

Are There Uniform Rehabilitation Protocols for Pediatric Anterior Cruciate Ligament Tears? *A 5 year Systematic Review*

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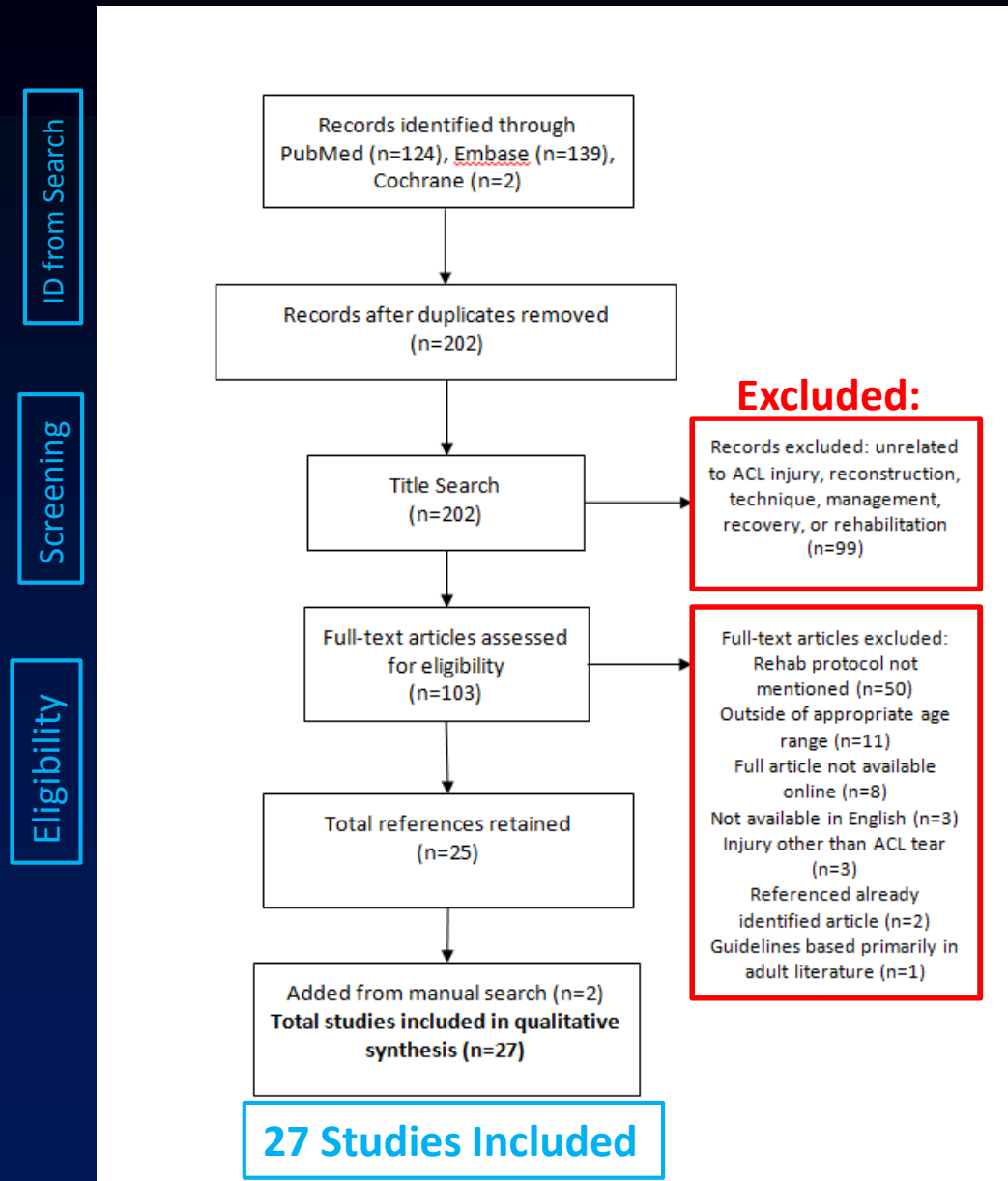
Introduction

- In the pediatric patient population, as overall sports participation, early sport specialization, high-intensity training, and improved injury recognition continue to rise, treatment of sports-related injuries have consequently risen as well.
- Studies have shown knee injuries account for approximately 50-60% of high school related surgeries, with anterior cruciate ligament (ACL) tears and ACL reconstruction (ACLR) becoming increasingly prevalent.
- While ACL rehabilitation is an essential component of recovery following injury and reconstruction, there are few published reports describing specific pediatric ACL rehabilitation protocols in the context of varying treatment interventions.
- **Aim:** to systematically review the literature over the last 5 years for rehabilitation following ACL ligament tears in children in order to identify common principles among different treatment options and areas of future research.

