1985), (Fried & Lloyd, 1992). The knee joint is vulnerable to such injuries in some sports situations because of its anatomy (Rushdy M. 1999: 226).

Therapeutic exercises are meant to help to restore the injured body part after treatment to its normal condition and full function, moreover in preventing recurrence injuries by performing exercises that improve strength, flexibility and coordination (Zaher, A. 2005: 49). Sports rehabilitation accompanied with continuous effort is very significant for athletes in general and especially soccer players. Athletes after healing and pain free are able to start the rehabilitation program with dynamic exercises (Baumgart et al., 2015). If severe pain appears the knee range of motion is decreased, and if pain persists, the athlete turns to static exercises (Lee et al., 2016). Previous studies indicated that there are various types of programs and exercises that may help injured athletes to return quickly to their sport e.g. for knee joint injuries, exercises of strength and range of motion have been used (Indelicato et al., 1990), (Rawanat & Rawanat. 2007), (Longstaff et al., 2009), (Awadalla, A. 2012), (Farber et al., 2014).

Aim:

The current study aims to use muscular strength test exercises and range of motion (ROM) of the knee joint as a rehabilitation training program for the knee extensor and flexor muscles in athletes with ACL injuries.

Hypothesis:

The recommended muscular strength and range of motion exercises contribute in rehabilitating the injured knee in athletes with ACL injuries.

2. Methods:

Approach:

The researcher used the experimental approach (one-group design) with pre-test, during-test and post-test.

Subjects:

Fourteen (n=14) male football players aged between 19 and 22 years with ACL injury purposefully chosen to participate in this study. The injured soccer athletes play in different sporting clubs and had finished the ACL surgery. The procedure was designed after a few pilot experiments in the Sports Medicine and Health Awareness Center (SMHAC) which is affiliated with the Public Authority for Sport in The State of Kuwait. Upon arrival to the clinic, personal information such as name, age, height and weight were recorded, table (1).

Table (1): mean, SD and Skewness for all participants

	Variable	**Unites**	**Mean**	**SD**	**Median**	**Skewness**
Descriptive Data	**Age**	**Year**	20.7	0.90	20.50	0.67
	Height	**Cm**	164	0.33	164.1	0.91
	Weight	**Kg**	65.9	0.363	66	0.83
Physical Variables	**Trunk flexibility**	**Cm**	2.40	1.38	2.00	0.87
	Leg width	**Cm**	48.50	1.94	48.00	0.77
	Standing Long jump	**Cm**	140.40	1.82	140.00	0.66
	Vertical jump	**Cm**	22.10	1.01	22.30	-0.59
	Zigzag agility	**Sec**	11.10	0.87	11.00	0.34
	Static balance	**Sec**	3.30	1.11	3.00	0.81
	Dynamic balance	**Degree**	42.00	1.68	42.50	-0.89

Table (1) indicated that skewness values ranged from 0.67 to 0.91 for growth factors and from -0.87 to -0.89 for physical variables. These values are between (±3). This indicates normality of data.

Data collection instruments:

Equipment:

The following devices were used: Dynamometer for Isokinetic testing, Ergometer cycle, treadmill, scale for height measurements, medical weight scale, balance board, and leg curl bench.

Physical tests:

The researcher prepared a list with all physical qualities that may be useful for this research and presented it to a group of experts to choose the most relevant physical qualities as seen in table (2).

Agreement percentages were ranged between 20% and 100%, whereas the variables below 70% were excluded and the following tests were chosen: Trunk flexibility, leg width, standing long jump, vertical jump, zigzag agility, static balance and dynamic balance tests.

Muscular Strength:

Muscular Strength for the knee flexors and extensors muscles using:

- Muscular strength test
- Isokinetic dynamometer for measuring maximum flexion and extension of the knee.

The athletes were asked to make full range of motion to ensure full muscle stretching.

Pilot study:

A pilot study was applied for two athletes (n=4) with the recommended rehabilitation exercises to ensure the devices and to identify the time of the experiment.

The recommended rehabilitation program:

The program aims to rehabilitate athletes with ACL according to principles of rehabilitation through improving muscular strength, flexibility and dynamic/static balance (Long staff et al., 2009), (Ranawat & Ranawat, 2007), (Indelicato et al., 1990). According to literature review, the researcher prepared a list of exercises to be used in the program and presented it to some experts. The experts decided to choose (5) exercises with number and frequency, table (1) & (2).

The program lasted for (8) weeks with (3) sessions per week. The program included a total of (24) rehabilitation sessions. The procedure was as follows; three measurements (pre-test/during-test/post-test) on isokinetic muscular strength for right leg flexion and extension at both tests (60°/sec) and (180°/sec) and also, for the left leg flexion and extension at both (60°/sec) and (180°/sec).

Main application:

The program was applied to the experimental group with three separate measurements (pre-test, during test and post-test) following the same protocol for all participants and all measurements. All measurements were performed in The Sports Medicine and Health Awareness Center (SMHAC), Kuwait.

Statistical treatment:

All data were collected, analyzed using Statistical Package for Social Sciences (SPSS) version 21.0 with level of significant set at p≤ 0.05. The calculations were made for mean, SD, skewness, correlation coefficient, (t) test, (F) test, LSD test, and variance rate (%).

