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Original Research Article

OBJECTIVE CRITERIA ASSOCIATED WITH UNRESTRICTED RETURN TO SPORTS ACTIVITIES AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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ABSTRACT

Background: After an anterior cruciate ligament reconstruction (ACLR), athletes return to full sports activities based on a clinical decision following postoperative rehabilitation. The purpose of this study was to find if clinical decision to release athletes back to unrestricted sports activities afterACLR matches the findings of objective criteria of muscle strength and lower limb symmetry.

Materials and Methods: The study used a cross-sectional observational design.Thirty-two athletes who were released within 1 to 7 months to full sports activities were recruited from Lebanese first, second and third sports divisions. Participants performed a battery of tests including: knee extension/flexion, single leg press to assess muscle strength and single leg hop, triple hop, cross-over hop, timed hop and single hop after fatigue for distance to assess lower limb symmetry.

Results: Demographic results showed that mean age of participants was 24.37 years. Bone-patellar tendon bone (BPTP) autograft was the most used surgical technique for ACLR. Ten athletes passed the muscle strength testing, whereas twelve athletes had passed that of lower limb symmetry. Therefore, only 18.75% (six athletes out of thirty-two) could be released back to full sports activities following the combined testing of muscle strength and lower limb symmetry, whereas, they all had been released previously to full sports activities based on clinical decision.

Discussion and Conclusion: Despite that athletes have been released by a clinical decision in a range of one to seven months, there were still significant deficit in muscle strength and lower limb symmetry. The results of this study show noteworthy problems in muscle strength and lower limb symmetry following ACLR. Use of objectives criteria might be a useful adjunct to clinical decision before release of athletes to unrestricted sports activities.

KEY WORDS: Anterior cruciate ligament reconstruction, Clinical decision, Return to athletics.

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INTRODUCTION

ACL injury is a physically debilitating knee injury to athletes that may impact function leading to deficits, increase risk for a second ipsilateral and/or contralateral ACL injury, and other prospective joint morbidity (e.g.: early cartilage degeneration) as well as loss of functional joint stability [1].

Reconstruction is recommended after injury to restore normal knee function, maximize stability, functional capacity and recovery and to allow subsequent return of athletes to pre-injury level in sport activities [2]. Unfortunately, this reconstruction may fail, and many problems may arise including: ACL rupture in the contralateral knee or reinjuring of the ACL-reconstructed knee compromising therefore the return to sport (RTS) activities [3].

The decision to RTS is a potentially sensitive landmark for athletes, and especially for those who have a strong desire to return to immediate sports participation after ACLR.

Many studies have been conducted to identify objective and subjective criteria used to determine when RTS activities were allowed after primary ACLR [3,4]. The objective criteria included the following: time postoperatively; knee range of motion (ROM) and knee effusion; stability; muscle strength testing or thigh muscles circumference measurement; dynamic function; neuromuscular function; aerobic capacity assessment; and sports specific testing [3]. However following rehabilitation, the ACL-reconstructed athletes are not being well objectively assessed prior to release to unrestricted sports activities [3], and two-third of athletes who undertook ACLR did not return to pre-injury sports activity levels. Further-more, among those who did RTS, ACL re-injury occurred at 3% to 19% in the ipsilateral reconstructed knee, and 5% to 24% in the contralateral knee [4].

To our knowledge, no studies have been conducted about objective criteria prior to release to unrestricted sports activities after ACLR in the Middle Eastern context, especially in Lebanon where a haphazard clinical decision is used to determine who among the athletes can successfully RTS activities after ACLR. Therefore, the aim of this study was to find if clinical decision of releasing athletes back to unrestricted sports activities matches the findings of the most common objective criteria of muscle strength and lower limb symmetry.

MATERIALS AND METHODS

Study design: This study used a cross sectional observational design. The study protocol was revised and approved by the Institutional Board of the Physical Therapy Department of the university.

