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ORIGINAL ARTICLE

RELIABILITY OF UNINJURED LIMB AS A REFERENCE FOR LIMB SYMMETRY INDEX ASSESSMENT IN SPORTSMEN UNDERGOING ANTERIOR CRUCIATE LIGAMENT SURGERY

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ABSTRACT

Objectives: This study aimed to describe changes in the uninvolved limb jump results over three timepoints between preoperative status and one year after anterior cruciate ligament (ACL) reconstruction. The hypothesis was that uninvolved limb jump performance would be comparable between preoperative and one year following ACL reconstruction, making it a reliable data to use when reporting limb symmetry index (LSI).

Methods: Thirty patients who had undergone ACL reconstruction were evaluated pre-operatively, 6, and 12 months after surgery. Jumping ability was instrumentally assessed through an infrared optical acquisition system using a test battery including monopodalic countermovement jump (CMJ), monopodalic drop jump, and monopodalic side-hop test.

Results: Average age was 34.6 years (SD 11.3). No difference was observed in the uninjured limb while performing monopodalic CMJ, drop jump and side-hop test at 6-month evaluation compared to pre-operatory status ($p = 0.47$, $p = 0.40$, $p = 0.48$, respectively). Conversely, increased values were observed while performing the battery of jump test at 12-month follow-up compared to 6 months follow-up ($p < 0.01$), as well as at 12-months follow-up compared to baseline ($p < 0.05$).

Conclusions: No differences in jumping ability in the uninjured limb were observed between pre-operatory status and 6-months follow-up after ACL surgery, thus allowing a stable comparison for the injured limb in this time frame. Conversely, improved jumping performances were observed in the uninjured limb one year after ACL reconstruction compared to 6 months and baseline, making it more difficult to use LSI as a reliable tool one year after surgery.

KEYWORDS

Anterior cruciate ligament, ACL reconstruction, uninjured limb, limb symmetry index, jump test battery

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INTRODUCTION

Return to sport (RTS) is a major issue for patients who had undergone anterior cruciate ligament (ACL) surgery[1], and there is much interest in determining objective criteria to RTS allowing patients to safely resume sporting activities, thus minimizing complications such as graft re-ruptures[2]. For this reason, in addition to commonly used patient-reported outcome measures (PROMs), functional tests have been introduced to monitor patients' capacity to RTS following ACL reconstruction[3].

Among functional tests, jump test batteries are valid instruments used by physician to monitor patients' functional ability and allow resuming sporting activities. Jump tests have been demonstrated to reliably detect functional asymmetries between limbs and assess knee biomechanics by measuring explosive strength, power and reactivity[4-6].

Limb symmetry index (LSI), which compares the involved and uninvolved limbs, is commonly used to represent the findings of jump tests[7]. Because of worries that performance may decline in the uninvolved limb as well and that the comparison may not be consistent over time, using it as a comparative measure has been questioned, since it may produce a biased LSI[8].

This study aimed to describe changes in the uninvolved limb jump results over three timepoints between preoperative status and one year after ACL reconstruction. The hypothesis was that uninvolved limb jump performance would be comparable between preoperative and one year following ACL reconstruction, making it a reliable data to use when reporting LSI.

PATIENTS AND METHODS

Patient treatment

Thirty non-professional patients who underwent ACL reconstruction between January and December 2021 were enrolled in the present study and followed prospectively up to 12 months after ACL surgery. Inclusion criteria were: primary unilateral ACL reconstruction; participation to sporting activity at recreational/competitive level (graded 4 to 9 according to Tegner activity scale); same postoperative rehabilitation protocol. Exclusion criteria were: past history of ligamental surgery on the same or contralateral knee; concomitant surgical procedures with the exception of treatment for meniscal pathology; inability to complete clinical and functional testing.

The present investigation is a secondary analysis from a parent study which received Institutional Review Board (IRB) approval from IRCCS San Raffaele Hospital, Milan, Italy (IRB number: 57/INT/2020)[9]. All participants gave informed consent.

Surgical technique and rehabilitation protocol

All patients underwent arthroscopic assisted ACL reconstruction using doubled autologous hamstring graft. The tibial tunnel was drilled using a 55° guide (Acufex; Smith & Nephew, Andover, USA) on the ACL tibial footprint, while the femoral half-tunnel was drilled through the anteromedial portal. Fixation was achieved proximally with a cortical suspension device (Retro-button; Arthrex Inc., Naples, USA) and distally through a bioadsorbable interference screw (Milagro; DePuy Mitek, Raynham, USA). A brace-free rehabilitation protocol starting the day after surgery was adopted in all patients, with immediate regaining of extension, isometric exercises and walking with crutches with partial weight bearing for the first 3 weeks. Swimming and indoor cycling were permitted after 12 weeks, while after 5 months a protocol of jump technique training and plyometric exercises was started. Jogging and non-contact sports were allowed after 6 months, and return to contact sports was permitted after 9 months.

Jump test battery protocol

A series of vertical jump tests was executed in accordance with a previous protocol[10], using an infrared optical acquisition system (OptoGait; Microgate, Bolzano, Italy). The test was performed pre-operatively, 6 and 12 months after surgery. The test battery included three types of jump performed consecutively. Monopodalic countermovement jump (CMJ), consisted of a vertical jump performed from an upright position followed by a quick sinking reaching a half-squat position. Monopodalic drop jump (DJ) was performed dropping from a 30 cm-box, and immediately performing a vertical jump as high as possible. During the side-hop test as many as possible lateral monopodalic lateral jumps were performed over 2 strips placed 30 cm apart within 30 seconds. CMJs and DJs were recorded in centimeters; for side-hop tests the number of jump performed in 30 seconds was recorded.

