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Original Research

Utilizing Hip Abduction Strength to Body-Weight Ratios in Return to Sport Decision-Making After ACL Reconstruction

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Background

Despite the association between hip abduction weakness and non-contact anterior cruciate ligament (ACL) injury, hip abduction strength is rarely considered in return to sport decision-making following ACL reconstruction (ACLR).

Hypothesis/Purpose

The purpose of this study was to compare self-reported function, objective functional test performance, and re-injury rates in patients with high (≥33%) versus low (<33%) isometric hip abduction strength to body weight (BW) ratios when returning to activity following ACLR.

Study Design

Cohort study

Methods

Data were gathered from a single-surgeon database and included baseline demographics. Clinical outcomes were assessed at the time of release to activity and included self-reported outcomes and a functional testing battery. Isometric hip abduction strength was obtained using a handheld dynamometer. Groups were dichotomized into those with low vs high strength to BW ratios. Two-year follow-up was performed using the single assessment numeric evaluation (SANE). Data were analyzed using univariate general linear models with an alpha level of .05.

Results

Of the 528 enrolled patients, 364 (68.9%) demonstrated a low strength to BW ratio. Baseline comparisons revealed more females and higher BMI (P <.05) in the <33% group. At release to activity, the <33% BW group demonstrated lower International Knee Documentation Committee survey scores (88.2 ± 13.6 vs 93.5 ± 10.3, P<.01), ACL-Return to Sport After Injury (76.2 ± 15.4 vs 88.5 ± 16.9, P<.01) scores, and isokinetic hamstring peak torque (P=.04). At 2-years, the <33% group reported lower SANE scores (83.3 ± 21.1 vs 92.83 ± 11.4, P=.05) with no significant differences in re-injuries.

Conclusion

Patients with low hip abduction strength to BW ratios demonstrated lower subjective function, psychological readiness, and isokinetic hamstring peak torque when completing functional testing following ACLR. Subjective deficits remained at 2-years.

Level of Evidence

Level 3

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Key Terms

ACL injury, hip abduction strength, return to sport, strength ratio

Clinical Relevance

Assessing isometric hip abduction strength to body weight ratio may be beneficial in determining readiness to return to sport following ACL reconstruction.

What is Known About the Subject

Three prospective studies have provided conflicting evidence regarding the relationship between hip abduction strength and ACL injury. A clinical cut-point of hip abduction strength:BW ratio <35.4% has been suggested to identify athletes at risk of sustaining a non-contact ACL injury. To our knowledge no studies have examined isometric hip abduction strength:BW ratios in athletes attempting to return to sport following ACLR.

What This Study Adds to Existing Knowledge

This study examines the potential for hip abduction strength:BW ratio to be included as an additional metric in return to sport testing batteries.

INTRODUCTION

Non-contact injury mechanisms are responsible for approximately 70% of anterior cruciate ligament (ACL) ruptures.[1,2] Several biomechanical and neuromuscular factors have been identified as risk factors for non-contact injuries,[3,4] with prevention strategies often targeted at reducing dynamic knee valgus.[5–7] Hip abductor strength may assist in controlling dynamic knee valgus by reducing hip adduction and internal rotation associated with dynamic knee valgus.[4,8] Strengthening programs targeting the hip abductors are frequently included following ACL reconstruction (ACLR) to assist in normalizing lower-extremity strength and facilitating normal trunk, hip, and knee mechanics when returning to sport.[9,10] However, despite the supporting evidence, few studies have included hip abduction strength as a functional criterion when determining readiness for return to sport.

