"When Can I Play Again?": Measures to Improve Return to Sport Decision Making

Illinois Athletic Trainers Association
State Symposium

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University of Illinois Sports Medicine

ILLINOIS iata ATHLETIC TRAINERS ASSOCIATION

ILLINOIS

Disclosures

I have no financial disclosures to make regarding this presentation.

I am an employee of the University of Illinois Department of Intercollegiate Athletics.

Content in this talk is collected and given on my own professional and personal views around this topic.

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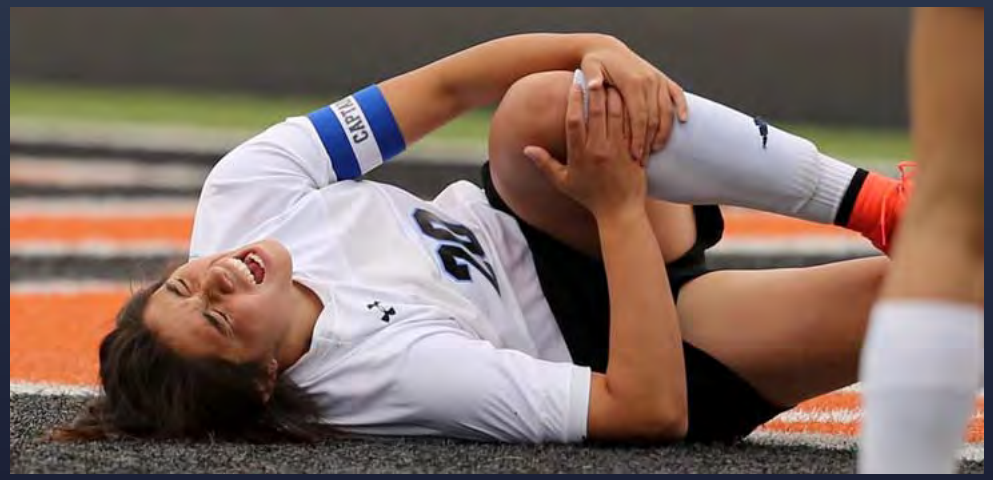
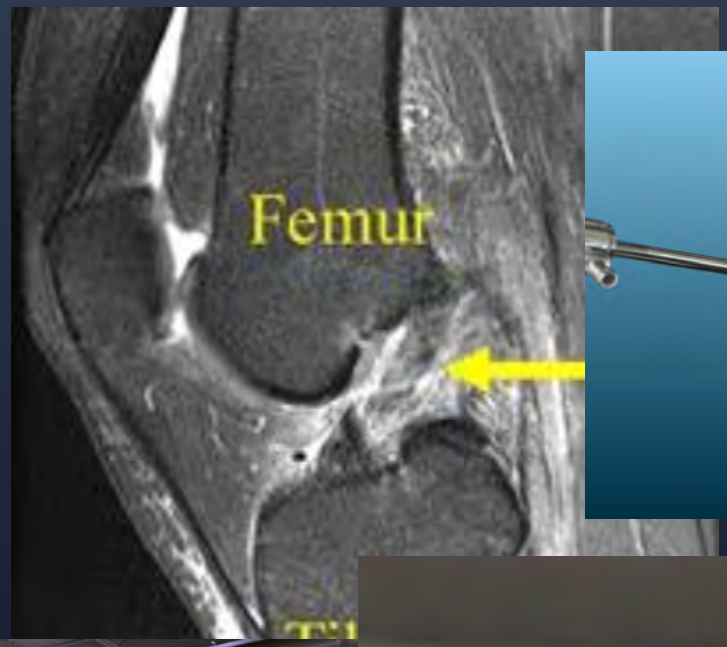
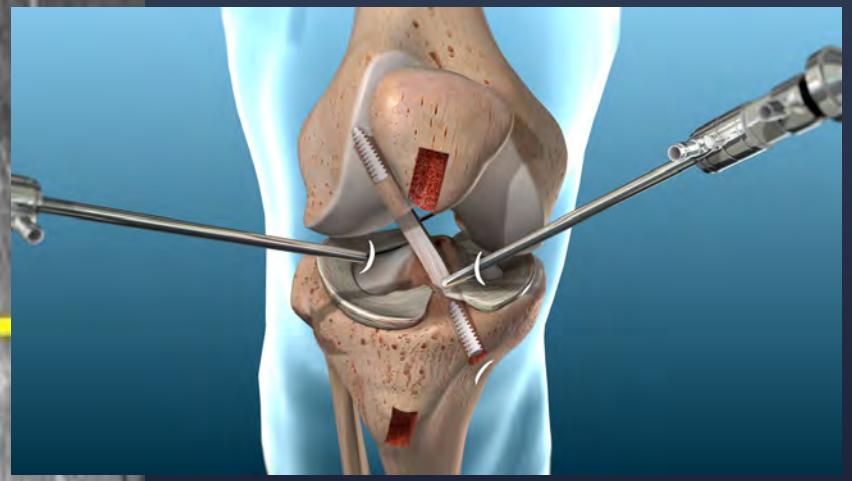
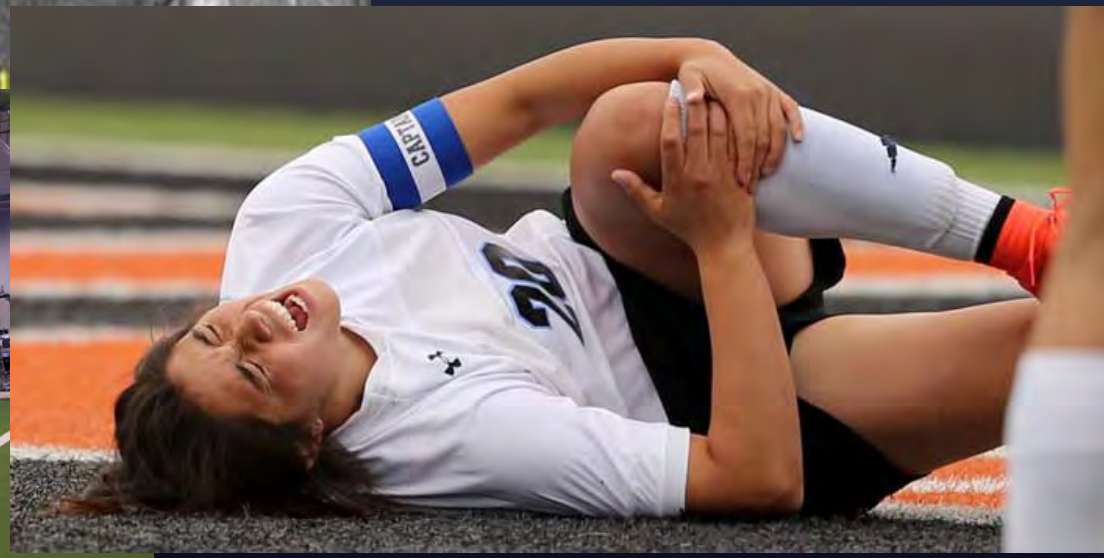
WHY THIS TALK?









