

Research Article

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LESS score and isometric lower limb strength after ACL reconstruction in female handball players

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Abstract

Background: Anterior Cruciate Ligament (ACL) injuries have amplified dramatically in the last years in female team sports due to the incrementing number of teams and players, an increase in speed and competitiveness, and in some areas due to insufficient strength training in young athletes. Return to play is main goal after ACL reconstruction. Access to surgery and rehabilitation is mandatory for an successful return to sport after the injury;

Methods: We analysed a sample of high-performance female athletes with ACL tears, all professional sport athletes, after surgery and during the rehabilitation process, to determine more specific returning to sport criteria based on the relation between the Landing Error Score System (LESS) and isometric limb strength measurements. Returning to sports and returning to play are the most difficult challenges after an ACL injury, requiring a long rehabilitation period, with multiple possible reasons for graft failure.

Results: The force-to-weight ratio of all dynamic stabilizers of pelvis and knee, both in the frontal and sagittal planes, significantly improved between the two testing sessions as follows: Flexion of the operated limb +0.78 N/kg (SD=1.022, p=0.0061), Extension of the operated limb +1.65 N/kg (SD=1.618, p=0.0003), Adduction +1.77 N/kg (SD=2.021, p=0.0012), Abduction +1.33 N/kg (SD=2.069, p=0.0120). We also found a significant reduction in the difference in isometric muscle strength

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between the operated limb and the contralateral limb before and after the rehabilitation protocol, with a value of -37 N for flexion (± 5.54 , $p < 0.0001$) and a value of -76.77 N for extension (± 20.68 , $p = 0.0016$). The LESS Score significantly diminished between the two sessions by 6 points on average. ($p < 0.0001$).

Conclusions: The LESS Score and isometric muscle strength measurements are complementary to each other and useful in accurately describing the patient's status who benefited from a well-conducted rehabilitation program, by diminishing the dynamic valgus, the abnormal knee kinetics and kinematics, and their deleterious effects and in assessing the readiness for return to play together with complimentary criteria in female team sport.

Keywords: Anterior cruciate ligament reconstruction; ACL; Isokinetic strength; Female athletes; Less score; Handball; Return to play.

Introduction

Non contact injuries represent the most frequent mechanism involved in Anterior Cruciate Ligament (ACL) lesions in female athletes participating in a contact team sport like handball, basketball, lacrosse. These usually occur during abrupt deceleration, landing, or lateral pivoting, with the involvement of underlying chronic fatigue, hormonal variation, familial factors [1–4,47].

Dynamic Knee Valgus (DKV) is a combination of hip adduction, internal rotation, and abduction of the knee. This is one of the most frequently involved patterns in non-contact ACL injuries and re-injuries in landings or high speed cutting and although many studies have shown the DKV importance regarding injury prevention and return-to-sport, it is still difficult to quantify the extent of this condition [3,5-10].

Female athletes are more prone to this specific type of injury, because of various factors including biomechanical (larger pelvic width, increased Q angles) and hormonal factors (lower testosterone levels, increased hormonal-induced muscle inhibitions in the first 12-16 months after birth or during the luteal phase of the menstrual cycle) [6,10-12].

The decision to return to sport after ACL reconstruction surgery is complex, and multifactorial and comprises biological, biomechanical, and psychosocial factors. Thus far no consensus, well-established criteria or clear guidelines exist in the literature to guide the process but recent studies show that delaying it reduces the re injury rate [13-19].

Isokinetic testing represents an objective way to assess muscle strength and along-side various functional testing (single leg hop, cross-over hop, triple hop, shuttle run, carioca test, Landing Error Scoring System - LESS) [20,21]. may be used to evaluate the dynamic stability of the knee correlated with isokinetic strength of main muscle groups. The aim of our study is to evaluate the strength of the muscles involved in the dynamic stability of the knee, pelvic abductors and adductors and knee flexors and ex-tensors, after ACL reconstruction and rehabilitation in professional female handball players through isokinetic and functional testing for determining the readiness for contact sport reintegration.

