

Original Research

Limb Dominance Does Not Affect Y-Balance Performance in Young Athletes 12 Weeks After Anterior Cruciate Ligament Reconstruction

Matt Turner, PT, DPT, Ph.D, OCS¹^a, Joseph Hannon, PT, DPT, Ph.D, SCS², Shiho Goto, Ph.D, ATC³, Sharon Wang-Price, PT, Ph.D, COMT, FAAOMPT⁴, Craig Garrison, PT, Ph.D, ATC⁵, Steven Singleton, MD⁶

¹ Department of Rehabilitation Sciences, The University of Oklahoma Health Campus, ² Young Athlete Center, St. Louis Children's Hospital,

³ University of Louisiana at Lafayette, ⁴ Physical Therapy, Texas Woman's University, ⁵ Orthopaedic Surgery, Memorial Hermann, ⁶ Orthopaedic Surgery, University of Texas Southwestern

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Background

The Lower Quarter Y-Balance Test (YBT-LQ) has been shown to be a reliable and valid tool for assessing lower extremity balance in the athletic populations. It is commonly included in the test battery used to determine athletes' readiness for return to sport. As the dominant limb has been associated with a lower rate of second anterior cruciate ligament (ACL) injury in athletes after ACL reconstruction (ACLR), early detection of the effects of limb dominance on YBT-LQ performance can provide insight into athletes' rehabilitation progression and prognosis after ACLR.

Hypothesis/Purpose

The purpose of this study was to determine whether limb dominance would affect YBT-LQ performance in young athletes 12 weeks after ACLR. It was hypothesized that limb dominance would have a significant effect on YBT-LQ performance in this patient population.

Study Design

Retrospective cohort study

Methods

A total of 110 athletes following ACLR were included in this secondary analysis. The dominant limb was defined as the limb that participants would choose to kick a ball. Participants were grouped based on whether the ACLR limb was their self-reported dominant limb (n = 50) or non-dominant limb (n = 60). YBT-LQ performance was assessed at 12 weeks postoperatively as part of a battery of tests. Two separate 2 (group) x 4 (YBT-LQ score) mixed ANOVAs were performed for the surgical and non-surgical limbs

Results

There were no significant group x direction interactions or main effects of surgical limb dominance for the surgical limb (p = 0.527) or non-surgical limb (p = 0.207). Effect sizes were trivial (Cohen's d = 0.03 – 0.17)

^a Corresponding Author:
Matt Turner, PT, PhD
The University of Oklahoma Health Campus
Department of Rehabilitation Sciences
1200 N. Stonewall Avenue, AHB 3109
Oklahoma City, OK 73117
Email: Matthew-j-turner@ou.edu

Conclusion

Limb dominance does not seem to affect YBT-LQ performance in a young athletic population at 12 weeks after ACLR.

Level of Evidence

Level 3

INTRODUCTION

A plethora of research on anterior cruciate ligament reconstruction (ACLR) has emerged in the past decades, as approximately 200,000 ACL tears occur annually within the United States.¹ Despite the abundance of research, the rate of young athletes returning to their previous level of function remains low, between 53 and 63%.² Furthermore, some studies have shown that as high as 29.5% of athletes suffer a second ACL injury within 24 months and 20% at any point following return to sport (RTS).^{1,3} The re-injury rate is reportedly between 4.7-11% on the ipsilateral surgical limb and between 6-30% on the contralateral surgical limb. The high re-injury rates after RTS indicate inadequate ACLR recovery or rehabilitation.^{4,5} Poor performance and a lack of symmetry on lower extremity functions could lead to an increased risk of future injury and inability to return to pre-level of sports competition.^{6,7} However there is no consensus regarding which factors affect lower extremity symmetry and functional performance in athletes after ACLR.

Literature indicates that limb dominance significantly affects lower extremity biomechanics in patients with an ACL injury, but conflicting results also exist.⁸⁻¹⁰ The rate of ACL injuries in the dominant limb has been reported to be between 45% and 69%.^{2,11} When examining a sample of 100 soccer players at an average of seven years after RTS from ACLR, Brophy et al.² found that those who originally injured their dominant limb had a lower rate of second ACL injury (3.5%) on the contralateral limb compared to those who originally injured their non-dominant limb (16%). The difference was attributed to possible changes in neuromuscular function between the limbs, suggesting the presence of inherent motor planning differences between the dominant and non-dominant limbs.