Subjects: For the purpose of this study, convenience sampling was used to recruit thirty-two athletes with ACLR (22 males, 10 females) aged between 18 and 40 and newly released (less than seven months), from sports rehabilitation centers and from the Lebanese first, second and third divisions of collective sports: 1) soccer; 2) basketball; 3) handball; 4) rugby; 6) and futsal, and individual sports: 1) kung fu; and 2) swimming during April 2013.

Participants were included if they had a primary unilateral ACLR with no effusion and complete ROM compared with the non-operative limb; thigh circumference less than 1cm measured comparatively to the contralateral sound thigh; stable contralateral knee (no injury or surgical interventions in the past year); able to read and understand English. Athletes with concomitant meniscal injury that required repair were included in the study, provided that they were permitted to undergo typical rehabilitation after ACLR involving immediate full weight-bearing gait and unrestricted non–weight-bearing range of motion, and that meniscal injury was asymptomatic, what means, that at baseline examination, they were able to run and perform single legged hop without knee pain or subsequent effusion.

Exclusion criteria were posterior cruciate ligament injury and any other concomitant ligamentous injury; intra-articular fractures; cartilage injury affecting the subchondral bone plate observed on MRI; being skeletally immature; symptomatic meniscus injury; history of low back injury or either lower extremity injury or surgery (beyond ACL injury) requiring the care of a physician in the past year or any concurrent musculoskeletal condition (eg: back, hip, or ankle injury) rendering them unable to hop on either extremities. Athletes who met inclusion criteria after clinical assessment (full passive ROM, thigh circumference less than 1cm comparatively, and underwent a battery of tests in one of the following two locations based on their place of residence (1-Specialized rehabilitation department of Al-Sahel General Hospital; 2- Specialized Top Form Gym). Testing started with the following order: 1) general warm-up followed by specific warm-up prior to each test; 2) leg extension; 3) leg flexion; 4) and leg press for 1RM testing. After two hours approximately of rest, hop test started in the following order: 1) single leg hop for distance; 2) 6-m timed hop; 3) triple hop for distance; 4) crossover hop for distance; 5) hop test while developing fatigue. Testing took about 35 to 45 minutes.

Demographic characteristics includs 1) age; 2) gender; 3) height; 4) type of sports discipline; 5) division; 6) weight; 7) injury; 8) surgery; 9) and release to unrestricted sports activities respectively; 10) which leg is ACL-reconstructed; 11) Who permitted the release to unrestricted sports activities; 12) testing submitted before release; 13) type of the graft; 14) category of sports; 15) and BMI.

MATERIALS

1RM tests: An estimation of Hamstring and Quadriceps 1RM was done using Brzycki equation after a battery of tests including: 1) leg extension; 2) leg flexion; 3) and single leg press [5].

The Brzycki formula**:**Weight lifted ÷ (1.0278 - (0.0278 × Number of repetitions) exhibited relatively low level of bias (1.6 to 0 kg) and had Intraclass correlation coefficient (ICC) above 0.97 and the lower end of the 95% confidence interval above 0.94 [6]. The ICC for 1-RM test-retest measures was 0.983 (95% confidence interval= 0.964–0.997) [7].

Hop tests: The second indicator used was hop tests which measure the lower limb symmetry. The hop tests included: 1) the single leg hop for distance; 2) 6-m timed hop; 3) triple hop for distance; 4) crossover hops for distance; and 5) single hop during fatigue. ICC's ranged from 0.82 to 0.93 and can be described as indicating excellent relative reliability [7].

Study procedure: Before testing, general warm-up (cardiovascular warm-up) consisted in spending for at least 5 min cycling on a stationary bicycle at a moderate pace (approximately 60 revolutions per minute). Afterwards the athlete performed a specific warm-up including a set of ten repetitions, with a light load prior to each tests. One min is given between each test as rest time. After estimating the 1RM, the Quadriceps index (QI) for the Quadriceps strength, Hamstrings Index (HI) for the Hamstrings muscle strength and the ratio of single leg press (SLP) test was calculated through the following formula: Maximum weight on the involved limb / the maximum weight on the uninvolved limb x 100 for each index [1].

To be efficient muscles need that the athlete scores on each of QI, HI, and SLP a ratio equal or above 90% [5].