Perhaps the omission of hip abduction strength from return-to-sport decision-making may be due to the inconsistencies found within the current literature and heterogeneity in testing procedures. Specifically, three prospective studies have provided conflicting evidence regarding the role of hip abduction strength in identifying athletes at risk for non-contact ACL injury. An investigation of 867 elite Norwegian female athletes demonstrated no association between hip abduction strength and ACL injury.[11] In contrast, an additional study suggested increased hip abduction strength was an independent risk factor for non-contact ACL injury in female Japanese high school basketball athletes.[12] The authors suggested that athletes with greater hip abduction strength may be predisposed to move into hip adduction in an attempt to counterbalance, highlighting the lack of consistent findings with regard to this clinical measure. Khayambashi et al.[13] identified hip abduction weakness as an independent predictor of non-contact ACL injuries. In a study of 501 athletes, hip abduction weakness was significantly associated with ACL injury and explained 10.2% of the variation in injury status. A clinical threshold of hip abduction strength < 35.4% of body weight (BW) was reported to identify athletes at risk for future non-contact injury.[13] The authors suggested using this hip abduction strength to BW ratio (sensitivity 0.87, specificity 0.65) to assist in screening for ACL injury risk.[13]

Despite the potential link between hip abduction strength and ACL injury, little evidence exists regarding the inclusion of hip abduction strength in return to sport assessments. A recent systematic review of 209 studies identified only 86 studies utilizing strength measures as return to sport criteria, with minimal reporting of hip abduction strength.[14] Several case-control and cross-sectional studies have compared hip abduction strength between healthy controls and ACLR patients who had already returned to sport,[15–18] though none utilized hip abduction strength as a return to sport decision-making tool. To our knowledge, no studies have assessed the relationship between isometric hip abduction strength on a combined subjective and objective functional testing battery at time to return to sport. Further, no studies have examined if meeting a suggested hip abduction strength to body weight (BW) ratio is associated with improved outcomes following ACLR. Therefore, the purpose of this study was to compare self-reported function, objective functional test performance, and re-injury rates in patients with high (⩾33%) versus low (<33%) isometric hip abduction strength to BW ratios when returning to activity following ACLR. The authors hypothesized that individuals demonstrating hip abduction strength ⩾33% BW would perform better on self-reported outcomes, demonstrate superior objective functional testing performance, and demonstrate a lower re-injury rate when compared to those who exhibited lower strength ratios.

METHODS

A retrospective comparison study was conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines using a single surgeon (WRL) database of 829 patients who underwent ACLR from 2017-2019. All participants provided verbal and written consent. This study was approved by the University of Texas Health Sciences Center Institutional Review Board (HSC-MH-14-0734) and registered with Clinicaltrials.gov (NCT03704376). The study inclusion criteria were patients who underwent ACLR, completed hip abduc-

tion strength testing and functional testing at time of release to activity, and completed follow-up surveys at two years post-surgery. Patients were excluded if they had orthopaedic conditions or medical complications preventing them from performing standard post-operative rehabilitation (fracture or deep vein thrombosis) or if they did not intend to return to sports participation. A total of 829 patients were reviewed in the database with 528 patients meeting inclusion criteria.

HIP STRENGTH-TO-BODYWEIGHT RATIOS

Bilateral isometric hip abduction strength testing was performed with the patient in supine and the hip in ten degrees of abduction (Figure 1). The testing leg was secured to the table with a belt placed proximal to the lateral femoral condyle. A HOGGAN microfet-2 handheld dynamometer (Hoggan Scientific, 3653 W. 1987 S., Salt Lake City, UT, USA) was secured between the belt and the testing leg. The patient was instructed to perform a maximum hip abduction contraction into the fixed resistance of the belt and examiner (make test) for 5 seconds. Standard verbal cueing instructions were used to minimize compensatory strategies. Three trials were completed and then averaged with the force being recorded in pounds. All testers completed reliability training and demonstrated excellent reliability with intraclass correlation coefficients ranging from 0.921-0.927 ($P < .01$). Patients were dichotomized into two groups for analysis: those demonstrating <33% hip abduction strength to BW ratio (low strength) and those ⩾33% (high strength). The cut-off of ⩾33% BW was used instead of the previously referenced 35.4% as it seemed more practical for clinical use. Specifically, ⩾33% BW may provide a notable threshold to aid in guiding clinical decision and counseling patient readiness to return to sport with the sports medicine team.