Due to the high re-injury rate following ACLR, the effect of limb dominance on ACLR recovery has been studied recently. A recent study of 108 individuals between 13-25 years old who were post ACLR examined the difference in energy absorption contribution (EAC) based on limb dominance and found that individuals who injured their dominant limb had a significantly smaller EAC at the hip, but larger EAC at the knee compared to those who injured their non-dominant limb following an ACLR.¹² Therefore, limb dominance was considered to have a significant role in loading strategies after ACLR.

The Lower Quarter Y-Balance Test (YBT-LQ) is used as a measure of lower extremity function and has the ability to evaluate range of motion (ROM), strength, and neuromuscular control of the lower extremity.¹³ Research has shown that the YBT-LQ has moderate-to-good reliability (ICC = 0.57 - 0.990),^{14,15} and is valid for assessing dynamic balance in athletes recovering after lower extremity in-

juries,¹³⁻¹⁶ and surgeries.¹⁷⁻¹⁹ The YBT-LQ is often used as an assessment of postural control and dynamic balance following ACLR because it has been shown to have a close relationship with functional performance and strength.²⁰ Although YBT-LQ performance has been shown to have a statistically significant association with hop testing and isometric knee extension strength at 12 weeks following ACLR and at time of return to sport after ACLR, limb dominance was not controlled in these studies.^{13,20,21}

To date, only a few studies have examined the effect of limb dominance on YBT-LQ performance. One study found no significant difference in YBT-LQ performance between the dominant and non-dominant limbs in non-athlete adolescents.²² Another study also found no significant differences in YBT-LQ scores between the dominant and non-dominant limbs in healthy young male soccer players.²³ However, no study has yet examined the effects of limb dominance on YBT-LQ performance in injured populations, such as patients following ACLR. As loading patterns following ACLR appear to be dependent on limb dominance, YBT-LQ performance may also be different between limbs after ACLR. Therefore, the purpose of this study was to determine whether limb dominance would affect YBT-LQ performance in young athletes 12 weeks after ACLR.

METHODS

PARTICIPANTS

This secondary analysis included athletes who participated in a large-scale study examining outcomes following ACL injury (IRB approval # STU-2019-1184) and completed a battery of tests at their 12-week follow-up. Individuals were considered eligible for this secondary analysis if they were between 13-18 years of age and were involved in a Level 1 (e.g. basketball, football or soccer) or 2 (softball, baseball) sport.²⁴ Participants were excluded from this study if they had a previous history of a full-thickness chondral injury, had a Grade II or III injury of the medial collateral ligament (MCL), lateral collateral ligament (LCL), posterior collateral ligament (PCL) or had suffered a radial split meniscal tear. Radial split meniscal tears were excluded from this analysis because these tears are often handled differently in surgery and rehabilitation. Consequently, a total of 110 athletes who met the inclusion criteria and completed the YBT-LQ at 12 weeks after ACLR were included in this secondary analysis. Eligible participants were assigned one of two groups based on whether the ACLR limb was their self-reported dominant limb or non-dominant limb. Limb dominance was defined as the limb with which the athlete would prefer to kick a ball. In addition, each participant's de-

mographic information, injury history, sports participation, leg length, and self-reported dominant leg were extracted.

Y-BALANCE TEST LOWER QUARTER (YBT-LQ)

A YBT-LQ Kit™ (Perform Better, West Warwick, RI) was utilized to administer the YBT-LQ test throughout the study. The YBT-LQ procedure was standardized in the large ACLR outcome study. During the testing, the investigators used verbal cues and demonstration to instruct the participants to perform the YBT-LQ following a previously reported protocol.¹⁸ All participants wore shoes to perform the test and began on their involved (surgical) limb followed by uninjured (i.e., non-surgical) limb. The participants were asked to perform a single-leg stance on one limb while using the other limb to push a reach indicator box along the measurement pipe. The participants performed the test in three directions following the same order: anterior (ANT), posteromedial (PM) and posterolateral (PL) directions. Each participant was allowed at least four practice trials in each direction prior to the start of the YBT-LQ testing. Each participant was required to perform three valid trials in each direction. Elevation of the heel, toe or loss of balance resulting in a stepping strategy was considered as a trial of error, and another trial was repeated. The measurements (cm) were taken from the start position to the point where the most proximal part of the reach indicator box. The maximal reach distance of the three trials was used for data analysis.