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OBJECTIVES

1) Appraise current literature regarding varying degrees of return to sport (RTS) criteria and testing procedures.
2) Identify inconsistencies in clinical practice patterns of RTS testing compared to current evidence.
3) Describe various methods of quadriceps testing and its importance to recovery post ACLR.
4) Identify limitations of hop testing and LSI calculation for RTS testing.
5) Describe how psychological testing (ACL-RSI, TSK-11) can adjunct rehab progression and RTS decision making.
6) Briefly describe use of UE RTS testing methods and directions for improvement.

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Ultimate Goal in RTP???

TO…

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What is Return to Play?

The three elements of the RTS continuum.

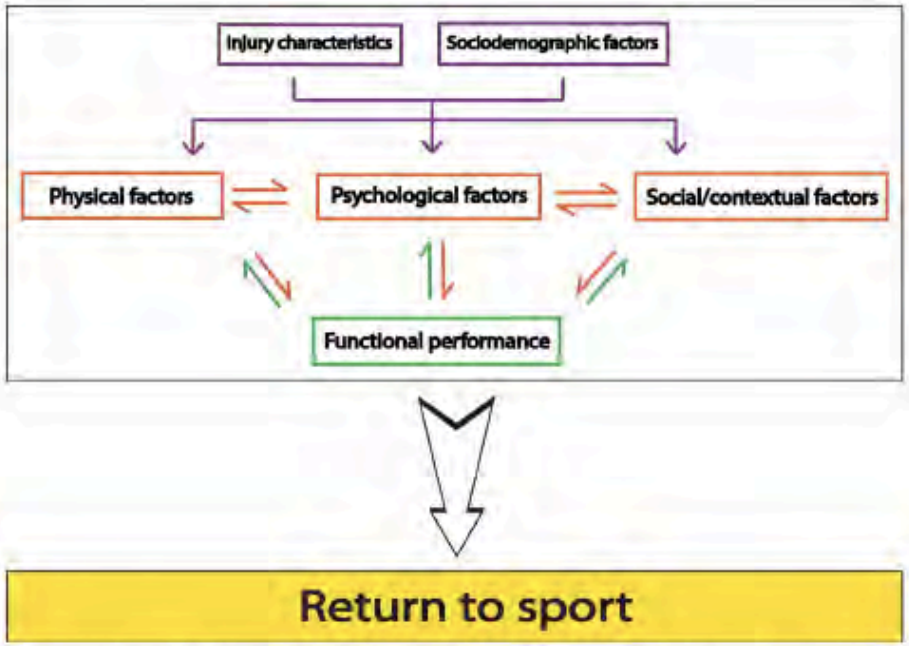

Figure 3 Biopsychosocial model of RTS after injury.[151] Examples of physical, psychological and social factors that may influence RTS are listed (reproduced with permission).

2016 Consensus statement on return to sport from the First World Congress in Sports Physical Therapy, Bern

Clare L Ardern,[1,2,3] Philip Glasgow,[4,5] Anthony Schneiders,[6] Erik Witvrouw,[1,7] Benjamin Clarsen,[8,9] Ann Cools,[7] Boris Gojanovic,[10,11] Steffan Griffin,[12] Karim M Khan,[13] Håvard Moksnes,[8,9] Stephen A Mutch,[14,15] Nicola Phillips,[16] Gustaaf Reurink,[17] Robin Sadler,[18] Karin Grävare Silbernagel,[19] Kristian Thorborg,[20,21] Arnlaug Wangensteen,[1,8] Kevin E Wilk,[22] Mario Bizzini[23]

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StARRT Framework

Strategic Assessment of Risk and Ris
(StARRT) framework for return-to-pla
decision-making

