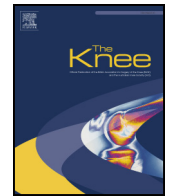




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The Knee



The relationship between performance on the modified star excursion balance test and the knee muscle strength before and after anterior cruciate ligament reconstruction☆

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ABSTRACT

Objectives: The objective of this study was to evaluate the dynamic balance of the injured and uninjured limb before and after the anterior cruciate ligament (ACL) reconstruction and compare with the control group.

Study design: Prospective longitudinal.

Setting: Biomechanics laboratory.

Participants: Participants are 24 males (mean age, 27.5 years) with unilateral ACL injury (ACLG) and 24 male healthy volunteers (CG).

Main outcomes measures: The modified star excursion balance test (SEBT) and isokinetic knee extensor and flexor strength were applied in the ACLG preoperatively and after surgery. The dominant limb of CG was evaluated at a single time.

Results: There was no difference between the injured and the uninjured limb of the ACLG ($P > 0.05$) before and after surgery. Preoperatively, both ACLG limbs had a significantly lower reach distance in posteromedial (PM) and posterolateral (PL) directions and in composite reach (CR) score compared to the control group ($P < 0.001$). Postoperatively, no significant differences were found between ACLG and CG ($P > 0.05$). There was a positive correlation between preoperative PL (0.59) and CR (0.51), postoperative PM (0.36), PL (0.36) and CR (0.46) with flexor strength at 12 months after surgery.

Conclusion: Patients with ACL injury presented a worse performance in the SEBT in the preoperative period compared to the control group. After ligament reconstruction, the performance in the SEBT became equivalent to that of the control group. The strong correlation between flexor strength and posterior directions of the injured limb demonstrates the importance of the knee flexor muscles in the neuromuscular control of patients submitted to ACL reconstruction.

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☆ Ethical approval: The study protocol was approved by the Medical Ethics Committee of the Clinics Hospital at Ribeirão Preto School of Medicine, in Ribeirão Preto, Brazil.

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1. Introduction

Anterior cruciate ligament (ACL) injury is one of the most extensively studied orthopedic conditions in the literature [1]. In the United States, the annual incidence of ACL injury is 68.6 per 100,000 people per year, with a significantly higher rate in males (81.7 per 100,000) when compared to females (55.3 per 100,000) [2,3]. After ACL reconstruction, different factors deserve attention in order to increase the safety to return to sports practice, such as strength symmetry and neuromuscular control of the lower limbs [4,5].

The star excursion balance test (SEBT), which has high intra- and interexaminer reliability rates [6,7], is one of the well-established methods in the literature for identifying dynamic balance and postural control deficits. It requires from the patient neuromuscular capacities such as lower limb coordination, balance, flexibility, and muscular strength. A muscular strength evaluation, the isokinetic dynamometer, is the gold standard for quantifying strength asymmetry [8].

Studies have demonstrated postural control deficit through the SEBT in subjects with ACL injury [9], and after ligament reconstruction [10,11]. However, to our knowledge, no study has yet evaluated the evolution of SEBT performance throughout the preoperative period (PRE) and after ACL reconstruction. Therefore, the objective of this study was to evaluate prospectively the dynamic balance of the injured and uninjured limb of individuals undergoing ACL reconstruction through the SEBT preoperatively and up to 12 months after surgery and compare to a non-injured control group and to correlate with the muscle strength of knee extensors and flexors.

We hypothesized that there is a correlation between the performance of SEBT with muscle strength of knee extensors and flexors before and after ACL reconstruction. The existence of this correlation would be important because the SEBT is a simple test and is easy to apply, without presenting great risks to the integrity of the neoligament.

In addition, as expected in preoperative evaluation, the ACL reconstruction group would show reduced performance on the modified SEBT compared to the control group. After 12 months post-surgery, the performance of the ACL reconstruction group was expected to be similar to the control group.

2. Methods

Male subjects aged 20–40 years, with a body mass index (BMI) of between 18 and 30 kg/m² and who participated in physical activity at least three times a week were recruited for both groups. Volunteers from the control group (CG) and the ACL reconstruction group (ACLG) participated in soccer, running or attended the gym. The ACLG included 24 males, mean age of 27.5 years (standard deviation (SD), 6.2) and BMI 24.8 (SD, 2.5), with clinical and imaging diagnosis of complete unilateral ACL injury and with medical recommendation of reconstructive surgery. All subjects in the ACLG were operated on at the Clinics Hospital at Ribeirão Preto School of Medicine, in Ribeirão Preto, Brazil. The CG included 24 healthy males with a mean age of 26 years (SD, 2.1) and BMI 25.3 (SD, 2.8), and with no previous history of any injury in the lower limbs. The subjects in the CG came from the academic community and hospital staff.

We excluded from the study subjects with infection, pain that would prevent performing the test, graft failure, graft revision, other ipsilateral and/or contralateral ligament injuries, associated lower limb fractures, advanced osteoarthritis process, and neurological dysfunction.

All ACLG subjects performed the surgical procedure using a semitendinosus autograft. The rehabilitation protocol consisted of physiotherapeutic care on the first postoperative day, focusing on early gait training with partial weight bearing, edema control, quadriceps contraction, and range of motion gain. After hospital discharge, patients were referred to the physiotherapy service closest to their home and oriented to walk with full weight bearing after the third week, restoration of neuromuscular control, and progressive muscular strengthening. Three months after surgery, the patient was allowed to start running and performing progressive plyometric training after isokinetic test with limb symmetry index (LSI) $\geq 70\%$ of quadriceps. Six months after surgery, the patient was allowed to return to training the sport modality if the LSI of the isokinetic tests (quadriceps and hamstrings) and Hop Tests $\geq 85\%$. The total return to sport was allowed nine months after surgery [12].

All subjects participating in the study signed an informed consent form, and agreed to participate in the research project approved by the Ethics Committee of the Clinics Hospital at Ribeirão Preto School of Medicine.

2.1. Procedures

The test was applied by two experienced physiotherapist examiners (A.M.F., P.C.D.), according to the method of Plisky et al. [13]. The modified SEBT was drawn on the ground with adhesive tape. The volunteers received verbal instructions and a visual demonstration of the test by the examiner. The test was performed with the volunteer barefoot, in orthostatism and unipodal stance, with the most distal aspect of the hallux in the center of intersection between the lines (Figure 1).

One lower limb remained in the drawing center, and the individual received a verbal command to direct the free limb three times to the anterior (ANT), posteromedial (PM), and posterolateral (PL) directions, always keeping the entire supporting foot in contact with the ground. In order to mark the distance reached, washable paint was used in the subject's hallux. The maximal reach distance was measured by marking a tape measure at the most distal part of the foot reached. The test was carried out in the following order: ANT right, ANT left, PM right, PM left, PL right and PL left, in order to improve the reproducibility of the test and establish a consistent protocol. Before starting the test, the patient was instructed to practice each of the three directions six times to minimize the learning effect [6]. The test was discarded and repeated when the subject was not able to remain

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