The composite scores were calculated by adding the reach distances of ANT, PM, and PL, dividing by three times the participant's leg length, and then multiplying by 100 to obtain a percentage.¹⁸ Leg length was the measured distance between the most prominent portion of the greater trochanter and the floor while the individual was in a standing position. Composite YBT-LQ scores of the surgical and non-surgical limbs were computed for each of the athletes in this study. Previous studies performed from this data-set have shown that the reliability of the measurements for the ANT, PM and PL directions (ICC 3,1 = .086, .99, and .95 respectively) are acceptable.^{13,16} Composite scores were also similar to previously published data on intrarater (ICC3,1 = 0.91) and interrater (ICC2,1 = 0.99) reliability of composite scores for this test.^{18,25}

DATA ANALYSIS

All data were analyzed utilizing IBM SPSS statistics for Macintosh, Version 28 (IBM Corp., Armonk, NY). Independent *t*-tests and chi-square tests were used to determine demographic differences between groups. To compare YBT performance between groups, two separate 2 x 4 mixed ANOVAs were used to analyze the YBT-LQ scores, one for the surgical limb and the other for the non-surgical limb. The alpha level was set at 0.05 for all statistical analyses. Effect sizes (Cohen's *d*) were calculated to quantify the magnitude of between-group differences and were interpreted as trivial (< .20), small (0.20–0.49), moderate (0.50–.79), and large (≥ 0.80).

RESULTS

Of 106 athletes (16.0 ± 1.6 years; 59 males, 47 females) included in this study, 47 had an ACLR on their dominant limb and 59 had an ACLR on their non-dominant limb. [Table 1](#) displays the demographic information of all participants, separated by the dominant surgical limb group, and the non-dominant surgical limb group. There were no significant differences in any of the demographic data between the two groups ($p > 0.05$).

[Table 2](#) lists the composite score of the YBT-LQ and the normalized scores in all three directions for both surgical limb and non-surgical limb. The ANOVA result showed no significant interaction or main effect of limb dominance for the involved limb: $F(1.79, 191.39) = .527, p = 0.527$, or for the non-surgical limb: $F(1.75, 182.30) = 1.61, p = 0.207$.

DISCUSSION

The results of this study showed that limb dominance did not have a significant effect on YBT-LQ performance in young athletes 12 weeks following ACLR. Between-group differences were minimal for the surgical limb (0.34 – 1.72%) and non-surgical limb (0.84 – 1.54%). The results of this study are in agreement with those of previous studies in asymptomatic healthy individuals,^{22,23} indicating that limb dominance does not influence YBT-LQ performance after ACLR. This finding was unexpected as YBT-LQ performance has a strong correlation with functional outcomes for athletes after ACLR.^{13,16}

Notably, prior research has reported significant differences in joint loading between dominant and non-dominant limbs after ACLR.¹² However, the performance difference between limbs was found while the athletes performed a jump landing task, rather than the YBT-LQ.¹² Additionally, previous studies have documented differences in central brain activation and lateralization between the dominant and non-dominant limbs.^{26,27} Specifically, magnetic resonance imaging (MRI) has revealed significant variations in signal changes with the primary sensorimotor cortex and basal ganglia between the two limbs. Despite these findings, evidence suggests that trained athletes exhibit greater neural efficiency, requiring reduced brain activation during single-limb tasks,²⁸ which may explain why the YBT-LQ lacks the sensitivity to detect dominance-related disparities.

Another possible explanation why limb dominance does not have an effect on YBT-LQ performance relates to the method used to define the dominant limb. This study utilized the widely accepted self-reported definition of the kicking limb. However, previous research has highlighted discrepancies between self-reported and observed limb dominance, particularly in closed-kinetic-chain (CKC) movements. One study found 100% agreement between self-reported dominance and a kicking task, but only 85% and 71% agreement for standing on one leg and single leg jumping, respectively.²⁶ These findings suggest that limb dominance may not be consistently expressed across differ-