Ian Shrier

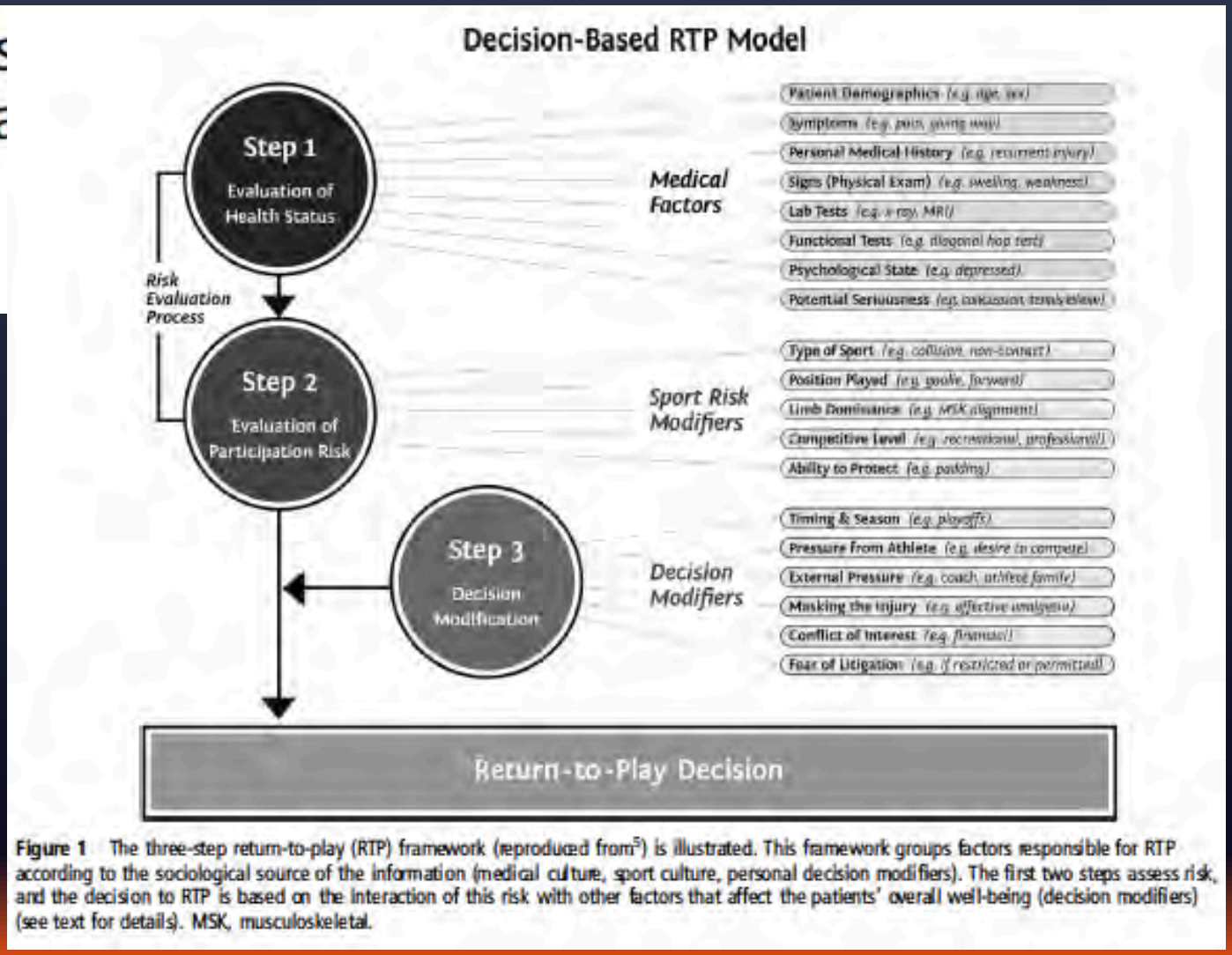

Figure 1 The three-step return-to-play (RTP) framework (reproduced from[5]) is illustrated. This framework groups factors responsible for RTP according to the sociological source of the information (medical culture, sport culture, personal decision modifiers). The first two steps assess risk, and the decision to RTP is based on the interaction of this risk with other factors that affect the patients' overall well-being (decision modifiers) (see text for details). MSK, musculoskeletal.

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Let's Start at the Scope…

ACL Injuries >>> 250,000 – 300,000/yr

Level	Sports Activity	Occupation Activity
I	Jumping, cutting, pivoting (basketball, soccer, football)	Activity comparable to level I sports
II	Lateral movements: less jumping, pivoting than level I (baseball, racket sports)	Heavy manual labor, working on uneven surface
III	Straight-ahead activities; no jumping or pivoting (running, weightlifting)	Light manual work
IV	Sedentary	Activities of daily living

Intent to return to Level I sports

>>>ACL Reconstruction (ACLR) [90%]

Those younger, returning to Level I sports, female

Likelihood re-injury (Ipsilat or Contralat), meniscus injury, OA

Greater Health care costs & reduced HRQoL

Griffin et al 2006, Linko et al 2005, Filbay et al 2014, Frobell et al 2013, Paterno et al 2014, Hurd et al 2008

Cost of ACLR

Estimated Lifetime Healthcare Burden?

**Figuring in initial ACLR
& potential secondary injury
(2nd ACL, Meniscus, post traumatic OA)

$7.6 – 17.7 Billion/yr!

Mather et al 2013, Grooms et al 2015

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Risk of Injury and RTS

Risk for Primary ACL injury (*Montalvo et al 2019*)
1/29 F; 1/50 M (spanning 1 season to 25 yrs)

Return to sport (*Ardern et al 2011, 2014*)
- SOME kind of sport participation = 82%
- Pre-injury sport participation = 63%

- Competitive Sport = 44-55%

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What about 2nd ACL Injury?

Those with ACLR 15x GREATER Risk vs control

Female w/ ACLR = 16x injury vs Control

Published in final edited form as:
Clin J Sport Med. 2012 March ; 22(2): 116–121. doi:10.1097/JSM.0b013e318246ef9e.

Incidence of Contralateral and Ipsilateral Anterior Cruciate Ligament (ACL) Injury After Primary ACL Reconstruction and Return to Sport

Mark V. Paterno, PT, PhD, SCS, ATC[*,†,‡,§], **Mitchell J. Rauh, PT, PhD, MPH**[‖], **Laura C. Schmitt, PT, PhD**[†,‡,**], **Kevin R. Ford, PhD**[†,§], and **Timothy E. Hewett, PhD**[*,†,§,††,‡‡,§§]

Females Athletes = 4x likely to suffer 2nd ACL injury

And…

6x more likely to injure CONTRALATERL knee!