Materials and methods

Study design

After ACL reconstruction surgery, all or athletes underwent a specific rehabilitation program focused on protecting the joint, restoring range of motion, obtain static strength and stability and finally good plyometric qualities for reintegrating the athlete in a ballistic contact sport. During the rehabilitation process we tested the athlete on the Easy Torque device for isokinetic strength of main muscle groups – pelvic stabilizers [hip adductors and abductors] and knee flexor and extensors, at 12-16 weeks and 24 after surgery and during same test session LESS test was performed as described further. The main objective was to correlate the growth of isokinetic force [maximal value and specific value strength/body weight] with the diminishing of the LESS score [the lower the better -meaning lower value show good knee hip/knee/ankle stability during landings and no dynamic knee valgus] because horizontal hop tests alone are not as specific in determining the return to play after ACL surgery and we consider that time after surgery is not an criteria [9,42].

Data collection

We examined, operated on, and followed during the rehabilitation process until return to play a group of 28 professional female handball players, aged 18 to 34, who sustained a non-contact sports injury resulting in an ACL rupture. All the subjects playing at the time of injury in the Romanian National Women's Handball League were of different nationalities – Romanians, Brazilians, Serbians, Spaniards, and Byelorussians – and members of their respective national handball teams. The diagnosis was made after a thorough examination of the mechanism of injury, which was very typical and caught on live TV, clinical examination, knee radiographs, MRIs, and con-firmed arthroscopically at the time of definitive surgery.

Test Data collection from Easy Torque device after testing was in specific patient named folder with printing of individual results, statistic analysis was made on this data, same electronic measurement machine Easy Torque with specific and individual inputs [sex, age, bodyweights] make data acquisition and measurements reliable and accurate. LESS test was recorded on

camera and data and measurements were made electronically by the same group of authors with marginal error possible as on all HOP and Landing Tests.

Exclusion and inclusion criteria

Exclusion criteria were multiple ligament injuries – 1, unstable meniscal tears – 3, bony deformities – increased posterior tibial slope – 1, genu varum/valgus more than 5 degrees – 1, severe flatfoot – 1, ipsilateral previous knee surgery – 2. After exclusion, 19 patients were included in our study. The study was conducted between January 2019 and December 2022.

All patients signed informed consents and participated willingly in our studies. Approval from the ethical commissions of the rehabilitation facility and the clinical hospital was obtained.

ACL reconstruction surgery

All patients underwent 2-4 weeks of prehab. The surgery was performed by the same senior surgeon carrying out more than 150 ACL reconstructions/per year. Standard arthroscopic reconstruction of the ACL was carried out using a quadrupled Semitendinosus and Gracilis graft used in all cases [22]. All grafts below 7 mm in diameter were braided in order to increase the diameter and tensile strength, while grafts between 7 mm and 8 mm were reinforced using Fiber Tape, an ultra-high-strength non-absorbable suture (Arthrex, Naples, Florida, USA) – so final diameter of all grafts was over 8 mm. Femoral cortical fixation was achieved using an adjustable loop but-ton, ACL Tight Rope II (Arthrex, Naples, Florida, USA), while bioresorbable interference screws were utilized for tibial fixation of the graft (Arthrex, Naples, Florida, USA), doubled in some cases by a titanium staple.

Rehabilitation protocol

All patients were allowed to weight-bear as tolerated immediately after surgery and the postoperative rehabilitation protocol commenced the first day after surgery with cvadriiceps contractions, hip and ankle mobility exercises, with an extension orthosis used 7-10 days after surgery. The rehabilitation program was focused on achieving dynamic knee stability and was based but not limited on practice guidelines provided by van Melick et al [23].

After protection phase the goal was to obtain full range of motion, decrease swelling, improve muscle strength, slowly isometric exercises were developed into eccentric strength exercises, stability and proprioception exercises with focus on knee stability. at and after 12-14 weeks strength training for lower limb was introduced in all cases and progressing to light running and plyometric training with and without external perturbations was started at 16-18 weeks depending of individual tolerability. Normal Range of Motion and absence of knee effusion was considered mandatory for progressing to running and plyometric training.