DATA COLLECTION

Baseline patient demographic characteristics were obtained for age, gender, height, weight, body mass index (BMI), and preinjury activity level via the Marx activity score.[19] Subjective function at time of release to activity was assessed via the International Knee Disability Committee (IKDC-2000) survey[20] and the ACL Return to Sport Index (ACL-RSI)[21] psychological readiness survey. Both groups were compared on functional test performance including passive knee range of motion (ROM), Y-balance anterior reach testing, four single-leg hop tests, and Biodex isokinetic quadriceps and hamstring testing. Y-balance (YBT) and hop test performance was assessed using previously established protocols[22,23] with three trials being completed on the uninvolved and involved limbs. Isokinetic quadriceps and hamstring peak torque testing were completed via an isokinetic dynamometer (Biodex Medical Systems Inc., 20 Ramsey Rd., Shirley, NY, USA) at 60 (5 repetitions), 180 (10 repetitions), and 300 degrees (15 repetitions) per second (°/sec). Patients completed serial functional testing until demonstrating ⩾ 85% quadriceps limb symmetry index (LSI) via isokinetic dynamometry, ⩾90% LSI on the remaining functional tests, and being cleared by the surgeon. Surgical data were reviewed from operative reports with comparisons made based on graft type, procedure type, use of platelet-rich-plasma (PRP) or bone marrow aspiration (BMA), and type of rehabilitation protocol (accelerated or delayed). All patients followed a standardized accelerated or delayed rehabilitation protocol based on physician judgement at time of surgery. Patients in the delayed protocol group had protected weight-bearing and knee flexion ROM for the first four weeks following surgery. Two-year follow-up data was collected via electronic survey and included the Single Assessment Numeric Evaluation (SANE),[24] current level of sport participation, and re-injury status.



Figure 1. Hip Abduction Strength Testing

Isometric hip abduction strength testing was completed in supine with the hip in 10 degrees of abduction. The patient was secured to the table via a stabilization belt. The patient completed a make test for 5 seconds with the peak force being recorded in pounds via a handheld dynamometer.

STATISTICAL ANALYSIS

Baseline patient demographic and surgical (graft type, use of BMA or PRP, rehabilitation protocol) information were analyzed via one-way (group) analysis of variance (ANOVA). Comparisons for subjective and objective functional testing scores at time of release to activity were analyzed via univariate analysis of variance. Between groups differences for all subjective reports at two-year follow-up were analyzed using an independent Student *t*-test. An *a priori alpha* of .05 was considered to be statistically significant for between groups' comparisons. All statistical analyses were performed using IBM SPSS Statistics (version 24, Armonk NY, USA) statistical software.

RESULTS

Of the 528 patients enrolled in the study, 364 (68.9%) had a ratio of <33% hip abduction strength to BW, and 164

Table 1. Patient Demographics

	Low Strength (n=364)	High Strength (n=164)	P Value
Age (years)	25.59 ± 12.36	22.84 ± 9.99	.031*
Gender (% male)	189 (51.9%)	103 (62.8%)	.036*
Height (inches)	68.03 ± 4.61	68.55 ± 4.10	.289
Weight (pounds)	172.61 ± 45.12	157.35 ± 30.91	.001*
BMI (kg/m^2)	26.03 ± 5.12	23.47 ± 3.45	.000*
MARX Score (0-16)	9.10 ± 5.48	10.39 ± 5.35	.347

Values reported as mean ± std dev. *Statistical Significance at ⩽ .05; Low Strength= patients demonstrating hip abduction strength: body weight (BW) ratio < 33%; High Strength= patients demonstrating hip abduction strength ratio ⩾ 33%

Table 2. Subjective Scores and Functional Test Performance at Time of Release to Activity