Hop tests procedure: For each hop test, the subjects performed one practice trial for each limb, followed by two measured and recorded trials. Athletes were encouraged to wear the footwear they normally wear during their rehabilitation sessions. The hop testing was created on a 6-m long course. A standard cloth tape measure was fixed to the ground, perpendicular to a marked starting line. Athletes were instructed to begin each set of tests, with the non-reconstructed limb. To lessen fatigue, two type of rest periods were offered: 1) between types of hop tests (up to 2 minutes); and 2) between individual hop test trials if needed (typically less than 30 seconds). Subjects started each test with the lead toe behind a starting line. During testing, no limitations were placed on arm movement, as well as regarding to where to look. For the hops for distance (single, triple, crossover and after fatigue) to be considered successful, the landing must have been maintained for two seconds. A hop was considered unsuccessful in case of: 1) touching down of the contralateral lower extremity; 2) touching down of either upper extremity; 3) loss of balance; 4) or an additional hop on landing. In these cases, the athlete was reminded of the requirement to maintain the landing, and the hop was repeated [7].

The single hop for distance was performed as outlined by Daniel et al. (1982) cited in Reid et al. (2007). Athletes stood on the leg to be tested, with the great toe on the starting line, hopped, and landed on the same limb. The distance hopped was measured to the closest centimeter at the level of the great toe.

The timed 6-m hop was performed as outlined by Barber et al. (1990) cited in Reid et al. (2007). Athletes were instructed to perform large one-legged hops in series over a total distance of 6 meters, while a standard stopwatch was used to record time. The stopwatch was started when a subject's heel left the starting position and was stopped the moment that the tested foot crossed the finish line. Measurements were recorded to the nearest 10th of a second.

The triple hop for distance was performed as outlined by Noyes et al. (1991) cited in Reid et al. (2007). Athletes were taught to stand on one leg and perform three consecutive hops as far as possible which were recorded, and land on the same leg.

The crossover hop for distance was performed over a 15-cm strip on the floor. Athletes hopped forward three times while alternately crossing over a marked line where this distance was recorded.

The hop test while developing fatigue was performed after a fatiguing exercises protocol that consisted of working consecutive unilateral knee extensions till fatigue, performed by as many repetitions as possible in a single set, at a load of 80% of 1RM, using a variable resistance knee-extension machine, followed immediately by single-leg hop (the approximate time delay was between 5 and 10 sec) [8].

The distance hopped on each leg is recorded and the LSI is calculated after finding the mean of the two trials. LSI was expressed as a percentage of the averaged involved limb hop distances divided by the averaged uninvolved limb hop distances for each participant and each hop distance test. For the 6-m timed hop, LSI was expressed as the percentage of the averaged uninvolved limb hop time divided by the averaged involved limb hop time [9]. For the single leg, triple, and after developing fatigue hops, LSI should be 90% and above. The optimal cutoff for the 6-m timed hop was 87.7% LSI, whereas the optimal cutoff for the crossover hop was 94.9% [9]. To be efficient, lower limb symmetry needs the athlete to score on all the hop tests above their cut-off [5].

Data analysis: Statistical analyses were performed with PASW version 18 (SPSS) and Statistical significance was set at p<0.05. As for demographics and participant's characteristics, the ones that were used for further statistical analysis were: 1) age; 2) type of discipline; 3) height; 4) date of injury; 5) date of surgery; 6) date of release; 7) person who permitted the release; 8) side of ACL injury; 9) testing done before the release; 10) type of graft; 11) gender; 12) weight; 13) BMI; 14) category of sports; 15) and the division.

Descriptive statistics were conducted for all the attributes and main key variables (muscle strength and lower limb symmetry) as well as for the unrestricted release.

Inferential statistics sought relationships between main key variables and the release to unrestricted sports activities, using:

a) t-test for: 1) age; 2) height; 3) date of injury; 4) date of surgery; 5) date of release; 6) weight; 7) and BMI;

b) Fisher's exact test (two-sided) for BPTB autograft;

c) Fisher's exact test (two-sided) for: 1) gender; 2) side of ACLR; 3) category of sports; 4) the most common in: a) type of testing done before release, b) who permitted the release, c) type of discipline, d) division and finally;

d) Fisher's exact test between UR to sports and EMS, ELLS respectively and between EMS and ELLS.

