Gait & Posture 41 (2015) 960–963

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Short Communication

Are practice trials required for hop tests?

Chandramouli Krishnan *

Department of Physical Medicine and Rehabilitation, University of Michigan Medical School, Ann Arbor, MI, USA

ARTICLE INFO

Article history:
Received 10 December 2014
Received in revised form 11 February 2015
Accepted 19 March 2015

Keywords:
Knee surgery
One leg hop
Lower extremity
Hop index
Performance-based measures

ABSTRACT

Single-legged hop tests are commonly used in clinic and research settings to obtain information on functional performance of the injured leg. When performing these tests, it is typical to provide a few practice trials before performing actual test trials. However, the importance of practice trials and how it affects performance during actual test trials are not known. This study investigated the effect of practice trials on single-leg hop performance using a marker-based kinematic tracking approach in individuals with anterior cruciate ligament (ACL) reconstruction and athletic controls. Thirteen subjects with ACL reconstruction and thirteen uninjured healthy subjects performed the single hop for distance test for both legs. Three practice and five test trials were performed on each leg. Single-leg hop distance scores and hop indices (i.e., side-to-side hop distance ratios) obtained from practice and test trials were compared. There were significant differences in the mean hop distance between practice and test trials ($P < 0.05$) when raw scores were compared, but no differences were observed when comparing the side-to-side distance ratios ($P > 0.05$). There were also significantly high correlations between practice and test trials ($P < 0.01$) and the agreement between practice and test scores was very good (ρ_c = 0.88–0.98). The findings suggest that subjects indeed improve their performance during test trials; however, the improvements had an inconsequential effect on the side-to-side hop distance ratios. Therefore, if the examiner is interested only in side-to-side ratios, then practice trials can be minimized or even avoided to improve efficiency and minimize time and costs associated with additional trials.

1. Introduction

Single-legged hop tests are commonly used to evaluate functional performance of the leg muscles after an injury or surgery to the lower-extremity [e.g., after anterior cruciate ligament (ACL) injury/reconstruction] [1–7]. These tests are routinely used in both clinic and research settings as they require minimal equipment and time, and the outcomes can be reliably compared to the contralateral leg [3,8,9]. When performing these tests, it is typical to provide the subject with a few practice trials (about 1–3) before performing the actual test [3,8,10,11]. The rationale for providing practice trials is that it would familiarize the subject with the testing conditions, facilitate maximum effort, and improve their ability to provide a reliable hop, thereby leading to valid test results [10]. However, there is also an inherent trade-off between the number of trials performed and factors such as validity, efficiency, and safety as a greater number of trials may increase fatigue, data collection/processing time, and risk of injuries during task performance. Therefore, it is important to establish the benefits of practice trials on hop performance, as this information would help to make an informed decision about the choice of using practice trials in clinical practice and research.

While the reliability of hop tests (both for hop distance and side-to-side ratios) has been well-established [8,9], it is not clear to what extent the performance in test trials actually changes with the provision of practice trials. Further, it is not known whether practice trials will have a differential effect between legs (e.g., involved vs. uninvolved leg), as this would create significant differences between side-to-side hop ratios obtained from practice and test trials. This information will be meaningful to both researchers and clinicians as it would improve the accuracy and-or efficiency of administering single-leg hop tests. Therefore, the purpose of this study was to evaluate the differences in single hop for distance scores between practice and test trials in ACL-reconstructed individuals and matched athletic controls. We chose to use only the single hop for distance test, as we wanted to minimize the confounding effects of fatigue. Further, it is the

* Correspondence to: Neuromuscular & Rehabilitation Robotics Laboratory (NeuRRo Lab), Department of Physical Medicine and Rehabilitation, University of Michigan, 325 E Eisenhower Parkway (Suite 3013), Ann Arbor, MI 48108, USA. Tel.: +1 319 321 0117; fax: +1 734 615 1770.

E-mail address: mouli@umich.edu

http://dx.doi.org/10.1016/j.gaitpost.2015.03.011
0966-6362/

recommended functional test in the International Knee Documentation Committee (IKDC) knee evaluation forms.

2. Methods

2.1. Subjects

Thirteen (8 females, 5 males) ACL-reconstructed individuals [mean age: 27.6 ± 8.3 years, height: 1.7 ± 0.1 m, weight: 75.2 ± 23.3 kg] (see Table 1 for clinical characteristics) and 13 (7 females, 6 males) uninjured healthy subjects [mean age: 25.4 ± 8.6 years, height: 1.7 ± 0.1 m, weight: 68.6 ± 14.9 kg] participated in this study. All subjects except one were right leg dominant, as established by their preferred leg to kick a ball. Informed consent was obtained prior to participation using a form approved by the University of Michigan Institutional Review Board.