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More Info on 2nd Injury

Wiggins 2016 - Risk Secondary Injury after ACLR

- 1 in 4 pt 20-25 yo who have ACLR and RTS will re-injure
- 30-40x greater risk than matched *UNINJURED* controls

Kyristis 2016 - Likelihood of ACL graft rupture (meeting 6 criteria)

- 158 athletes (26 re-rupture (16%)) avg 105 days post RTS
- 6 criteria (Isokinetic H:Q ratio, hop testing (single, triple, triple x), T-test, On Field)
- 26 re-ruptures (19 hams, 7BTB)

Paterno 2014 - Incidence of Second ACL 2 yrs post ACLR

- 5x greater risk for females returning to sport vs uninjured controls
- 30% female ath suffered 2nd ACL injury (20% contra; 10% ipsilat)
- female pt 2x likely to suffer contralateral injury after ACLR

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But if we meet RTP testing = ALL OK?

Losciale 2019 - Meeting RTP criteria and 2nd ACL injury

- low quality of evidence, lack of studies, imprecision of studies and heterogeneity
- No association with passing RTS criteria and ↓2nd ACL injury risk

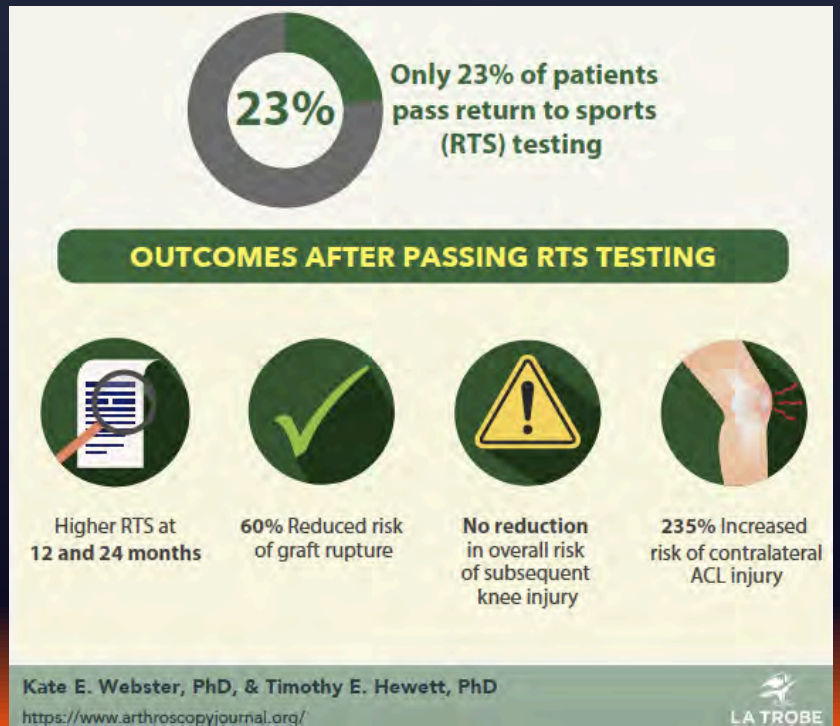
WHAT?????

Sports Medicine
https://doi.org/10.1007/s40279-019-01093-x

SYSTEMATIC REVIEW

What is the Evidence for and Validity of Return-to-Sport Testing after Anterior Cruciate Ligament Reconstruction Surgery? A Systematic Review and Meta-Analysis

Kate E. Webster[1] · Timothy E. Hewett[2,3,4,5]



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Just Abandon RTS Testing?

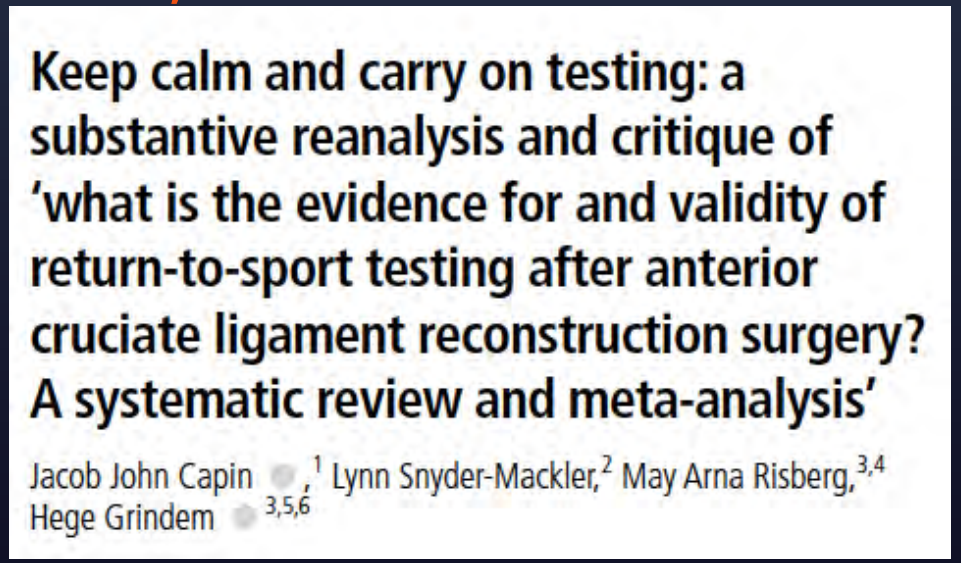
Excluded (2) Articles

- *Sousa et al & Wellsandt et al*

** These studies looking at different questions, methodological/clinical variation and bias

Conclusions: Athletes who pass RTP

1) Lower risk ANY knee re-injury
2) Lower risk any 2nd ACL injury
3) Lower risk of ACL graft rupture
4) Contralateral injury risk = unknown (insufficient data)


Keep calm and carry on testing: a substantive reanalysis and critique of 'what is the evidence for and validity of return-to-sport testing after anterior cruciate ligament reconstruction surgery? A systematic review and meta-analysis'

Jacob John Capin [1], Lynn Snyder-Mackler,[2] May Arna Risberg,[3,4] Hege Grindem [3,5,6]

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WHAT DO I DO NOW???

https://depositphotos.com/126430598/stock-photo-pondering-girl-in-black-cardigan.html

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So what DO Clinicians use for RTP?