Statistical analysis

Data were analyzed using Graphpad Prism v8.0 (Prism Software, La Jolla, CA, USA). Data distribution was assessed by Shapiro-Wilk test. In presence of normally-distributed data, paired Student t-test was used to assess

No. of patients	31
Sex	
Male	31
Female	0
Mean age at surgery (SD) (yr)	34.6 (11.3)
Mean BMI (SD)	25.5 (3.0)
Mean time from injury to surgery (range) (mo)	3.0 (1.2-5)

Table 1. *Patient demographics and anthropometric data. Abbreviations: SD, standard deviation; BMI, Body Mass Index.*

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No. of patients	Pre-operative	6 months	12 months
Monopodalic CMJ uninjured limb (mean, SD, range)	10.5 (4.1)	10.8 (3.6)	12.5 (3.5) *, **
Monopodalic DJ uninjured limb (mean, SD, range)	13.3 (4.2)	12.7 (4.6)	15.0 (5.0) *, **
Monopodalic Side Hop Test uninjured limb (mean, SD, range)	32.9 (11.4)	34.5 (14.1)	40.9 (13.8) *, **

Table 2. *Overall comparison between pre-operative and follow-up status.*

*Abbreviations: CMJ, countermovement jump; DJ, drop jump; SD, standard deviation; *Statistical difference from preoperative; **Statistical difference from 6 months.*

differences among time-points. p values <0.05 were considered statistically significant.

RESULTS

The patient cohort considered for analysis was composed of 30 male patients. Mean age at surgery was 34.6 years (SD 11.3). Mean body mass index (BMI) was 25.5 (SD 3.0). Average time between injury to surgery was 3.0 months (SD: 1.1). Patients' demographics and anthropometric data are reported in *Table 1*. Eight medial and one lateral meniscectomies were performed at time of surgery. In two patients medial meniscal sutures and in one case lateral meniscal suture were performed. No differences were observed in the performance of the uninjured limb between 6-month evaluation and baseline for all jump tests considered. Regarding CMJ, DJ and side-hop test, the differences were not statistically significant concerning this time frame (p = 0.47, p = 0.40, p = 0.48, respectively).

Monopodalic CMJ and DJ showed improvements at 12-month evaluation compared to 6 months (p <0.001); statistically significant differences were also observed regarding side-hop test (p <0.01) in favor of 12 months assessment.

Similarly, a statistically significant difference was observed when comparing CMJ performed 12 months after surgery to baseline (p<0.001), DJ at 12 months compared to baseline (p<0.05), and side-hop test between one year after surgery and pre-operative status (p <0.001) *(Table 2)*.

DISCUSSION

Compared to bipodalic jumps, monopodalic functional tests give a more accurate esteem of leg power, since subjects cannot compensate with the uninvolved limb during jumping performance[10]. For this reason, monopodalic jump tests are widely used to detect asymmetries between limbs pre-operatively and during the rehabilitation phase, thus quantifying the level of functional recovery following ACL surgery[11-13]. When allowing the resumption of sporting activity following ACL reconstruction, an LSI ≥90% is the most commonly reported tool. This assessment uses the contralateral uninvolved extremity as the standard for comparison[14].

According to the results of the present study, jumping ability in the uninjured limb tends to be similar pre-operatively and 6 months after surgery, thus allowing a stable comparison for the injured limb. However, the performance of the uninjured limb significantly improved 12 months after surgery compared to 6 months and to baseline. This suggests that muscular coordination recovery and explosive leg power do not differ 6 months after surgery from pre-operative status, while these parameters significantly improve one years after surgery. While its value remains similar within the first 6 months after surgery, the failure to maintain the same performance 12 months after surgery might make it more difficult to use the uninjured limb as a reference for the injured limb.

According to some studies, the uninjured limb does not represent a reliable benchmark to be used as a comparison with the injured limb following ACL surgery, as authors hypothesize that decreased performance on the uninjured limb could potentially bias the outcomes in favor of the injured limb, providing unreliable LSIs[15,16]. Conversely, the findings of the present study suggest that improved jumping performances can be observed in the uninjured limb one year after ACL surgery when performing CMJs, DJs, and side-hop tests.

According to Arhos et al., uninjured limb demonstrated similar results while performing hop for distance from pre-surgery up to 24 months after ACL reconstruction and support the use of the uninjured limb as a stable comparison for assessing LSIs affecting RTS clearance[8].

The present study differs since mostly vertical jump tests were used to assess functional performance instead of horizontal hop tests, and this may justify the dissimilarity of the results. The improved performance of the uninjured limb 12 months after surgery determines a higher target for the injured limb to achieve limb simmetry. This data are in line with recent sudies demonstrating no evidence of reduced power performance in the uninjured limb in subjects with a history of ACL tear[8,17].

Limitations of the present study include the relatively small sample size, thus limiting the ability to detect small differences between groups regarding some parameters. Jumping ability was assessed used OptoGait system, although other devices are available for this purpose. Eventually, only male patients were included in the present investigation, therefore these results are not generalizable to females.

CONCLUSIONS

No differences in jumping ability in the uninjured limb were observed between pre-operatory status and 6-months follow-up after ACL surgery, thus allowing a stable comparison for the injured limb in this time frame. Conversely, improved jumping performances were observed in the uninjured limb one year after ACL reconstruction compared to 6 months and baseline, making it more difficult to use LSI as a reliable tool one year after surgery.

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