Disagreements in Pass Rates Between Strength and Hop Tests in Healthy and ACLR Patients

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INTRODUCTION: Patients who undergo anterior cruciate ligament reconstruction (ACLR) typically complete a battery of quadriceps strength and hop tests that assess readiness to return-to-sport (RTS). A limb symmetry index (LSI) score of over 90% for each test has been used as a clinical threshold to ensure adequate recovery. Yet, determining RTS readiness can be challenging when the threshold is met for some but not all tests. Patients post-ACLR frequently pass jump testing in the presence of quadriceps weakness, with rates of disagreement between tests ranging from 36-47%. However, some asymmetry is considered normal, and it is unclear if the disagreement between strength and jump tests occurs similarly in a healthy population. Therefore, the purpose of this study is to compare 1) the rates of disagreement between quadriceps strength and hop tests in a healthy population and 2) the rates of disagreement between patients post-ACLR and healthy controls.

METHODS: This is a retrospective, cross-sectional study. Participants included 200 healthy controls (119 female and 81 male) and 254 patients (147 female and 107 male) 8-12 months post-ACLR that were recruited from a single academic institution. Both patient groups completed the same RTS protocol in a controlled sports medicine laboratory setting which included collection of demographic data, isometric (90° of knee flexion, ISOM90) and isokinetic (90°/s, 180°/s, ISOK90 and ISOK180, respectively) knee extension and flexion strength measures, along with single leg hop for distance (SLH), triple hop for distance (TH), and the 6-meter timed hop (6m). The LSI was calculated as the ACLR surgical or healthy nondominant limb divided by the ACLR contralateral limb or healthy dominant limb multiplied by 100%. An LSI value between 90% and 110%, or a 10% asymmetry was defined as a "pass" and the number of discordant pairs of passes with each combination of strength and jump test were counted in both populations and organized into 2x2 contingency tables. A McNemar test for purpose 1) was used to determine if discordant pair outcomes significantly ($p<0.05$) differed in the healthy population test combinations and binomial logistical regressions were performed to analyze for co-variation with age, sex, and activity level. A chi-square test for independence for purpose 2) was used to determine if rates of disagreement were significantly ($p<0.05$) different between the healthy and ACLR populations and binomial logistical regressions were again performed to analyze for co-variation with age, sex, and activity level.

RESULTS SECTION: There were statistically significant differences in the proportions of discordant pairs across all test combinations within the healthy population ($p<0.001$, $p<0.05$ in MVIC x TH and 6m hop). For all combinations, healthy participants were more likely to pass the hop tests and fail the strength tests (see **Table 1**). Odds ratios ranged from 1.95 (ISOK180 x 6m hop) to 39.25 (MVIC x TH), and there were no significant demographic-based relationships between the discordant pairs and participant age, sex, or activity level. The chi-square analyses revealed statistically significant differences ($p<0.001$) in the proportion of disagreements between the healthy and ACLR populations across all test combinations except for ISOM90 x SLH (see **Table 2**). Disagreement rates in healthy participants ranged from 27-61% and 54-71% in ACLR participants (see **Figure 1**), with healthy participants 1.51 to 5.25 times more likely to agree in their test combination compared to the ACLR participants. All significant comparisons had small to moderate effect sizes ranging from 0.097 to 0.390. Only the group classification (healthy or ACLR) came back as significantly ($p<0.001$) contributing to the outcome in each test combination when compared with age, sex, and prior activity level in a binomial regression, however there was a lesser explanatory effect ($p<0.05$) by participant sex in ISOK180 x SLH which had one-fifth of the odds ratio that group classification had.

DISCUSSION: The results from purpose 1) established the two test types assessed different metrics and that discordant pairs were sufficiently common in healthy individuals. With that baseline, ACLR patients recovering from an injury would logically demonstrate more skewed disagreements. This questions what returning to a "healthy" state looks like for ACLR patients and points to improvements in ACLR revision rates lying in moving away from the uniform use of LSI criteria as a strict threshold, and that it may be more appropriate as a supplemental piece of information within a broader scope of RTS variables. The results from purpose 2) further cement this conclusion, as the higher rates of disagreement in ACLR patients may represent differential recovery patterns rather than insufficient rehabilitation or compensatory movement patterns. A uniform use of an LSI criteria would fail to uncover or account for these factors. Clinicians could benefit more by comparing performance metrics of their patient to those of a comparable healthy control and future research can investigate sports-specific LSI criteria that would provide a more accurate assessment of RTS.

SIGNIFICANCE/CLINICAL RELEVANCE: Rather than using a uniform LSI criterion for all test batteries in the ACLR RTS setting, comparing performance metrics (e.g. isometric torque or hop distance) relative to a comparable healthy control may be more beneficial for clinicians in determining RTS. Also, future clinical research may be beneficial by developing sports-specific LSI criteria that provide a better assessment of RTS.

IMAGES AND TABLES:

Table 1. Sample 2x2 Contingency Table for McNemar Analysis

		SLH	
		Fail	Pass
ISOK90	Fail	3	55
	Pass	13	129

Table 2. Sample 2x2 Contingency Table for Chi-Square Analysis

Group		Pass Data		Total
		Disagreement	Agreement	
ISOK90 x SLH Healthy	Observed	68	132	200
	Expected	95.8	104	
ISOK90 x SLH ACLR	Observed	139	93	232
	Expected	111.2	121	
Total		207	225	

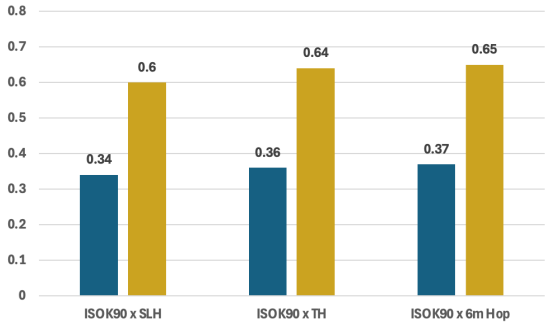

Figure 1. Clustered Chart showing proportion of disagreements in both groups with ISOK90 and all hop tests