Return to sport and consequently return to play was allowed after passing the second test with normal LESS, limb symmetry index of more than 90% on strength measurement and horizontal hop test -single-triple- of more than 90 % compared to contralateral leg.

Study outcomes

We measured and analysed isometric muscle forces on the Easy Torque machine (TONUS sports & reha GmbH, Zemmer,

Germany). The tests were performed in two sessions, the first one at 12-16 weeks after surgery and the second 24-26 weeks after surgery before finalizing the rehabilitation protocol and re-integration in team activity.

The testing procedure was modified after the one described by Cvjetkovic et al [24] as following: each patient performed a 6 minute active warm-up; they were tested in a seated position (Figures 1); both limbs were tested simultaneous; for the sagittal plane movement, the range of motion of the knee joint was from 0° to 90°; adduction and abduction were measured without restricting the range of motion; all tests were performed three times with a two minute rest period between the tests; vocal encouragement was performed systematically; The maximum value of each parameter (flexion, extension, abduction and adduction) were considered and compared with the reference values which were calculated based on the Easy Torque machine software, taking into account gender, age, weight and height; The force-to-weight ratio for each movement was also calculated (Figure 2).

During the same testing sessions, the LESS was also performed as described by Padua et al (Figure 3) [21]. The subjects were filmed from two angles while performing a drop-vertical jump from a 30 cm box to a distance of one half of their height, followed by a maximal vertical jump. The two videos were then analysed and the LESS calculated. Improvement of LESS score shows a reducing of the score because being a Landing Error Score a number is attributed to each error, so the lower the score the better and the more stable landing and knee we have.



Figure 1: Testing procedure in seated position, measuring isometric muscle forces on the Easy Torque machine.

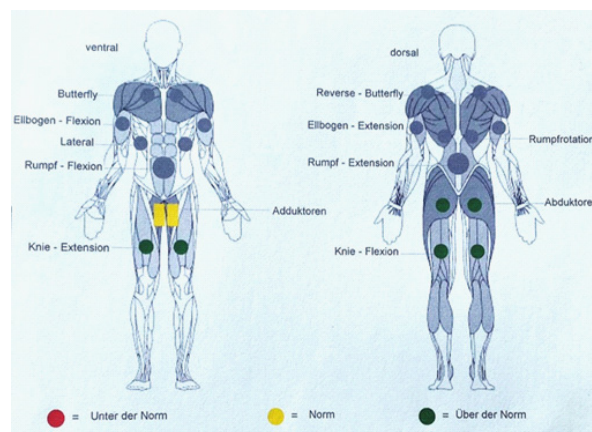


Figure 2: Characteristics of Easy Torque machine software measurements results.

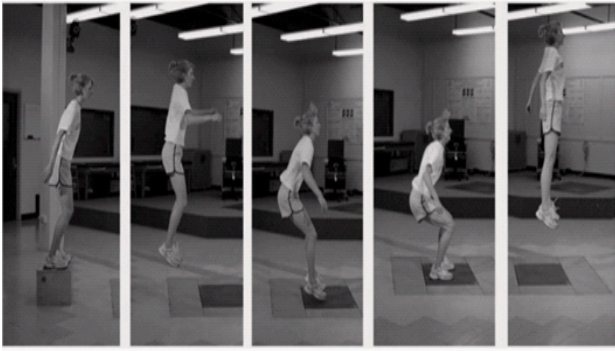


Figure 3: Representation of LESS test protocol, of the drop-vertical jump.

Statistical analysis

The statistical analysis was performed using Prism 9 for Windows, Version 9.4.1 (681), GraphPad Software, LLC. And results are displayed below.

Results

The maximum strength of all parameters which were measured during the first testing session was above the reference values in 92.1% of the cases and twice above the reference values in 27.2% of all cases which represent very good values for the same gender and age group.

The average time elapsed between the two testing sessions was minimum 56 days maximum 72 days.

