Joint Angular Impulse and Neuromuscular Control during the Y Balance Test in ACLR Individuals

Moore, Logan N.[1] Decker, Meredith N.[1] Ricard, Mark D.[1]
[1]The University of Texas at Arlington, College of Nursing and Health Innovation, Department of Kinesiology
Email: logan.moore@uta.edu

Introduction

The Y Balance Test™ (YBT) is used to measure lower extremity dynamic balance and stability [5]. The YBT is a modified version of The Star Excursion Balance Test (SEBT) looking solely at three reach distances (anterior, posteromedial, and posterolateral) [3, 5]. Dynamic stability tests have been used by clinicians to detect injury risk and as a criterion for return to sport in patients with anterior cruciate ligament (ACL) injuries [2-4]. Patients that have had ACL reconstruction (ACLR) are at a higher risk of reinjury of the ACL and development of osteoarthritis in the knee [1, 2]. Continued dynamic stability tests post rehabilitation could provide insights in the increased risk of reinjury. To our knowledge, there have been no studies focused on neuromuscular control and the joint moments of the lower extremity in patients that are several years out from ACLR. The purpose of this study was to determine if limb to limb differences were present in lower extremity joint moments and neuromuscular control in ACLR patients several years post reconstruction in the anterior direction while preforming the YBT.

Methods

Data collection occurred in one session in the University's Biomechanics Laboratory. Twelve recreationally active adults (male=5, female=7, age=24.7±3.6yrs, mass=76.1±12.3kg, height=168.7±10.1cm) volunteered to participate in this study. All participants had a previous history of unilateral ACLR with an average time of 7±3.1 years post reconstruction. EMG data were recorded at 1000 Hz using DE 2.1 electrodes (Delsys Inc.) for gastrocnemius, gluteus maximus, gluteus medius, biceps femoris, semimembranosus, tibialis anterior, vastus medialis, and vastis lateralis. Participants completed 3 trials of the YBT while being recorded at 100 Hz using Vicon Nexus software and an AMTI force plate (1000 Hz). EMG data was processed by using a critically damped low pass filter and normalized to the maximum amplitude attained during all YBT attempts by muscle. 3D internal joint moments about the hip and knee joints were computed using Visual3D and integrated from 100 ms prior to, and 100 ms after max reach in YBT. Linear mixed-effects were used to determine differences between limbs (affected, unaffected) in joint angles and joint angular impulses with EMG linear envelopes as covariates.

Results and Discussion

There was no significant difference in the anterior reach between the affected 54.92 ± 9.40 cm and unaffected 54.09 ± 9.40 cm, p = 0.23 limbs in the YBT. In the knee joint, the angular impulse for the affected limb was found to have significantly greater abduction impulse, and there was no significant difference found in the knee joint angles (Figure 1). The hip of the affected limb was demonstrated to have significantly greater external rotation and to have greater extension. The angular impulse of the affected limb in the hip was shown to have greater external impulse. While not significant (p=0.08), there was a greater hip abduction impulse in the affected limb.

While there were no significant differences in maximal reach distance, how the reach was obtained did change. To compensate for putative deficiencies in the affected limb, subjects exhibited greater knee joint abduction (valgus alignment) and greater hip external rotation and hip extension to attain the same reach distance, when compared to the unaffected limb. These differences in joint angular impulses and joint angles illustrate dynamic balance asymmetries. Dynamic balance asymmetries may be indicative to having a greater risk of injury in the affected limb. There were no significant differences in the maximal amplitude of the EMG between limbs, however strength measurements could further explain the asymmetries in joint angular impulse and neuromuscular control in ACLR patients.

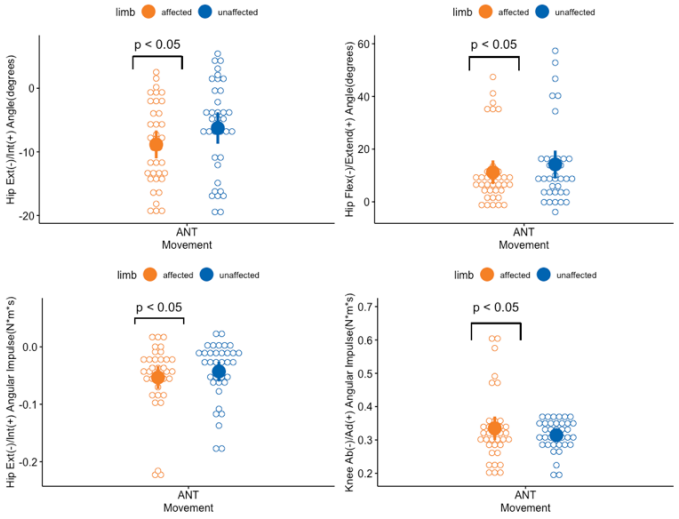

Figure 1: Mean ± 95% CI for hip and knee joint angles and joint angular impulse centered at ± 100 ms at maximum reach by limb (affected, unaffected) in the YBT anterior direction.

Significance

In the anterior direction of the YBT, there were significant differences in the hip and knee joint angular impulses at maximum reach in the affected limb in patients several years post ACLR. There were significant differences in hip joint angles in the affected limb. Continued dynamic stability testing needs to occur post ACLR to identify limb asymmetries and prevent future knee injuries.

Acknowledgements

We would like to thank the University of Texas at Arlington, and all the participants that volunteered for this study.

References

1. Brumitt J, et al. JSAMS, 22:1309-1313, 2019.
2. Cervenka J, et al. *IJES* 11: 817-826, 2018.
3. Hudson C, et al. Phys Ther Sport, 22:61-66, 2016.
4. Plisky P, et al. J Orthop Sports Ther, 36:911-919, 2006.
5. Shaffer SW, et al. Military Med, 178:1264-1270, 2013.
6. Hewett TE, et al. Am J Sports Med, 33:492-501, 2005