REVIEW:

42% = Time SOLE criterion!

41% = used strength testing
(varying LSI, Q:H ratios, speeds, etc)

14% = Hop testing

20% = Performance Based Criteria

10% = Contextual Factors

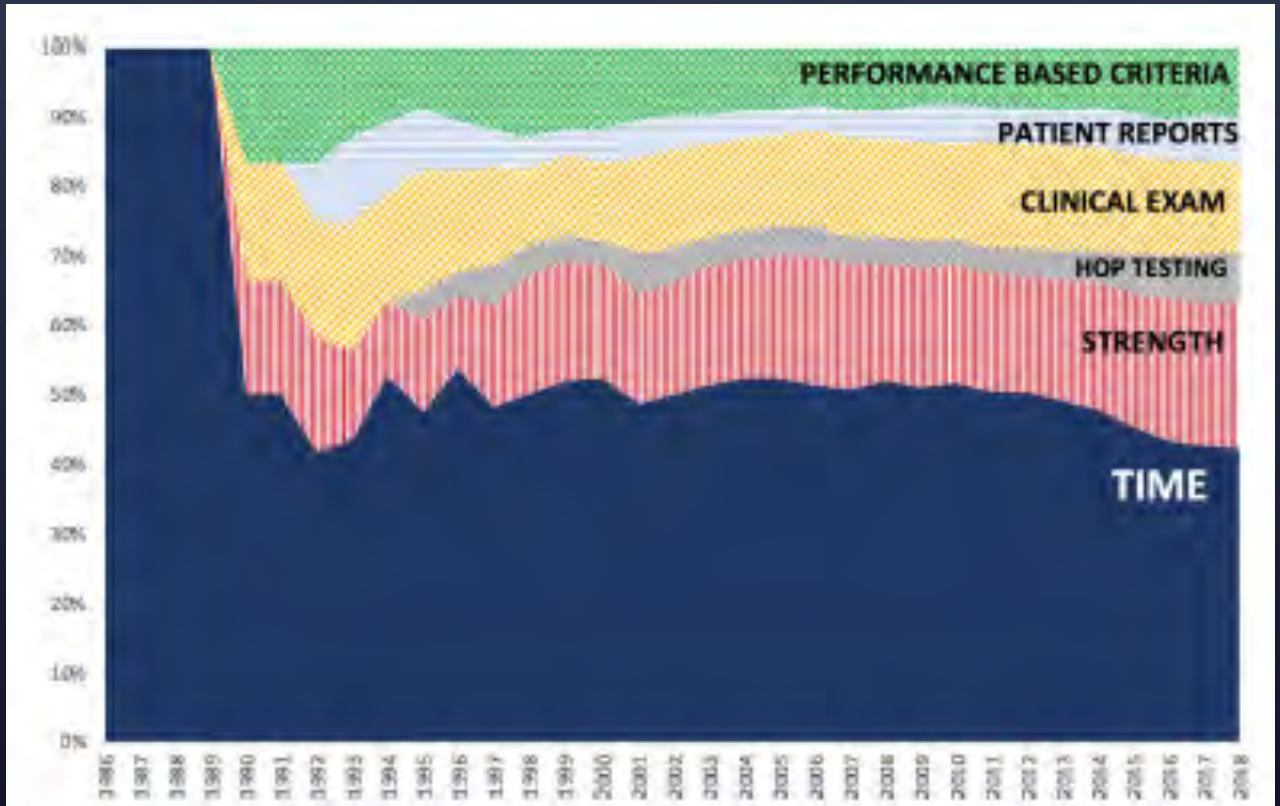

Figure 2 Relative proportion of return to sport criteria reported in a given year.

Burgi et al 2019

Rehab Practice Patterns

Barber-Westin et al 2011

- More than 70% published studies excluded functional measures in RTP

Greenberg et al 2018

- Considerable variation of practice patterns for rehab

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Survey of PTs

Greenberg et al 2018

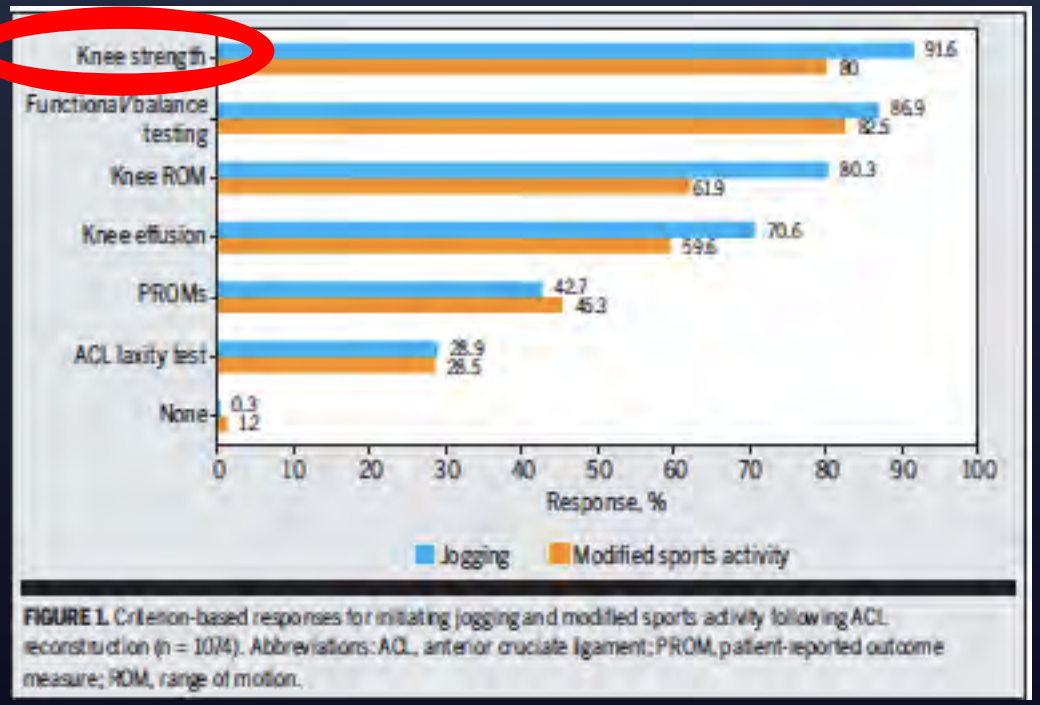

FIGURE 1. Criterion-based responses for initiating jogging and modified sports activity following ACL reconstruction (n = 1074). Abbreviations: ACL, anterior cruciate ligament; PROM, patient-reported outcome measure; ROM, range of motion.