Methods

- Study design: Systematic Review of Pubmed, EMBASE, and Cochrane*
- Inclusion criteria:
 1. Pediatric patient population (<18 years-old)
 2. ACL tear rehabilitation protocol directly mentioned (in meta-analyses, randomized controlled studies, prospective cohort studies, retrospective case-control and cohort studies, case reports, and review articles)
- Exclusion criteria:
 1. Full article not available in English language
 2. Full article not available online
 3. Article was published >5 years from search date
 4. Article limited to patients with closed physes

PRISMA Flow Diagram of Search



Results

27 Articles Met Inclusion

Criteria*:

- 1 Level II article
- 2 Level III articles
- 12 Level IV articles
- 3 Level V articles
- 9 Review articles

Interventions Discussed:

- 3 articles solely addressed non-operative treatment
- 10 discussed transphyseal ACLR
- 4 addressed all-epiphyseal ACLR
- 1 discussed extra-physeal ACLR
- 1 addressed partial transphyseal approach
- 8 articles discussed multiple techniques

*Included articles found on Reference slide

Rehabilitation Technique Compilation** (1)

Treatment	“Prehab”	Bracing	Weight Bearing Restrictions	ROM Restrictions	Modalities	Strength	Proprioception & Plyometrics	RTS Criteria	Prevention Program
Nonoperative Management (Reference 6 provides milestone-based rehabilitation protocol)	N/A	8 weeks ⁴	TTWB for 8 wks ⁴ ; PWB guided by pain ⁵	Wk 0-8: 0°-90° ⁴ ; Gradual increase between wk 6-12 ⁵	None described	Closed-chain isometric muscle ex. within 2 mos ⁴ ;	Wk 6-12 proprioceptive ex. ⁵ ; > wk 6: cycling & swimming ⁴ ; > wk 12: running ⁴	Mo 3-6 if sufficient muscle rehab ⁵ ; >12 mo: return to pivoting sports with brace ⁴	Functional ACL brace to be worn for all sports after full rehab, < Mo 6: No contact sports ⁵ ; Inform patient about secondary intraarticular risk and need for regular medical consultation ⁴
Transphyseal Reconstruction	None described	4 wks with 0-90° ROM ¹⁷ ; 6 wks ^{4,10,12,13,14} ; 8 wks ¹⁵ ; 12 wks ¹⁶	NWB for 3 wks followed by PWB for 2 wks ¹⁷ ; TTWB for 2 wks ^{10,12} , 4 wks ⁴ , or until full return of quadriceps function ¹⁶ ; Immediate WBAT ^{2,14,15,19}	Immediate passive ROM ^{13,15,16,19,20} with CPM device ^{12,13,15} ; Limit to 0-90° for 2 wks ¹² or 4 wks ^{4,17} ; Full knee ext by wk 2 ² Early patellar mobilization ^{10,14}	Electrical stimulation ^{10,14,15}	Closed-chain ex. ^{2,4,10,14,15,19,20} for quadriceps and hamstrings within 3 mos ^{10,15}	Proprioceptive training within 3 mos ^{2,14} >mo 3: plyometrics, straight line jogging ^{10,14} > wk 8: cycling & swimming ⁴ > wk 16: running ⁴	>6 mo: Full RTS ^{10,12,14,16,17} ; <9-12mo: Avoidance of cutting/pivoting sports ^{4,15} ; Passing functional tests (“sports test,” hop-tests) ^{2,20} – results in RTS between 6-12 mos	Functional ACL brace for 1-2 yrs ^{4,10,12,14} ; Formal ACL injury prevention program ²⁰

Abbreviations: “Prehab,” Prehabilitation (exercises conducted and goals prior to surgery); ROM, range of motion; RTS, return to sport; Wk, week; Mo, month; Yr, year; TTWB, toe-touch weight bearing; PWB, partial weight bearing; WBAT, weight bearing as tolerated; NWB, non-weight bearing; CPM, continuous passive motion; Ex., exercises; ITB, iliotibial band reconstruction; HEP, home exercise program; SLR, straight leg raise; SL, single leg; Ext, extension; Flex, flexion; PACU, Post-Anesthesia Care Unit

**Of the 27 articles included in the systematic review, articles were only featured in the compilation table if they specifically mentioned at least 1 of the above 9 rehabilitation categories

Rehabilitation Technique Compilation** (2)