RESULTS

Table 1a: Socio-demographic characteristics of the participants**.**

	Minimum	Maximum	Mean	SD
Age (years)	18	34	24.375	4.18715
Height (meters)	1.6	1.95	1.7972	0.07822
Weight (Kg)	69	106	83.6875	9.62167
BMI (kg/m2)	21.3	30.93	25.9522	2.37527
Date of injury (months)	6	20	12.6563	2.70733
Date of surgery (months)	5	15	10.7188	2.15877
Date of release (months)	1	7	3.84	1.706

The mean of age was 24.37 years, height 1.8 meters, BMI 25.95 kg/m2 and weight 83.69 kg. At testing time, 22 males and 10 females were included. From the 32 participants, 21 had right ACLR, and 10 had left ACLR. Twenty-eight of the ACLR were BPTB autograft. Prior to release 43.75% (n=14) were tested by Biodex and Lachman's test; 28.125% (n=9) were just tested by Lachman's test; 18.75% (n=6) were tested by Lachman's test and thighs circumference measurements; 9.375% (n=3) submitted Biodex testing, Lachman, and thigh circumference combined.

Table 1b: Socio-demographic characteristics of the participants. Con't.

	Total	Percentage
Participants	**32**	**100%**
Side of ACLR:		
Right	21	65.63%
Left	11	34.37%
Type of graft:		
BPTB [2] auto graft	28	87.50%
STG autograft	3	9.38%
2B STG autografts.	1	3.13%
Discipline:		
Soccer	10	31.25%
Basketball	14	43.75%
Handball	2	6.25%
Kung fu	1	3.13%
Rugby	1	3.13%
Futsal	3	9.38%
Swimming	1	3.13%
Division:		
First	20	62.50%
Second	8	25%
Third	4	12.50%
Released by:		
Surgeon	30	93.75%
PT	1	3.13%
Surgeon+PT	1	3.13%
Testing prior to release:		
Lachman	9	28.13%
Biodex+Lachman+TC	3	9.38%
Biodex+Lachman	14	43.75%
Lachman+TC	6	18.75%
Gender:		
Male	22	68.75%
Female	10	31.25%
Category of sports:		
Collective	30	93.75%
Individual	2	6.25%

The QI mean was 97.12% (±16.39 %). Whereas, HI recorded a mean of 97.12 %(±18.43 %) and the Ratio a mean of 97.05 % (±16.65%).

LSI mean of the single leg hop for distance was 95.74 % (±7.81%); that of 6-m hop test was 94.17% (± 10.56)%; whereas LSI mean for triple hop for distance mean was 95.7% (±5.89%). Crossover hop for distance LSI mean was 98.72% (±6.75%) and that of the hop test after fatigue was 94.45% (±6.72%).

Table 2: Descriptive statistics of main variables.

Muscle strength: 1RM tests	Mean	SD	Minimum	Maximum
LE[1] (right) (Kg)	70.05	26.35	27	123.5
LE (left) (Kg)	75.21	33.01	29	181
QI[2] (%)	97.12	16.39	74	157.3
LF [3] (right) (Kg)	65.43	20.01	34	103
LF (left) (Kg)	64.88	24.34	23	129
HI[4] (%)	94.64	18.43	45	143
SLP[5] (right) (Kg)	276.42	224.01	65	650
SLP (left) (Kg)	275.09	229.18	49	642
Ratio (%)	97.09	16.65	78.47	163.26
Lower limb symmetry: hop tests	Mean	SD	Minimum	Maximum
SLHD[6] (right) (cm)	117.9	15.38	79.5	137
SLHD(left) (cm)	120.92	17.03	71.5	156
LSI (%)	95.74	7.81	74.3	109.09
6-m hop(right) (seconds)	3.06	0.58	1.75	4.8
6-m hop(left) (seconds)	2.95	0.73	1.86	5.5
LSI (%)	94.17	10.56	75	123.14
THD[7](right) (cm)	382.19	61.2	235.5	488.8
THD(left) (cm)	393.25	63.66	256.3	501.3
LSI (%)	95.7	5.89	82.84	105.9
CHD([8]right) (cm)	337.95	59.1	215	503.5
CHD(left) (cm)	338.18	64.15	186.5	516.4
LSI (%)	98.72	6.75	84.39	115.28
HAF[9](right) (cm)	125.48	16.08	84	157
HAF(left) (cm)	128.17	18.23	81	161
LSI[10] (%)	94.45	6.72	79.25	107.26

