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## The Knee



# Associations of isokinetic and isotonic knee strength with knee function and activity level after anterior cruciate ligament reconstruction: a prospective cohort study

Yong-Hao Pua\*, Jia-Ying Ho, Suelyn Ai-Sim Chan, Shin-Jiun Khoo, Hwei-Chi Chong

Department of Physiotherapy, Singapore General Hospital, Singapore

## ARTICLE INFO

### Article history:

Received 9 March 2017  
Received in revised form 28 May 2017  
Accepted 29 June 2017  
Available online xxxx

### Keywords:

Dynamometry  
Quadriceps femoris  
Hamstrings femoris  
ACL

## ABSTRACT

**Background:** Although isokinetic dynamometry often serves as a reference to assess the concurrent validity of weight-machine isotonic strength testing, it is unknown whether isokinetic knee strength is associated with knee function and activity level more strongly than isotonic knee strength in patients with an anterior cruciate ligament reconstruction (ACLR). This study aimed to compare the associations of isokinetic and isotonic knee strength with knee function and work-and-sports activity levels in patients with ACLR.

**Methods:** One-hundred and six patients with a unilateral ACLR participated. At three months post-ACLR, isokinetic quadriceps and hamstrings strength was measured using an isokinetic dynamometer whilst isotonic strength was measured using weight machines. At six months post-ACLR, patients performed the single-leg hop-for-distance test. Self reported knee function and work-and-sports activity levels were assessed by the Lysholm Knee Score and Tegner Activity Score, respectively.

**Results:** In multivariable analyses, isotonic and isokinetic quadriceps strength limb symmetry indices (LSIs) were significantly associated with all outcomes ( $P \leq 0.03$ ) and had comparable predictive performance. Isotonic and isokinetic hamstrings strength LSIs were significantly associated with Lysholm scores ( $P \leq 0.03$ ) and isotonic hamstrings strength was additionally significantly associated with hop-for-distance LSI ( $P = 0.01$ ).

**Conclusions:** Weight machine-derived isotonic quadriceps strength was independently and consistently associated with knee function and work-and-sport activity level post-ACLR. Isokinetic knee strength was not more strongly associated than isotonic knee strength with the various outcomes. These findings have logistic and economic implications because the isokinetic dynamometer system is relatively expensive and its operation requires more logistic effort and technical skills.

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## 1. Introduction

In patients with an anterior cruciate ligament reconstruction (ACLR), weakness of the knee muscles is a risk factor for reduced knee function and sports activity level [1]. Although isokinetic dynamometry is considered the gold standard for muscle strength assessment in ACLR [1], the isokinetic dynamometer system is relatively expensive and its operation requires time and technical skills. Indeed, the impracticality of isokinetic testing in many clinical settings has been acknowledged and has even motivated research

\* Corresponding author at: Singapore General Hospital Rehabilitation Centre, National Heart Centre Building Level 7, 5 Hospital Drive, Singapore 169609, Singapore.  
E-mail address: [pua.yong.hao@sgh.com.sg](mailto:pua.yong.hao@sgh.com.sg) (Y.-H. Pua).

into self-report screening tools for isokinetic quadriceps weakness [2]. Among the alternatives to isokinetic dynamometry, isotonic knee strength measured using conventional weight machines has been shown to be reliable and closely correlated with isokinetic strength in people with [3] and without [4,5] ACLR. Although isokinetic dynamometry often serves as a reference to assess the concurrent validity of weight-machine isotonic testing, it is unknown whether isokinetic knee strength was associated with future knee function and activity level more strongly than isotonic knee strength in patients with ACLR. And given the increasing need to remove healthcare resources from less cost-effective technologies [6,7], a head-to-head comparison of the two assessment methods takes on even greater relevance.

Thus, our study aimed to compare, in patients with ACLR, the prospective associations of isokinetic and isotonic knee strength with knee function and work-and-sports activity level.

