INTRODUCTION

The single-leg hop for distance is a commonly used functional test in rehabilitation for knee injury or surgery. Results on the test have been used to guide clinical decision-making following anterior cruciate ligament (ACL) injury or reconstruction. For example, symmetry between limbs of 85% or greater has been suggested as satisfactory for safely returning to sports activity. Few studies have reported symmetry on the single leg hop test following meniscectomy has been studied less because the surgery is less invasive than ligament reconstruction. In addition, few studies have examined landing kinematics and kinetics on the single leg hop test following meniscectomy. However, landing from a hop places high demands on the lower limb to absorb ground reaction force, and poor force absorption may be a factor in the high incidence of knee osteoarthritis following meniscectomy.

The purpose of this study was to investigate in subjects with meniscectomy: (1) differences in single leg hop landing biomechanics between limbs, and (2) the relationship between the single leg hop test symmetry index and landing biomechanics on the surgical limb.

METHODS

Subjects with meniscectomy were selected to participate if they met the following criteria: (1) age 15-35 years, (2) traumatic-onset meniscal tears, (3) surgery performed within 1 year of injury, (4) meniscal tears confirmed at the time of surgery, (5) unilateral injury, (6) no concomitant other ligamentous injury > Grade II, and (7) no previous knee injury and surgery. At the time of testing, all subjects had undergone a supervised physical therapy program for 6 weeks.

Single leg hop test
Subjects first stood on the non-surgical limb and hopped forward as far as possible, landing on the same limb and holding for 3 seconds. The test was repeated on the surgical limb. Practice trials were performed for each limb until hop distance was stable. Three trials were then collected and the distances were averaged. The symmetry index was calculated using the following formula: [(average distance on surgical limb/ average distance on non-surgical limb) *100].

Landing biomechanics
Retro-reflective markers placed on anatomical landmarks and tracking shells were used to monitor lower limb motion. Marker positions were recorded with a six-camera, three-dimensional motion capture system (Motion Analysis Corporation, Santa Rosa, CA) collecting at 120 Hz. Synchronized force data were sampled at 1200 Hz with a six-component force plate (Advanced Mechanical Technology Inc.; Watertown, MA). Subjects performed a single leg hop test onto the force plate at 80% of the average hop distance and held their landing position for 3 seconds. Subjects performed at least 3 practice trials, and 3 successful trials were recorded.

Kinematic and kinetic variables were analyzed during the landing phase, including sagittal plane knee excursion (initial contact to peak knee flexion), peak vertical ground reaction force (PVGRF), time from initial contact to PVGRF and rate of loading. Rate of loading was calculated using the following formula: PVGRF/time from initial contact to PVGRF. PVGRF and rate of loading were both normalized for body weight.
Paired-sample t-tests analyzed the difference in single leg hop landing biomechanics between limbs. Pearson product-moment correlation was used to determine the association between the single leg hop symmetry index and biomechanical variables on the surgical limb.

RESULTS AND DISCUSSION

Twelve male subjects (age = 20.9 ± 1.4 years) participated in the study. The mean height and weight were 181.7 ±1.7 cm and 102.6 ± 8.8 kg, respectively. The mean time from injury to testing was 4.2 ± 3.2 months. The side of meniscectomy was lateral for 7 subjects and medial for 5 subjects.

The single leg hop symmetry index was 87.8± 1.2 %. The surgical limb demonstrated decreased sagittal plane knee excursion compared to the non-surgical side (Surgical = 32.5 ± 7.2°, Non-surgical = 40.8 ± 9.1°; p=0.008). The PVGRF was not significantly different between limbs (Surgical = 2.5 ± 0.6 BW, Non-surgical = 2.5 ± 0.6 BW; p=0.661). Compared to the non-surgical limb, the surgical limb demonstrated a trend toward increased time from initial contact to PVGRF (Surgical = 0.056 ± 0.015 s, Non-surgical = 0.049 ± 0.012 s; p=0.083) and decreased rate of loading (Surgical = 50.1 ± 18.5 BW/s, Non-surgical = 55.5 ± 18.5 BW/s; p=0.087).

A significant negative correlation (r=-0.595, p=0.041) was found between the single leg hop symmetry index and the time from initial contact to PVGRF on the surgical limb. No correlation was found between single leg hop symmetry index and sagittal plane knee excursion (r=0.050, p=0.878) or PVGRF (r=0.454, p=0.138) or rate of loading (r=0.468, p=0.125) on the surgical limb.

The mean single leg hop symmetry index met the current standard for returning to sport activation in ACL reconstruction is 85%. However, 4 of 12 subjects in this study were below this criterion. Asymmetry was seen in the landing biomechanics of a single leg hop. The surgical limb demonstrated a significant decrease in knee motion and the rate of force application to the body. This reduced loading strategy may lead to a reduced force absorption capacity, which indicates greater impact force at the knee. However, additional investigation is needed to examine whether the decreased knee motion is compensated by greater hip and/or ankle motion.

An interesting finding of this study was the negative correlation between the single leg hop symmetry index and time from initial contact to PVGRF on the surgical limb. This finding may indicate that subjects with meniscectomy who need more time to absorb force on the surgical limb may not be able to hop as far on the surgical limb. This finding may provide insight for clinicians to develop rehabilitation interventions to improve surgical limb hopping distance following meniscectomy.

CONCLUSIONS

Our findings indicate that following meniscectomy, the surgical limb displayed decreased sagittal plane knee excursion, increased time from initial contact to PVGRF and decreased rate of loading. The single leg hop symmetry index was negatively correlated with the time from initial contact to PVGRF on the surgical limb. Our findings provide insight for developing rehabilitation interventions to correct limb asymmetry in landing of a single leg hop and improve surgical limb hopping distance following meniscectomy. Future studies should examine the hip and ankle motion during landing of a single leg hop.

REFERENCES