1 BPTB: Bone patellar tendon bone
2 PT: Physical therapist.
3 LE: Leg extension
4 QI: Quadriceps index
5 LF: Leg flexion
6 HI: Hamstrings index
7 SLP: Single leg press
8 SLHD: Single leg hop for distance.
9 THD : Triple hop for distance.
10 CHD: Cross-over hop for distance.
11 HAF: Hop after fatigue.
12 LSI: Limb symmetry index.
13 EMS: Efficient muscle strength
14 ELLS: Efficient lower limb symmetry
15 UR: Efficient unrestricted return

overall, 68.75 didn't pass muscle strength testing, and 62.5% didn't also pass lower limb symmetry testing. 100% of athletes were either totally released by their surgeon (93.75%); or their physical therapist (3.125%); or by both (3.125%), whereas only 18.75% could be released after the combined testing of muscle strength and lower limb Symmetry back to unrestricted sports activities.

Table 3: Rate of success in the tests and release.

	Total	Percentage
EMS [1]:		
Yes	10	31.25
No	22	68.75
ELLS[2]:		
Yes	12	37.5
No	20	62.5
UR[3]		
Yes	6	18.75
No	26	81.25
Clinical decision:		
Yes	32	100
No	0	0

Table 4: Results of univariate analysis. P< 0.05 is significant.

	EMS	ELLS	UR
Categories of sports (Collective/individual)	P=1	P=0.5161	P=1
Most used discipline (Basketball)	P=0.2665	P=0.4709	P=1
Most used type of testing (Biodex+Lachman)	P=1	P=1	P= 0.6722
Most clinician responsible for release (surgeon)	P=0.5343	P=0.5161	P=1
First division as the most participation	P=1	P=1	P=0.6471
EMS (kg)	-	P=0.1190	**P=0.0002*** **
ELLS (cm or seconds)	P=0.1190	-	**P=0.0010****
Age (years)	P=**0.023***	P=0.251	P=0.148
Height (meters)	P=0.448	P=0.610	P=0.984
Weight (Kg)	P=0.822	P=0.925	P=0.589
BMI (kg/m2)	P=0.204	**P=0.009****	**P=0.034***
Date of injury (months)	P= 0.778	P=0.606	P=0.689
Date of surgery (months)	P=0.680	P=0.887	P=0.309
Date of release (months)	P= 0.611	P=0.880	P=0.295
BPTB autograft	P=1	P=0.6196	P=1
Gender (male/Female)	P=1	P=0.7026	P=0.6367
Side of ACLR (right/left)	P=0.7026	P=0.7026	P=1

*Significant **Very significant*** Extremely significant

There was significant correlation between EMS and age (p=0.023*). However, there was no statistical difference between EMS and other numerical attributes or main numerical variables.

For what concerns the efficiency of lower limb symmetry (ELLS), t-test was conducted between ELLS and the entire numerical sociodemographic attribute in addition to numerical values of LE (right and left), LF (right and left), LP (right and left) but no relation was detected. However, there was a very significant correlation between the BMI and the ELLS (P=0.009**) and no statistical difference between ELLS and other attributes or main numerical variables.

A significant correlation between the UR and the BMI (P=0.034*); whereas, an extremely high significance correlation was found (P=0.0002) between EMS and UR to sports activities, and a very high statistical significance (P=0.0010**) between the ELLS and UR to sports activities.