## 2. Methods

### 2.1. Patients

Our study cohort comprised patients from an ongoing longitudinal study that aimed to identify risk factors for knee disability after an ACLR. Between October 2014 and March 2016, we identified 265 patients who were at least moderately active before anterior cruciate ligament (ACL) rupture (Tegner activity level [8] 5 and above) and who underwent a primary ACLR and postoperative outpatient physiotherapy at a major metropolitan hospital. All patients were scheduled for evaluation within a month preoperatively and approximately three and six months postoperatively, and we selected a cohort of 106 patients who had no missing month-3 knee strength (isokinetic or isotonic strength) and month-6 outcome measures (hop distance or self-report measures). Included patients were similar to those who were excluded because of missing data (data not shown). The institutional review board approved the study.

### 2.2. Knee strength

At three months after ACLR, all patients underwent isokinetic dynamometry testing and isotonic strength testing on two occasions, separated by two to five days. Concentric isokinetic strength of the quadriceps and hamstrings was measured using a Biodex System 4 isokinetic dynamometer (Shirley, NY, USA). With the patients seated, the gravity compensation procedure was performed by measuring the patient's passive limb weight at 30° of knee flexion. Following three submaximal warm-up repetitions, all patients performed seven consecutive maximal-effort extension and flexion repetitions. Among these repetitions, isokinetic quadriceps and hamstrings strength represented the highest torque achieved by the respective muscle groups. Strong verbal encouragement was given during testing. To allow patients to gain confidence with the testing protocol, we tested the contralateral knee before the operated knee. Our isokinetic protocol used an angular velocity of 60°/s [1] and the range-of-motion was set from 90° to 40° of knee flexion. Of note, this testing range-of-motion was chosen because terminal knee extension was reportedly associated with substantial shear forces transmitted to the ACL graft [9,10]. Although we did not have reliability data for our isokinetic protocol, one previous study [11] has reported good test–retest reliability for the isokinetic quadriceps strength (intraclass correlation coefficient, 0.80; coefficient of variation, 18%) and isokinetic hamstrings strength (intraclass correlation coefficient, 0.74; coefficient of variation, 17%) measures.

Concentric isotonic strength of the quadriceps and hamstrings was measured using a Cybex (Medway, USA) seated knee extension machine and a Cybex prone leg curl machine, respectively. Isotonic knee strength was determined using the one repetition maximum test, which is the maximum load (measured in pounds) the patient could lift once in good form [5]. Submaximal warm-up trials were given and they comprised three repetitions of bilateral knee extensions at <30 lb. Consistent with the isokinetic protocol, the contralateral knee was tested before the operated knee. Identification of the one repetition maximum strength of the involved knee began with a load at ~75% of the contralateral knee strength. For the isotonic quadriceps strength test, the range-of-motion was set from 90° to 40° of knee flexion; and from 0° to 90° for the isotonic hamstrings strength test. Thirty-second rest periods were given between trials, and most patients reached their one repetition maximum load between the fourth and fifth trials. Although we did not have reliability data for our isotonic protocol, previous studies have reported good test–retest reliability for the isotonic quadriceps strength [12] (intraclass correlation coefficient, 0.97; coefficient of variation, 17%) and isotonic hamstrings strength [13] (intraclass correlation coefficient > 0.95) measures.

### 2.3. Outcomes

Trained technicians and physical therapists, who were unaware of the strength test results, assessed patients' hop performance and self-report knee function and work-and-sports activity level at six months after ACLR. Hop performance was assessed by the single-leg hop for distance test [14]. Patients stood on one leg and hopped maximally for distance. All tests were performed on the non-operated side followed by the operated side. Each patient performed two submaximal practice trials followed by three test trials, and the highest measurement was analyzed. Self-report knee function and work-and-sports activity level were assessed by the Lysholm Knee Scoring Scale [15] and Tegner Activity Score [8], respectively.

We used means with standard deviations (SDs) and medians with interquartile ranges (IQRs) for continuous variables and frequencies with percentages for categorical variables. A limb symmetry index (LSI) was calculated for the knee strength (isokinetic and isotonic) and hop-for-distance tests based on maximum load, peak torque, or hop distance ([involved limb / uninvolved limb] × 100%). Correlations between the various strength measurements were estimated using Spearman's rank correlation.

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