2.2. Single hop for distance test

Testing began by having the subject perform a 5 min warm-up on a static bicycle ergometer (Keiser Corporation). The subject then performed the single hop for distance test (without shoes) for both legs. The ACL-reconstructed subjects performed the test beginning with their non-reconstructed legs and uninjured subjects performed the test beginning with their dominant leg (i.e., the preferred leg for kicking a ball). The subject was instructed to hop as far as possible with their hands placed on their hips [10]. Three practice trials and five test trials were performed on each leg with 20–30 s of rest between trials. If the subject had a loss of balance, had an early touchdown of their contralateral leg, lifted the hands from their hips, or had additional hops after landing, the trial was repeated [5]. The distance hopped during the single-leg hop test was evaluated using the marker-based kinematic tracking approach, where the ankle position was tracked at 30 frames per second using a high definition motion capture camera (Noraxon USA, Inc.) with a retroreflective marker placed on the lateral malleolus of the ankle [12]. The average hop distance recorded during practice and test trials was used in further analyses. A hop index was also calculated by expressing the average hop distance of the reconstructed leg (or the dominant leg) as a percentage of average hop distance of the non-reconstructed leg (or the non-dominant leg) [13].

$$\text{Hop index} = \left(\frac{\text{Hop distance}_{\text{reconstructed leg}}}{\text{Hop distance}_{\text{nonreconstructed leg}}}\right) \times 100$$

2.3. Data analyses

A 2 × 2 × 2 repeated measures analysis of variance (ANOVA) with side and trial (i.e., practice vs. test) as within-subjects factors and group as between-subjects factor was performed to identify significant differences in hop distance scores between practice and test trials. A 2 × 2 repeated measures ANOVA with trial as within-subjects factor and group as between-subjects factor was also used to identify significant differences in hop indices obtained from practice and test trials. Lin's concordance correlation coefficients and Pearson's product moment correlation coefficients were used to evaluate agreement between the raw (i.e., hop distance) and normalized (i.e., hop index) scores obtained from practice and test trials. Correlational analyses were performed in addition to the ANOVA, as it captures the degree of agreement between the practice and test scores, which are not typically captured by ANOVA. All statistical analyses were performed using SPSS windows version 22.0 and a significance level of $\alpha = 0.05$ was used.

3. Results

There was a significant main effect for trial on single-leg hop distance scores ($P < 0.01$); however, no other main (side or group) or interaction (side × group, trial × group, side × trial, or side × trial × group) effects were observed ($P = 0.18$–0.99). The mean hop distance scores from test trials were significantly higher than those observed during practice trials in both the ACL-reconstructed group and the uninjured control group ($P = 0.03$ and $P < 0.01$; Fig. 1A). The 2 × 2 repeated measures ANOVA also showed no trial or trial × group interactions ($P = 0.33$ and $P = 0.53$), indicating that the hop indices (i.e., side-to-side hop distance ratio) did not vary between practice (97.6 ± 2.6%) and test (96.6 ± 2.4%) trials (Fig. 1B). There was a strong and significant correlation between hop distance scores recorded during practice and test trials ($r = 0.93$–0.98, $P < 0.01$; Fig. 2A). Similarly, the hop indices obtained from practice trials correlated significantly with those from test trials ($r = 0.89$ and $r = 0.93$, $P < 0.01$; Fig. 2B). The Lin's concordance correlation coefficients (ρ_c) between practice and test trials were also generally high (0.88–0.98), indicating a good agreement between scores obtained from practice and test trials.

4. Discussion

Single hop for distance is the most commonly used functional performance measure when evaluating athletes with lower-extremity sports injuries, particularly with ACL injury/reconstruction. While IKDC recommends performing three trials, the actual trials (both practice and test trials) utilized to evaluate a subject's functional performance varies based on the researcher or clinician performing the tests. Interestingly, a few researchers have even recommended performing up to 10–15 trials to find a patient's maximum performance in single-leg hop tests [14]. This recommendation is based on the fact that subjects tend to improve their confidence and learning of the task with repetition of trials. However, more is not always better, as a greater number of trials may increase fatigue, minimize efficiency, and increase the risk of injuries during task performance. While the results of this study indicate that hop performance improves with practice, the increase in hop distance was small (2–4 cm) and appeared to be clinically insignificant, as these values are lower than the reported minimal detectable change for single hop for distance test [8]. Moreover,

Table 1
Clinical characteristics of ACL reconstructed subjects.

Age (years)	Height (m)	Weight (kg)	Injured leg	Sex	Graft type	Injury to surgery (months)	Surgery to testing (years)	Tegner	Marx	Lysholm	KOOS
27.6 (8.3)	1.7 (0.1)	75.2 (23.3)	RT = 5 LT = 8	F = 8 M = 5	BPTB = 8 STG = 4 Allograft = 1	4.5 (3.2)	5.7 (6.9)	6.2 (1.6)	11.5 (3.8)	94.1 (4.0)	Symptoms = 93.5 (9.4) Pain = 88.2 (12.3) ADL = 96.7 (5.7) Sports = 88.8 (16.6) QOL = 88.3 (13.4)

m, meters; kg, kilograms; RT, right; LT, left; F, female; M, male; BPTB, bone-patellar tendon-bone; STG, semitendinosus and gracilis; KOOS, knee injury and osteoarthritis outcomes score; ADL, activities of daily living; QOL, quality of life; values are presented as mean (standard deviation).