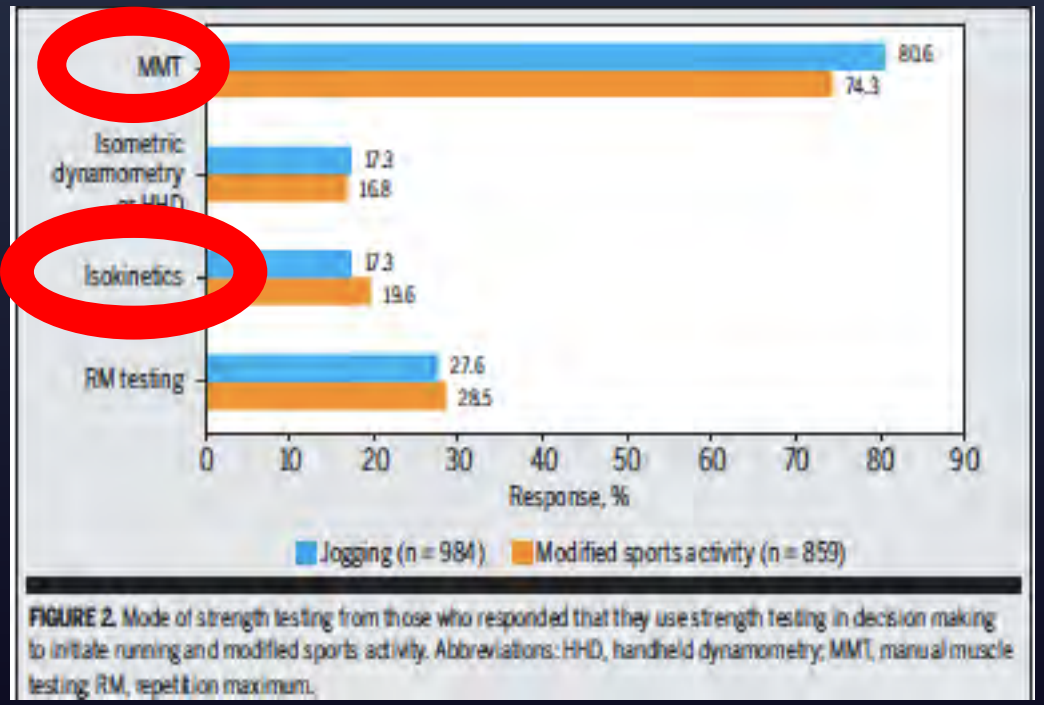

FIGURE 2. Mode of strength testing from those who responded that they use strength testing in decision making to initiate running and modified sports activity. Abbreviations: HHD, handheld dynamometry; MMT, manual muscle testing; RM, repetition maximum.