Treatment	"Prehab"	Bracing	Weight Bearing Restrictions	ROM Restrictions	Modalities	Strength	Proprioception & Plyometrics	RTS Criteria	Prevention Program
Physal-Sparing Reconstruction	<u>All-epiphyseal</u> ²³ : 1. No effusion 2. ≥4/5 quadriceps strength 3. Full knee ext 4. ≥120° active flex 5. Independence with gait 6. Independence with post-op ex. instruction 7. Patient & Family education (see manuscript)	<u>ITB</u> : 6 wks ^{10,12} <u>All-epiphyseal</u> : 4 wks: locked in full ext ^{1,23} Wk 4-6: unlock brace if: 1. SLR x10 without ext lag 2. Active knee flex > angle of brace ⁶¹ >Wk 6: discontinue brace if: 1. ROM >100° 2. SL squat of 30° with good knee control ²³	<u>ITB</u> : TTWB for 6 wks ^{10,12} <u>All-epiphyseal</u> : TTWB for 1 wk WBAT for wks 2-4 ²³ ; PWB for 4 wks ¹	Early patellar mobilization ^{10,22,24} <u>ITB</u> : 0-90° for 6 wks ¹² <u>All-epiphyseal</u> : CPM use encouraged ^{1,22} ; 90° flex by end of wk 2 120° flex by end of wk 4 – can use stationary bike ²³ ; 90° flex by end wk 4 125° flex by end wk 8 ²⁴	Cryotherapy in PACU ¹ ; Electrical stimulation during wk 1 ²² ; Underwater treadmill if patient apprehensive about weight bearing ¹	<u>ITB</u> : Closed-chain ex. for quadriceps and hamstrings within 3 mos ¹⁰ ; <u>All-epiphyseal</u> ^{23,24} : Wk 1: quadriceps activation, SLR, begin HEP Wk 2-4: resisted leg press, step-ups, mini squats, stairmaster, hip abduction, core, independence with HEP Wk 4-16: SL stance with neuromuscular control, squat to 90°, SL squats, retro-treadmill, core, continued HEP Wk 12: may add open-chain ext Wk 16-20: maximize strength	<u>ITB</u> : >mo 3: Straight line jogging, plyometrics ¹⁰ <u>All-epiphyseal</u> ^{23,24} : Wk 2-16: balance, proprioception Wk 16-24: athletic ready position stance, straight ahead running, double-leg hopping if criteria met Dynamic control with jumping & landing Wk 24-36: SL plyometrics, cutting/pivoting drills if criteria met	<u>ITB</u> : >6 mo: Full RTS ^{10,12} <u>All-epiphyseal</u> : 1. 90% on functional testing 2. >90% isokinetic testing at 180°/sec and 360°/sec 3. Full knee ROM 4. >9 mos post-op ²³ 1. Dynamic control with sport-specific movement 2. Hop test >85% of unaffected limb 3. Lack of apprehension with sport-specific movement ²⁴	<u>ITB</u> : Functional ACL brace for 1-2 yrs ^{10,12} <u>All-epiphyseal</u> : Wk 16-20: ACL injury prevention assessment Wk 28: evaluate for functional bracing compliance ²⁴
Concomitant Meniscal Repair			<u>Transphyseal</u> : TTWB for 2-6 wks depending on severity ¹² ; <u>All-epiphyseal</u> : PWB for 4 wks ²²	<u>Transphyseal</u> : "Restricted ROM depending on severity" ¹² <u>All-epiphyseal</u> : Wk 0-4: 0-90° limit ²²		<u>All-epiphyseal</u> : <Wk 6: Avoid squats below 60° and isolated hamstring strengthening ²²			

Abbreviations: "Prehab," Prehabilitation (exercises conducted and goals prior to surgery); ROM, range of motion; RTS, return to sport; Wk, week; Mo, month; Yr, year; TTWB, toe-touch weight bearing; PWB, partial weight bearing; WBAT, weight bearing as tolerated; NWB, non-weight bearing; CPM, continuous passive motion; Ex., exercises; ITB, iliotibial band reconstruction; HEP, home exercise program; SLR, straight leg raise; SL, single leg; Ext, extension; Flex, flexion; PACU, Post-Anesthesia Care Unit

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Conclusion

- ACL tear rehabilitation following injury and treatment is a fundamental component in the effort of a patient to regain pre-surgical functional ability.
- Currently, few youth-specific rehabilitation protocols have been described, with the majority based on a combination of adult literature and clinical expertise.
- Many current protocols are based on timeframe alone rather than functional milestones.
 - As evident in the preceding table, of the 16 articles that addressed return-to-sport criteria, 10 were based on temporal progression, while 6 also involved achievement of physical milestones.
- Two of the 10 articles that mentioned a future ACL prevention plan described a formal prevention program.
- Further studies should be conducted to prospectively evaluate rehabilitation protocols and return-to-sport criteria for young athletes while keeping in mind both physical and psychosocial differences between children and adults.

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