The force-to-weight ratio of all dynamic stabilizers of the knee, both in the frontal and sagittal planes, significantly improved between the two testing sessions as follows: Flexion of the operated limb +0.78 N/kg (SD=1.022, p=0.0061), Extension of the operated limb +1.65 N/kg (SD=1.618, p=0.0003), Adduction +1.77 N/kg (SD=2.021, p=0.0012), Abduction +1.33 N/kg (SD=2.069, p=0.0120), all represented in Figure 4.

Absolute strength and individual muscle group strength is one of the main contributor to knee injury prevention in female athletes [9,43-44].

The LESS Score significantly diminished between the two sessions by 6 points on average (p<0.0001) (Figure 5).

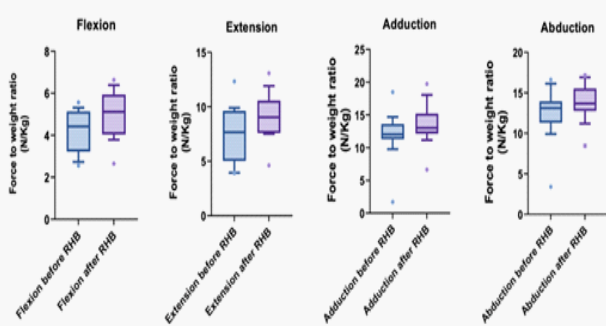


Figure 4: The force-to-weight ratio of all dynamic stabilizers of the knee, both in the frontal and sagittal planes. We also found a significant reduction in the difference in isometric muscle strength between the operated limb and the contralateral limb before and after the rehabilitation protocol, with a value of -37N for flexion (± 5.54 , p<0.0001) and a value of -76.77 N for extension (± 20.68 , p=0.0016) which means that the LIMB symmetry index improved during the second part of the rehabilitation period.

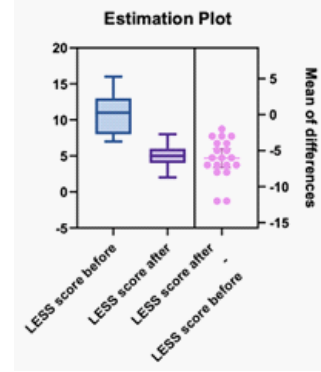


Figure 5: The LESS Score difference in evolution.

We found a direct between the LESS scores improvement [lower score number] and the measured muscle isometric strength parameters which shows that knee stability is improving both through the direct implication of analysed muscle groups in stabilization of knee and through the plyometric and proprioceptive rehabilitation specific training. In our group of players at 24 months we had no Return to Play before 32 weeks and we had no ACL reinjury or contralateral ACL Injury at 24 months after surgery.

Discussion

Return To Play (RTP) and Return To Sport (RTS) are the main objectives of professional athletes after technically successful surgery, with rates of returning to competitive sports varying between 55% and 83% [25,26]. Pressure on Team Player, Doctor and Physical Trainer or Physio therapist' is mounting as time after surgery goes by and reaches a summit in the return to specifically functional training during the athletes team re integration. Patient re-education and appropriate exercise-based rehabilitation protocols are the cornerstones of postoperative management after ACL reconstruction. The rehabilitation protocol should include weight-bearing, mobility, open and closed kinetic chain resistance-based neuromuscular control, and plyometric exercises [27]. Achieving pre trauma muscle strength is mandatory and comparing the operated limb to the non operating limb considered as individual golden standard is the only option we have .In order to achieve this, we consider that for female athletes the optimum timeframe to RTP is closer to 10 months considering that the ligamentisation process of the graft takes much longer than previously believed [45].

In order to clear an athlete to RTP, multiple factors should be considered, including body composition, aerobic fitness levels, and psychological readiness, along with passing the various tests for evaluating the dynamic stability of the knee criteria (Limb Symmetry Index, Vertical and Horizontal Hop Tests, isometric and Isokinetic Strength Tests, LESS). These are complementary to each other, with the literature suggesting a low to moderate correlation between tests and muscle strength measurements in patients who underwent ACL reconstruction [28]. These are the reason why multiple criteria should be used.