DISCUSSION

The purpose of this study was to find if the clinical decision for the release of athletes to Unrestricted sports activities after ACLR matches the findings of the most common objective criteria of muscle strength and lower limb symmetry used to release athletes back to sports activities. Although all athletes in our study had been cleared to full sports participation by either their orthopedic surgeons (30 athletes), their physical therapist (1 athlete), or combined clinical decision of the surgeon and physical therapist (1 athlete) and after a delay between 1 and 7 months (range of time post clinical release), deficit still existed in lower limb symmetry and maximal muscle strength. We hypothesized that: 1) socio-demographic characteristics influence objective criteria used for testing as well on the release to unrestricted sports activities; 2) the most used type of graft would influence efficiency of muscle strength, lower limb symmetry and the release to unrestricted sports activities; 3) there is a correlation between the muscle strength and lower limb symmetry; 4) there is a correlation between muscle strength and unrestricted return to sports; 5) there is correlation between lower limb symmetry and unrestricted return to sports; 6) and the objective criteria of thigh muscles strength and lower limb symmetry testing will influence more the return to unrestricted sports activities than the clinical decision.

This study showed that clinical decision taken prior to full releasing ACL-reconstructed athletes varied between testing by: 1)Biodex and Lachman's test for fourteen athletes (43.75%); 2) Lachman's test for nine athletes (28.125%); 3) Lachman's test and thigh's circumference measurements were taken for six athletes (18.75%); 4) Biodex, Lachman's test, and thigh circumference measurement were done for three athletes (9.375%). We also noticed that male's participation was way more than that of female's, twenty-two versus ten respectively, recruited the most from collective type of sports (30 participants) Basketball had the higher participation rate (n=14). Athletes were most recruited from the first division (twenty out of thirty-two). Right leg is more injured and reconstructed than the left one, twenty-one versus eleven respectively. BPTB autograft was the most used type of ACLR technique (twenty-eight out of thirty-two) whereas STG single bundle represented (three out of thirty-two) and double bundle STG represented (one out of thirty-two) knowing the disadvantage: 1) the Hamstrings graft is more than twice as strong as the BPTB graft; 2) donor site problems such as patellar tendon rupture and patellar fracture for the BPTB whereas the Hasmtrings grafts showed no significant donor site problems; 3) a higher rate of BPTB post-operative knee stiffness than the Hamstrings grafts; 4) much increased kneeling pain in BPTB than in STG grafts; 5) higher Quadriceps and Hamstrings weakness in BPTB than in STG grafts; 6) and higher stability in STG compared to BPTB grafts [10]. Rehabilitation time before releasing athletes back to their unrestricted sports activities ranged between four and eight months.

For what concerns the muscle strength 1RM test, we had the following means QI (97.12%); and HI (94.64%) respectively for LE and LF tests, where as SLP ratio 1RM mean recorded (97.09%). For the hop tests we had the following findings: 1) mean of SLHD's LSI (95.74%); 2) mean of 6-m hop's LSI (94.17%); 3) mean of THD's LSI (95.7%); 4) mean of CHD's LSI (98.72%); 5) and the mean of HAF's LSI (94.45%).

Basketball had the higher participation rate compared with each mean of EMS, ELLS, and UR, we found that, only age significantly influenced EMS (P=0.023 *). BMI influenced both ELLS very significantly (P=0.009 **), while UR significantly (P=0.034 *) what correlates with the findings of previous studies [11]. Additiona-lly no correlations were found between each of: 1) gender; 2) side a ALCR; 3) and categories of sports; 4) the most commonly played sport (basketball); 5) the dominant clinical decision (surgeon); 6) the first division as it represent the higher participation rate; 7) and the Biodex and Lachman as the most type of testing used, and each of EMS, ELLS, and UR. Between gender and EMS (P=1), No relationship was found between: gender and EMS (P=1); gender and ELLS (P=0.7026); gender and UR (P=0.6367); side of ACLR and EMS (P=0.7026); side of ACLR and ELLS (P=0.7026); side of ACLR and UR (P=1); categories of sports and EMS (P=1); categories of sports and ELLS (P=0.5161); categories of sports and UR (P=1); most type of sports played (basketball) and EMS (P=0.2665); most type of sports played (basketball) and ELLS (P=0.4709); most type of sports played (basketball) and UR (P=1); the dominant clinical decision (surgeon) and EMS (P=0.5343); the dominant clinical decision (surgeon) and the PLLS (P=0.5161); the dominant clinical decision (surgeon) and UR (P=1); the first division as it represent the higher participation rate and EMS (P=1);the first division as it represent the higher participation rate and ELLS (P=1); the first division as it represent the higher participation rate and UR (P=0.6471); Biodex and Lachman as the most type of testing used and EMS (P=1); the Biodex and Lachman as the most type of testing used and ELLS (P=1); the Biodex and Lachman as the most type of testing used and UR (P=0.6722).