Table (2): Experts Opinions about the Most Relevant tests

Variable	Number of agreements	Percentage	Rank according to relative importance
Balance	10	100 %	**1st**
Muscular strength	9	90%	**2nd**
Flexibility	9	90 %	**3rd**
Agility	8	80 %	**4th**
Muscular power	7	70 %	**5th**
Reaction	5	50 %	**6th**
Muscular endurance	4	40 %	**7th**
Coordination	3	30 %	**8th**
Muscular Strength	2	20 %	**9th**
Cardiovascular endurance	2	20%	**10th**

3. Results:

Table (3) indicated statistically significant differences among the three measurements (pre/during/post) for all participants on isokinetic leg muscular strength. This led the researcher to perform LSD analysis.

Table (3): analysis of variance among three measurements (pre/during/post) of isokineticleg muscular strength (flexion – extension)

Variables	Variance source	Sum of squares	Freedom degree	Mean of squares	(F)
Right leg extension (60°/sec)	Inter-group	143.00	2	71.50	9.12*
	Intra-group	211.68	27	7.84	
Right leg flexion (60°/sec)	Inter-group	74.82	2	37.41	6.33*
	Intra-group	159.57	27	5.91	
Right leg extension (180°/sec)	Inter-group	184.08	2	92.04	7.84*
	Intra-group	316.98	27	11.74	
Right leg flexion (180°/sec)	Inter-group	86.21	2	43.11	5.74*
	Intra-group	202.77	27	7.51	
Left leg extension (60°/sec)	Inter-group	116.47	2	58.23	8.64*
	Intra-group	181.98	27	6.74	
Left leg flexion (60°/sec)	Inter-group	80.52	2	40.26	4.66*
	Intra-group	233.28	27	8.64	
Left leg extension (180°/sec)	Inter-group	120.01	2	60.00	7.51*
	Intra-group	215.73	27	7.99	
Left leg flexion (180°/sec)	Inter-group	56.48	2	28.24	4.92*
	Intra-group	154.98	27	5.74	

P ≤0.05 = 3.15

Table (4): LSD analysis among the three measurements (pre/during/post) for all participants on isokineticleg muscular strength

Variable	Test	Mean	Difference			L.S.D
			Pre-	during	Post-	
Right leg extension (60°/sec)	Pre-	134.27		14.24*	28.45*	6.34
	during	148.51			14.21*	
	Post-	162.72				
Right leg flexion (60°/sec) Right leg extension (180°/sec)	Pre-	106.51		15.64*	36.15*	9.66
	during	90.87			20.41*	
	Post-	70.46				
Right leg flexion (180°/sec)	Pre-	142.67		18.52*	40.74*	11.27
	during	124.15			22.22*	
	Post-	101.93				
Left leg extension (60°/sec) Left leg flexion (60°/sec)	Pre-	42.97		5.19*	12.62*	3.55
	during	48.16			7.43*	
	Post-	55.59				
Left leg extension (180°/sec)	Pre-	132.23		15.41*	24.53*	4.29
	during	147.64			9.12*	
	Post-	156.76				
Left leg flexion (180°/sec) Right leg flexion (60°/sec)	Pre-	56.61		5.54*	11.23*	2.97
	during	62.15			5.69	
	Post-	67.84				
Right leg extension (180°/sec)	Pre-	77.45		8.22*	19.74*	5.79
	during	85.67			11.52*	
	Post-	97.19				
Right leg flexion (180°/sec)	Pre-	37.99		5.82*	12.38*	2.41
	during	43.81			6.56*	
	Post-	50.37				

LSD value on P ≤0.05= 0.25

Table (4) indicates that the least significant difference among the three measurements (pre/during/post) for all participants on isokinetic leg muscular strength was in agreement with the post-measurement.

Table (5): analysis of variance among the three measurements (pre/during/post)

Variables	Variance source	Sum of squares	Freedom degree	Mean of squares	(F)	Variables
Trunk flexibility	Cm	Inter-group	230.10	2	115.05	8.67*
		Intra-group	358.29	27	13.27	
Leg width	Cm	Inter-group	121.45	2	60.73	6.74*
		Intra-group	243.27	27	9.01	
Standing long jump	Cm	Inter-group	107.45	2	53.73	4.78*
		Intra-group	303.48	27	11.24	
Vertical jump	Cm	Inter-group	159.58	2	79.79	9.14*
		Intra-group	235.71	27	8.73	
Zigzag agility	Sec	Inter-group	124.38	2	62.19	8.27*
		Intra-group	203.04	27	7.52	
Static balance	Sec	Inter-group	113.13	2	56.56	6.37*
		Intra-group	239.76	27	8.88	
Dynamic balance	Degree	Inter-group	97.70	2	48.85	5.27*
		Intra-group	250.29	27	9.27	

P ≤0.05 = 3.15

Table (5) indicates statistically significant differences among the three measurements (pre/during/post) for all participants. This led the researcher to perform LSD analysis.