Horizontal and vertical Hop tests remain important tools in assessing the functional outcomes after ACL reconstruction, and alongside muscle power output measurements are useful in comparing the operated limb with the contralateral one – in our opinion, there should be a minimum of 95% symmetry.

Pressure on professional athletes to achieve an early RTP (under six months) re-mains elevated because of various factors – contract renewal, maintaining a first-team place, sustaining

their status, the eligibility to be selected for the national team's roster in order to participate in one of the numerous competitions which take place regularly – European Championships, World Cup, Olympics.

However, six months after the initial surgery, most of the athletes are not pre-prepared for RTP, with few passing the majority of the proposed RTS criteria. There is conclusive evidence to wait at least nine months until returning to pre-injury sports, a study by Bodkin et al. showing that second ACL reinjury risk was diminished by 28% for every month that RTP was delayed beyond 8 months [29].

MRI evaluation of the integration of the graft should also be considered [30-32]. Although the development of surgical techniques and improved rehabilitation protocols have been remarkable, the repercussions of an ACL injury are still significant. The average length of the professional career of an athlete who underwent ACL surgery is diminished when comparing it to uninjured athletes, and it is accompanied by decreased performance and less playing time [33-36].

The reinjury rates in the first months after RTP are especially high in female athletes [37-39]. A second injury on the contralateral leg is also to be considered [19,29]. The prevalence of secondary osteoarthritis after primary ACL surgery, as well as revision surgery, remains high [37,40,41].

Contralateral ACL injury is an event which occurs also often in the first two years after surgery and should be considered [46].

The authors observed through consecutive testing's on Easy Torque after Return To Play that actually during the first 6 months team playing, the absolute muscle strength measured on isokinetic machine diminishes probably due to fatigue, aerobic and plyometric or functional sport training and lack of strength training because of team schedule and coach preferences. Also being integrated in a team make it more difficult for a handball player to maintain a individual strength program than for an individual sport athlete.

Conclusions

We conclude that in the absence of a golden standard of RTP criteria, the LESS Score and isometric muscle strength measurements are complementary to each other and useful in accurately describing the patient's status who benefited from a well-conducted rehabilitation program, by diminishing the dynamic valgus, the abnormal knee kinetics and kinematics, and their deleterious effects. We consider that in the return to play criteria time after surgery should be measured in favour of the athlete as, as we showed the longer the rehabilitation the better the maturation of the graft, the lower the reinjury risk is.

Women Handball is a sport with a very high rate of ACL injury and reinjury, it is a very fast stop and go contact sport in which deceleration, pivoting, cutting and landing is producing an high amount of forces on an athlete's knee which is especially after an ACL surgery prone to re injury. Aerobic capacity and psychological readiness should always be considered individually.

Although recent advances in surgical technique and rehabilitation protocols are notable, the reinjury rate persists and an ACL re-injury is an devastating event for the carrier of an team athlete.

Time is not on the patient's side and is something which is

always forgotten, a hasty recovery process should be avoided because it leads to more injuries and reinjuries, and elapsed time from the index surgery should not be considered as an RTP factor on its own but should be considered when approaching the recovery process.

Declarations

Author contributions: Conceptualization, methodology, writing—original draft preparation, R.M.M., M.T.; software, A.B., O.A.B., D.N.Z-S.; formal analysis, investigation, G.K.; resources, D.A., A.D.I.; writing—review and editing, E.M.A., R.M.M.; data curation, project administration, visualization, supervision, M.T.; validation, all authors. All authors have read and agreed to the published version of the manuscript.

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Institutional review board statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Fizionova Sports Clinic, Targu Mures Romania (protocol code 3, on 01 December 2022) and Ethics Committee of Regina Maria Health Network Targu Mures, Romania (protocol code 202, on 02.09.2022).

Informed consent statement: Informed consent was obtained from all subjects involved in the study.

Data availability statement: Not applicable.

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Conflicts of interest: The authors declare no conflict of interest.

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