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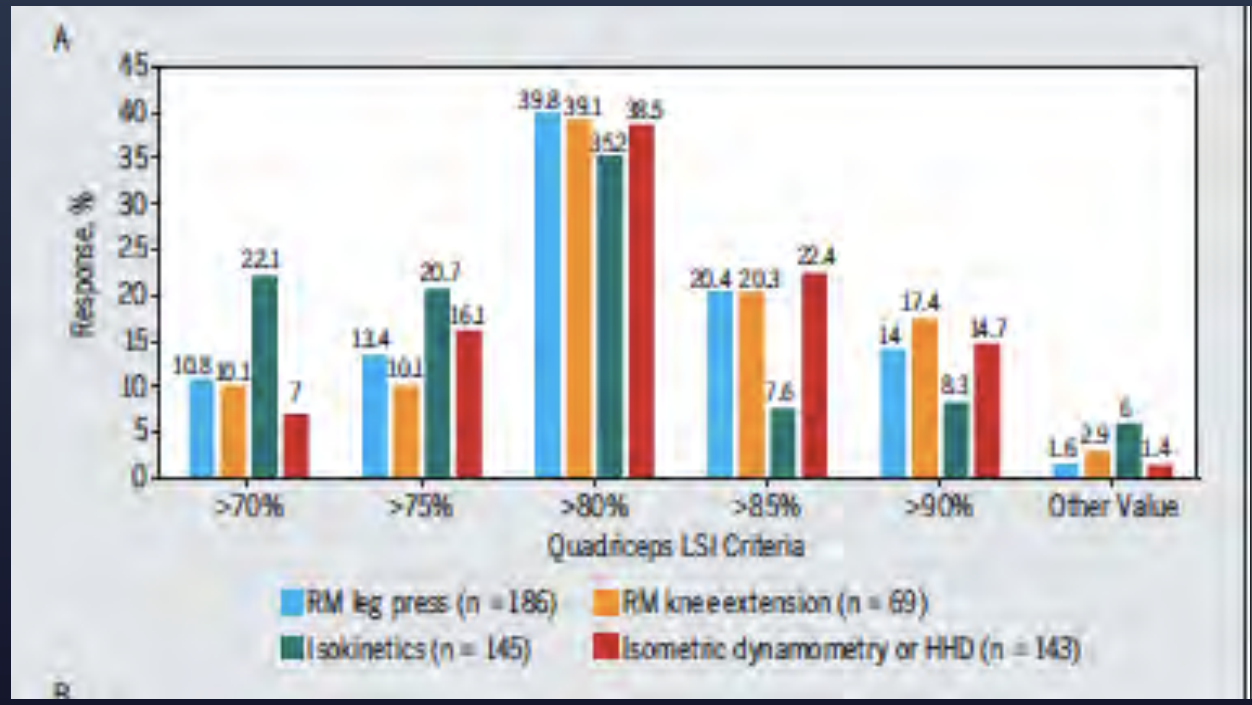
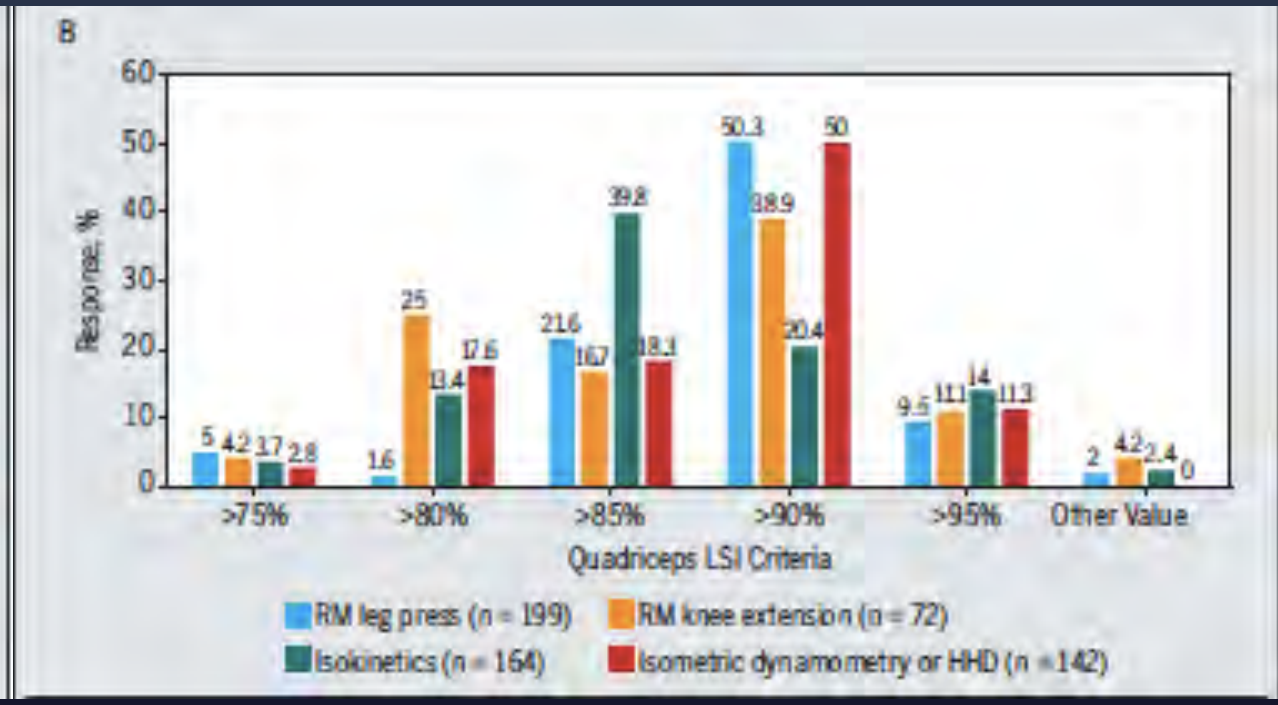
Greenberg et al 2018





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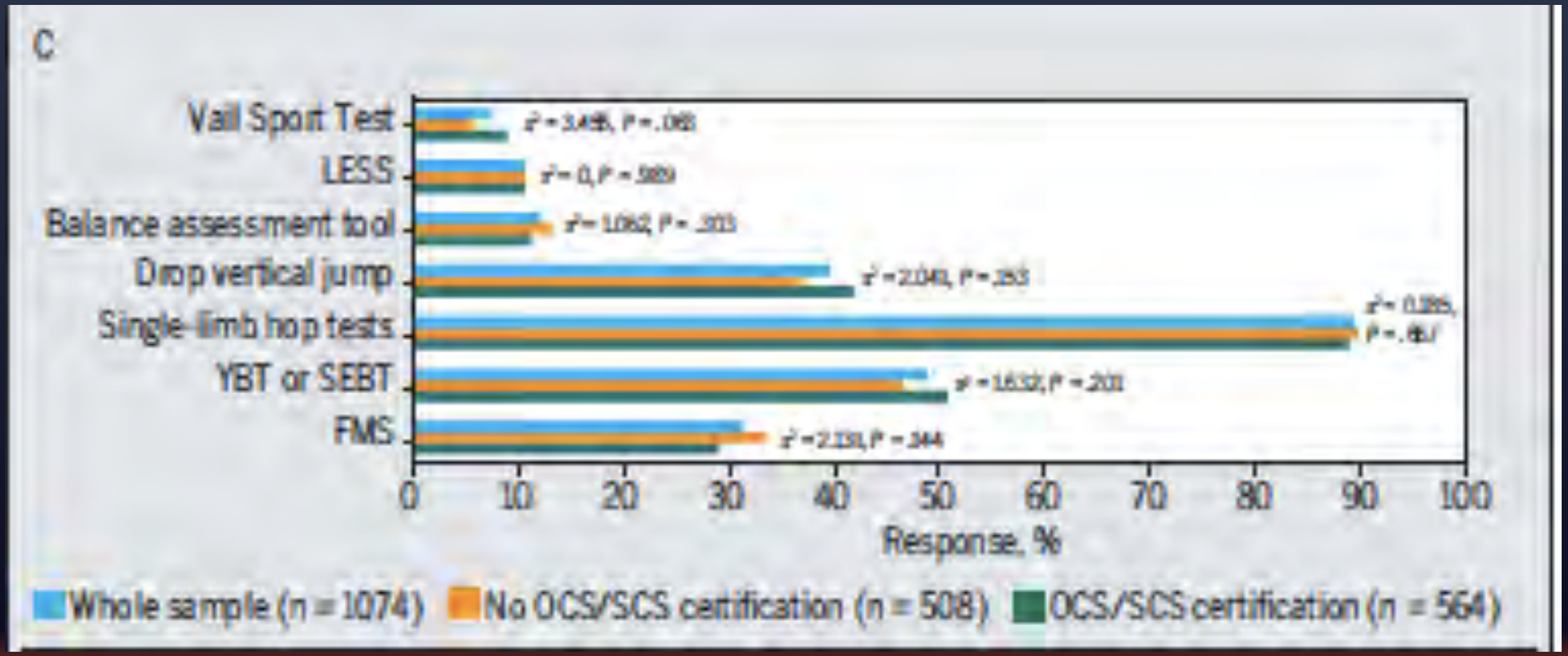
Greenberg et al 2018