The influence of the most used type of graft (BPTB autograft) on each of EMS, PLLS, and UR was also checked, no influence was found with the following p value respectively, (P=1); (P=0.6196); and (P=1).

We also checked if there is any correlation between the efficiency of muscle strength and the efficiency of lower limb symmetry tests, and no correlation was found between EMS and ELLS (P=0.1190).

In addition there was an extremely significant correlation between EMS and UR (P=0.0002***) what correlates with the findings of previous studies [1,4,5,12]; then we moved to test the correlation between ELLS and UR, where a very significant correlation was found (P=0.0010 **), and that correlates with was demonstrated with previous studies of [3,5,9,13,14],

Objective testing of muscle strength and lower limb symmetry usually should be done as mentioned in earlier studies, prior to releasing the athlete back to his unrestricted sports activities. In addition for the muscle strength to be efficient, it needs that the athlete scores on each of QI, HI, and SLP ratio equals or above 90%, as well as for the lower limb symmetry to be efficient, it needs that the athlete scores on all the hop tests above their cut-off [5]. Then after obtaining both acceptance of efficiency on each of the muscle strength and lower limb symmetry we can say that the athlete can be efficiently released back to unrestricted sports activities.

Finally, we noticed that even after a range between (1;7) months, and after all the athletes (100%) were already released earlier by a clinical decision by their orthopedic surgeons or their physical therapist or both, we found that only ten (31.25%) had EMS what confirms findings of studies conducted previously [1,5]; where athlete were required to score above or equal to 90% on each of the muscle strength tests, to be cleared; whereas only twelve (37.5%) had ELLS what supports findings in prior studies [5,8,9].

CONCLUSION

After testing the athletes, age was significantly correlated to EMS (P=0.023*), whereas BMI influenced ELLS very significantly and UR significantly (P=0.034*). BPTB grafts did not have any influence on EMS, ELLS, and UR but BPTP represents higher risks of complications. Efficiency of muscle strength had no effect on that of the lower limb symmetry. Whereas both influenced the unrestricted return, extremely significantly (P=0.0002***), and very significantly (P=0.0010 **) respectively.

When the proper testing included the following battery of tests: 1) LE; 2) LF; 3) SLP machines (muscle strength) and 4) single leg hop; 5) 6-m ho test; 6) THD; 7) crossover hop; 8) single hop after fatigue (lower limb symmetry) even after being released from 7 month based upon a clinical decision, only ten (31.25%) had succeeded the 1RM testing, whereas twelve (37.5%) had succeeded the hop tests. Finally six athletes (18.75%) out of thirty-two could be release unrestrictedly back to their sports activities.

Limitation: We acknowledge some limitations in the study. As it was stated previously that recruitment was conducted from multidisciplinary types of sports, and from more than one division, what makes the results wide and general.

Recommendations: Considerations for future studies may suggest that recruiting and testing of athletes to be done from one discipline at a time and from the first division only, to be able to derive conclusions that are sports-specific on the highest level of participation.

Furthermore fear of re-injury stated in many previous studies to be one of the main causes for not returning to pre-injury level of can also be assessed.

Implication for practice: The results indicate that muscle strength and lower limb symmetry might need to be considered for the assessment of the athletes, post–ACLR to determine recovery and readiness for unrestricted sports activities. Finally, we believe that our data could be considered as baseline for future studies.

Conflicts of interest: None

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