Table (6): LSD analysis among the three measurements (pre/during/post)

Variable	Test	Mean	Difference			L.S.D
			Pre-	during	Post-	
Trunk flexibility	Pre-	2.40		1.40*	4.00*	1.03
	during	3.80			2.60*	
	Post-	6.40				
Leg width	Pre-	48.50		9.00*	25.00*	7.61
	during	39.50			16.00*	
	Post-	23.50				
Standing long jump	Pre-	140.40		10.40*	20.20*	6.33
	during	150.80			9.80*	
	Post-	160.60				
Vertical jump	Pre-	22.10		2.50*	5.20*	1.18
	during	24.60			2.70*	
	Post-	27.30				
Zigzag agility	Pre-	11.10		1.32*	2.50*	0.99
	during	9.78			1.18*	
	Post-	8.60				
Static balance	Pre-	3.30		0.81*	2.30*	0.72
	during	4.11			1.49*	
	Post-	5.60				
Dynamic balance	Pre-	42.00		3.15*	10.90*	1.37
	during	45.15			7.75*	
	Post-	52.90				

LSD value on P ≤0.05= 0.25

Table (6) indicates that the least significant difference among the three measurements (pre / during / post) for all participants on physical tests was in agreement with the post-measurement.

Table (7): Improvement of the post-test from pre- and duringtest

Variable	Tests			Improvement percentage (%)		
	Pre-	during	Post-	1x2	1x3	2x3
Trunk flexibility	2.40	3.80	6.40	58.33	166.67	68.42
Leg width	48.50	39.50	23.50	18.56	51.55	40.51
Standing long jump	140.40	150.80	160.60	7.41	14.39	6.50
Vertical jump	22.10	24.60	27.30	11.31	23.53	10.97
Zigzag agility	11.10	9.78	8.60	11.89	22.52	12.06
Static balance	3.30	4.11	5.60	24.55	69.70	36.25
Dynamic balance	42.00	45.15	52.90	7.50	25.95	17.17

Table (7) show significant improvements from pre- to during and from during to post-testof all tests in agreement with post-test.

4. Discussion:

Tables (3) and (4) show statistically significant differences among the three measurements (pre/during/post) on isokinetic muscular strength test [resenting the post-test. The following results were obtained: right leg extension (60°/sec) (10.60% - 21.19% - 9.57%) - right leg flexion (60°/sec) (14.68% - 33.85% - 22.46%) - right leg extension (180°/sec) (12.98% - 29.37% - 15.43%) - right leg flexion (180°/sec) (12.08% - 29.37% - 15.43%) - left leg extension (60°/sec) (11.65% - 16.61% - 6.18%) - left leg flexion (60°/sec) (9.78% - 19.84% - 9.16%) - left leg extension (180°/sec) (10.61% - 25.49% - 13.45%) - left leg flexion (180°/sec) (15.32% - 32.59% - 14.97%). These results indicate the positive effects of maximum leg strength exercises that a muscle can generate against resistance in maximum voluntary contraction (Hammad, M. 2001: 131).

These statistically significant differences among the three measurements were representing the post-tests. This could be because of the recommended rehabilitation program using various resistance exercises that include strength exercises for leg and back major muscles (Longstaff et al., 2009), (Ranawat & Ranawat, 2007), (Indelicato et al., 1990).

Tables (5) and (6) indicate statistically significant differences among the three measurements (pre/during/post) for all participants and represent post-tests. These differences were confirmed with the results indicated in table (7) that significant improvements between pre- and during tests and during and post-tests represent the post-test.

The researcher believes that these results are due to the rehabilitation program according to modern rehabilitation trends used in major rehabilitation centers all over the world. Previous studies indicated that rehabilitation programs targeting knee injuries should concentrate on improving muscular strength, flexion and extension. These exercises help healing ligaments and restoring them to normal condition. The increase in strength generation is stimulating neuromuscular spines that work on recruiting more muscular fibers in addition to improving muscular tissue elasticity (Longstaff et al., 2009), (Ranawat & Ranawat, 2007), (Indelicato et al., 1990). Dynamic exercises based on physiological and anatomical principles help rehabilitating the injured part and restoring it function to normal condition before injury (Zaher, A. 2005: 84).

Results also indicated that the recommended rehabilitation program induced significant improvements among the three measurements as these improvements were obvious between pre- and during tests and during and post-tests. These improvements are because of implementing the recommended rehabilitation program.

Finally, the recommended rehabilitation program led to improving measurements of muscular strength and range of motion through progression from static to dynamic exercises and through using different resistances in different directions while maintaining progressive increase in volume and intensity (Longstaff et al., 2009), (Ranawat & Ranawat, 2007), (Indelicato et al. 1990). This proves the research hypothesis that "the recommended muscular strength and range of motion exercises contribute in rehabilitating the knee joint flexors and extensors muscles of athletes with ACL".

5. Conclusions:

The recommended exercises had positive effects on rehabilitating knee joint flexors and extensors muscles and helped improving knee range of motion in post-operative treatment of ACL.

Recommendations:

The recommended rehabilitation program with strength and ROM exercises should be used for rehabilitating athletes with ACL injuries.

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