	Low Strength (n=364)	High Strength (n=164)	P Value
IKDC (0-100)	88.15 ± 13.59	93.52 ± 10.27	.000*
ACL-RSI (0-100)	76.19 ± 15.39	88.52 ± 16.90	.000*
Extension ROM Deficit (deg.)	2.22 ± 1.75	2.38 ± 1.98	.432
Flexion ROM Deficit (deg.)	3.73 ± 4.41	3.86 ± 4.78	.782
Single Leg Balance Deficit (cm)	2.12 ± 4.13	2.19 ± 4.90	.892
Quadriceps LSI at 60 °/sec (%)	89.25 ± 20.24	86.55 ± 19.48	.149
Quadriceps LSI at 180 °/sec (%)	87.35 ± 17.60	87.88± 18.23	.511
Quadriceps LSI at 300 °/sec (%)	89.73 ± 15.94	89.77 ± 14.15	.723
Hamstring LSI at 60 °/sec (%)	94.38 ± 9.14	93.55 ± 6.27	.833
Hamstring LSI at 180 °/sec (%)	93.95 ± 7.03	96.23 ± 5.42	.035*
Hamstring LSI at 300 °/sec (%)	93.45 ± 7.37	99.93 ± 8.82	.041*
Single Leg Hop (LSI)	93.90 ± 6.86	94.04 ± 5.09	.248
Triple Hop (LSI)	92.37 ± 7.10	92.26 ± 7.37	.983
Cross-Over Hop (LSI)	91.29 ± 6.27	91.49 ± 6.95	.172
6m Timed Hop (LSI)	99.14 ± 1.14	99.13 ± 1.15	.681

Values reported as mean ± std dev. *Statistical Significance at ⩽ .05; Low Strength= patients demonstrating hip abduction strength: body weight (BW) ratio < 33%; High Strength= patients demonstrating hip abduction strength ratio ⩾ 33%; IKDC= International Knee Documentation Committee Questionnaire; ACL-RSI= Anterior Cruciate Ligament Return to Sport After Injury Scale; ROM= Range of Motion; LSI= Limb Symmetry Index (involved limb/uninvolved limb).

(31.0%) exhibited a ratio ⩾33%. Table 1 outlines the baseline demographic characteristics of each cohort. Differences existed between the groups with the <33% BW group having a significantly lower percentage of males (51.9% vs 62.8%), older age (25.59 ± 12.36 vs 22.84 ± 9.99 years), higher weight (172.61 ± 45.12 vs 157.35 + 30.91), and a higher BMI (26.03 ± 5.12 vs 23.47 ± 3.45). No significant differences existed for height or the Marx score (P > .05).

Subjective scores and functional test results at time to release to activity are shown in Table 2. The <33% BW group reported lower IKDC (88.15 ± 13.59 vs 93.52 ± 10.3) and ACL-RSI (76.19 ± 15.39 vs 88.52 ± 16.90) scores. No significant differences were present between groups on ROM, Y-balance anterior reach testing, the single-leg hop tests, and three-speed quadriceps isokinetic testing (P > .05). Patients in the <33% BW group demonstrated significantly lower isokinetic hamstring peak torque LSI at 180°/sec (93.95 ± 7.03 vs 96.23 ± 5.42, P = .035) and 300°/sec (93.45 ± 7.37 vs 99.93 ±8.82, P = .041). There were no significant differences in graft type, procedure type, surgical use of PRP or BMA, or rehabilitation protocol between groups. At two-year follow-up the <33% BW group reported significantly lower SANE scores (83.32 ± 21.06 vs 92.82 ± 11.36). No significant differences were observed for current level of sports participation (P = .071) and graft re-injury rate (4% vs 4%, P = .986) at two-years.

DISCUSSION

Hip abduction weakness is associated with altered jumping and landing mechanics[8] and impaired running biomechanics.[25,26] While these activities play a role in sports participation and returning to high-level activities, hip abduction

strength is rarely considered as a metric when considering an athlete's readiness to return to sport. Little evidence exists examining hip abduction strength following ACLR and its potential impact on subjective function and other objective measures of strength or stability. The current study is the first to our knowledge to demonstrate that athletes with low hip abduction strength to BW ratios report significantly lower subjective function and psychological readiness at time of release to activity and significantly lower subjective function at two-year follow-up.