Table 1. Demographic Characteristics of the Participants, mean (SD) or count

	All (N = 106)	Dominant Surgical Limb (N = 47)	Non-Dominant Surgical Limb (N = 59)	p-value
Age (years)	16.0 (1.6)	16.0 (1.5)	16.0 (1.7)	.926
Gender (Men/women)	59/47	27/20	32/27	.744
Height (cm)	172.7 (9.8)	174.0 (8.8)	171.5 (10.6)	.197
Weight (kg)	73.6 (15.1)	73.4 (12.0)	73.8 (17.3)	.907
BMI	24.6 (4.2)	24.2 (3.4)	24.9 (4.8)	.378
Days from Surgery	86.6 (4.3)	86.5 (3.9)	86.6 (4.6)	.942
Graft Type				.770
Ipsilateral patella	83	36	47	
Ipsilateral hamstring	15	8	7	
Ipsilateral quadriceps	8	3	5	
Sport				.804
Basketball	18	10	8	
Football	35	15	20	
Soccer	34	16	18	
Volleyball	6	2	4	
Softball	2	2	1	
Cheerleading	1	0	1	
Baseball	1	0	1	
Lacrosse	1	0	1	
Wrestling	1	1	0	
Gymnastics	1	1	0	
Other	2	1	1	

Table 2. The Normalized Mean Reach Distances and Composite Score of the Y-Balance Test – Lower Quarter (YBT-LQ) at 12 Weeks presented as mean $\pm$ SD (N = 106)

	Dominant Limb Group	Non-dominant Limb Group	p-value	95% CI	Effect Size (d)
Surgical Limb					
ANT	58.4 $\pm$ 6.8	57.4 $\pm$ 6.3	.48	1.6, 3.5	0.15
PM	107.9 $\pm$ 10.3	107.2 $\pm$ 11.4	.76	3.6, 4.9	0.06
PL	102.0 $\pm$ 10.5	102.7 $\pm$ 10.5	.74	4.7, 3.4	0.07
Composite Score	89.4 $\pm$ 8.0	89.1 $\pm$ 8.2	.86	2.9, 3.4	0.03
Non-surgical Limb					
ANT	65.3 $\pm$ 5.9	64.3 $\pm$ 7.3	.45	1.6, 3.6	0.15
PM	111.1 $\pm$ 9.3	112.8 $\pm$ 11.2	.40	5.7, 2.3	0.17
PL	105.5 $\pm$ 8.9	107.1 $\pm$ 10.4	.42	5.3, 2.3	0.16
Composite Score	93.9 $\pm$ 6.8	94.7 $\pm$ 8.2	.62	3.7, 2.2	0.11

ANT = anterior; PM = posteromedial; PL = posterolateral.

ent movement tasks, particularly when transition from OKC to CKC.

The variability in rehabilitation protocols among study participants may also contribute to the lack of observed differences in YBT-LQ performance. Rehabilitation was not standardized across participants. Given the variability in postoperative ACLR rehabilitation approaches, differences in rehabilitation may have influenced YBT-LQ performance at the time of testing.²⁹ Furthermore, early rehabilitation typically prioritizes the surgical limb, potentially mitigating any inherent effects of limb dominance on functional performance measures such as YBT-LQ.³⁰

Finally, neuroplastic adaptations following ACLR may have influenced the observed findings. Previous studies

have demonstrated bilateral deficits in knee joint proprioception during single leg squats.^{31,32} Similarly, studies examining dynamic postural stability following ACLR have reported reduced stability in both the surgical and non-surgical limbs during unipedal jump-landing tasks.³³⁻³⁵ These findings suggest that ACLR induces bilateral neuromuscular changes, which could explain the absence of significant limb dominance effects in YBT-LQ performance.

Limitations of this study include that both sexes (male and female) performed the testing which can have an influence on YBT-LQ performance due to movement strategy differences.³⁶ Second, the study population consisted of athletic individuals aged 13-18 years, limiting the generalizability of these findings to other age groups or less active

populations. Lastly, there was no control for activities that the participants may have engaged in immediately prior to testing sessions which could have affected a subject's performance.

CONCLUSION

The results of this study suggest that limb dominance does not affect YBT-LQ performance in either the surgical or non-surgical limb at 12 weeks after ACLR in a young athletic population. The criterion that was used to select dominant limb may not be sufficient. It is possible that the YBT-LQ may not be sensitive enough to discriminate between limb differences at 12 weeks after ACLR. There is a need for future studies to focus on limb dominance before and after ACLR with relation to functional testing performance, as well as studies comparing limb dominance in individuals after ACLR to healthy controls.

CORRESPONDING AUTHOR:

Matt Turner, PT, PhD
The University of Oklahoma Health Campus
Department of Rehabilitation Sciences
1200 N. Stonewall Avenue, AHB 3109
Oklahoma City, OK 73117
Email: Matthew-j-turner@ou.edu

CONFLICT OF INTEREST

The authors have nothing to disclose nor any conflicts of interests.

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