A large percentage of patients in our study (68.9%) failed to demonstrate hip abduction strength ⩾33% BW. Significant demographic differences existed between groups with those demonstrating <33% BW being more female, older, heavier, and having a higher BMI. This aligns with previous work demonstrating a reduction in hip abductor isometric peak torque with aging[27] and gender differences.[28] Patients with higher BMI's may have struggled to achieve the cutoff strength ratio as they needed to reach larger raw strength values. Previous work has demonstrated that obese individuals demonstrate lower quadriceps peak torque:BW ratios when compared to leaner counterparts,[29] though little evidenced has examined the impact of BMI on absolute and relative hip strength. Adjusting the 33% BW ratio based on gender or age may result in better identifying athletes with functional deficits at time of RTS.

In alignment with our hypothesis, those with low strength:BW ratios reported significantly lower psychological readiness and self-reported function at time of release to activity. Subjective deficits remained at two-year follow up with the <33% BW group reporting significantly lower function via the SANE score. Lower psychological readiness when returning to sport has been linked with second ACL injury[30] and failing to return to previous activity level.[31] However, this study found no significant differences between re-injury rate and level of sport participation at two-year follow-up. Caution should be used when interpreting these results as the between group differences, though statistically significant, did not exceed the minimal clinical important difference for the IKDC-2000 or SANE score.[32] Further, the ACL-RSI scores, though significantly lower in the <33% BW group, were above suggested cutoffs and previously reported average scores.[33,34]

No significant between group differences were present for knee ROM, YBT performance, quadriceps isokinetic peak torque, and single leg hop testing in this study. This aligns with previous work concluding hip abduction strength was not predictive of single-leg hop performance following ACLR[15,18] but differs from Clagg et al.[35] who found hip abduction strength was positively correlated with YBT reach distance. The subjective deficits observed in the <33% BW group may potentially be explained by hip abduction strength, as no significant differences existed between quad strength or functional performance. Patients in the <33% BW group had a significantly lower isokinetic hamstring peak torque LSI at 180 and 300 °/sec. Hip abduction weakness may occur alongside posterior chain weakness and assist in explaining these deficits. Although significantly different, both groups demonstrated hamstring LSI values greater than the 90% value typically used for RTS clearance. Despite the <33% BW group reporting lower subjective function at two-year follow-up, no significant difference existed with re-injuries. This may be explained by both groups demonstrating >85% LSI for quad strength and >90% LSI for all hop testing.[36,37]

Limitations of this study include the retrospective design and the lack of controlling for potential concomitant procedures (multi-ligament procedure, cartilage procedure, etc.) amongst the groups. The authors opted to use a cutoff score of 33% BW instead of the previously recommended 35.4% BW as it seemed for more practical for clinical practice. The use of a different BW ratio may serve as a more optimal cutoff to identify athletes who may perform more poorly at time of release to activity or two-year follow-up. Few previous studies exist for comparison with a wide heterogeneity in the methods used for hip abduction strength testing. The authors recommend future studies adopt a standardized, reliable methodology for assessing hip abduction strength. Future prospective studies would assist in determining the effect of hip abduction strengthening on outcomes following ACLR. Hip extensor strength,[15] external rotation strength,[13,18] and hip ROM[38] have been linked to ACL injury and should also be investigated in those returning to sport following ACLR.

CONCLUSIONS

Hip abduction strength to body weight ratio may provide helpful insight for clinical decision-making when determining when to release patients back to sport after ACL reconstruction. Patients failing to demonstrate hip abduction strength ⩾33% BW demonstrated lower psychological readiness, subjective function, and isokinetic hamstring peak torque at time of release to activity. Self-reported knee function remained significantly lower at two-year follow-up. Clinicians should consider the potential utility of hip abduction strength to body weight ratio when assessing readiness for return to sport following ACLR.

DISCLOSURES

Dr. Walter Lowe is a medical consultant of Don Joy Inc. and Arthrex Inc.

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