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What SHOULD we be using for RTP Testing?

Hartigan et al 2010

7 return to play measures

(Quad strength index, Hop tests (4), KOS-ADL, Global Rating

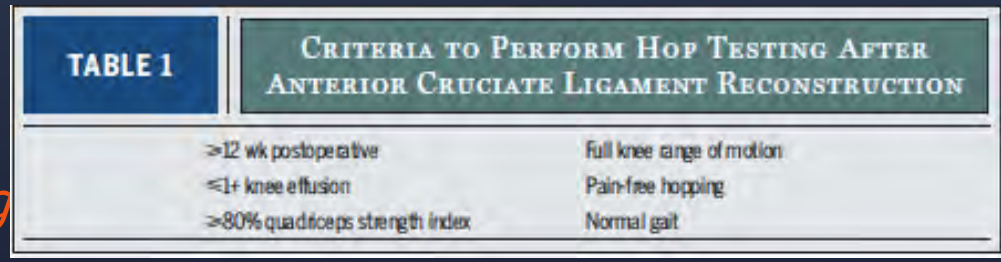

TABLE 1	Criteria to Perform Hop Testing After Anterior Cruciate Ligament Reconstruction	
	≥12 wk postoperative	Full knee range of motion
	≤1+ knee effusion	Pain-free hopping
	≥80% quadriceps strength index	Normal gait

Barber-Westin, Noyes 2011

Muscle strength, stability, neuromuscular control, and lower limb function should be measured before release to unrestricted activities.

Our criteria for release include less than 10% deficit quadriceps and hamstring on isokinetic testing at 180°/s and 300°/s,

Less than 15% deficit in lower limb symmetry on single-leg hop testing (single hop, triple hop, crossover hop, and timed hop28),

Less than 3 mm of increased anterior-posterior tibial displacement on Lachman or knee arthrometer testing,

Greater than 60% normalized knee separation distance on a video drop-jump test

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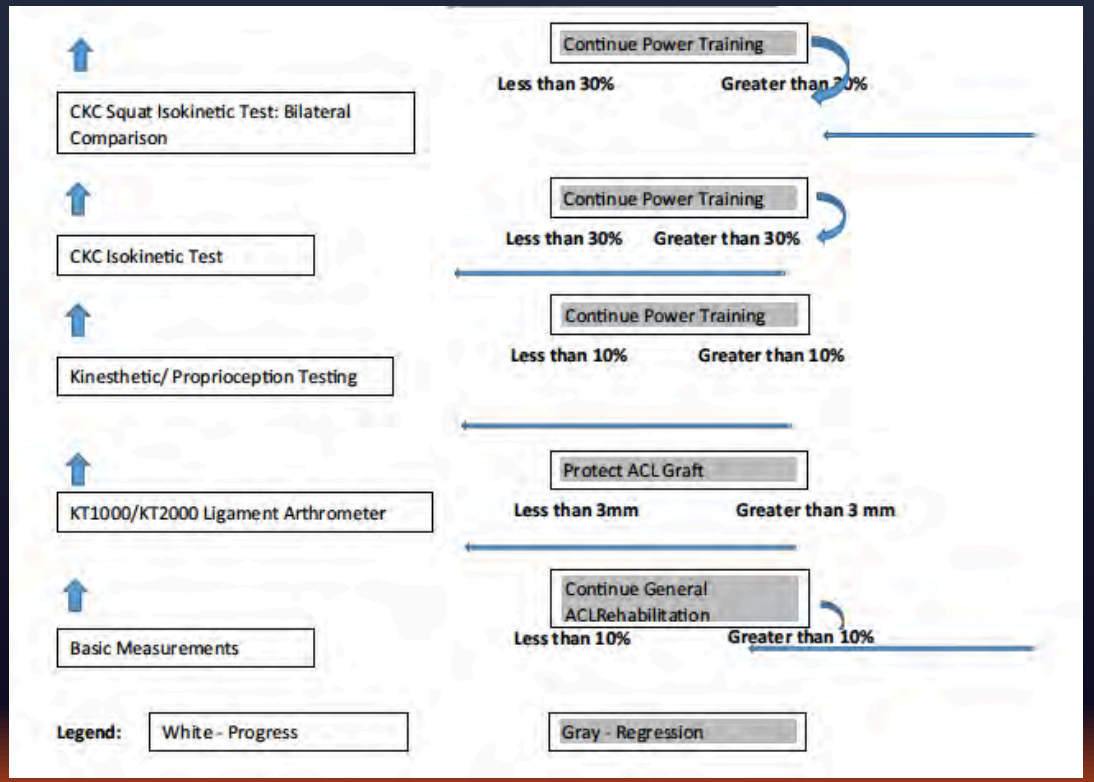
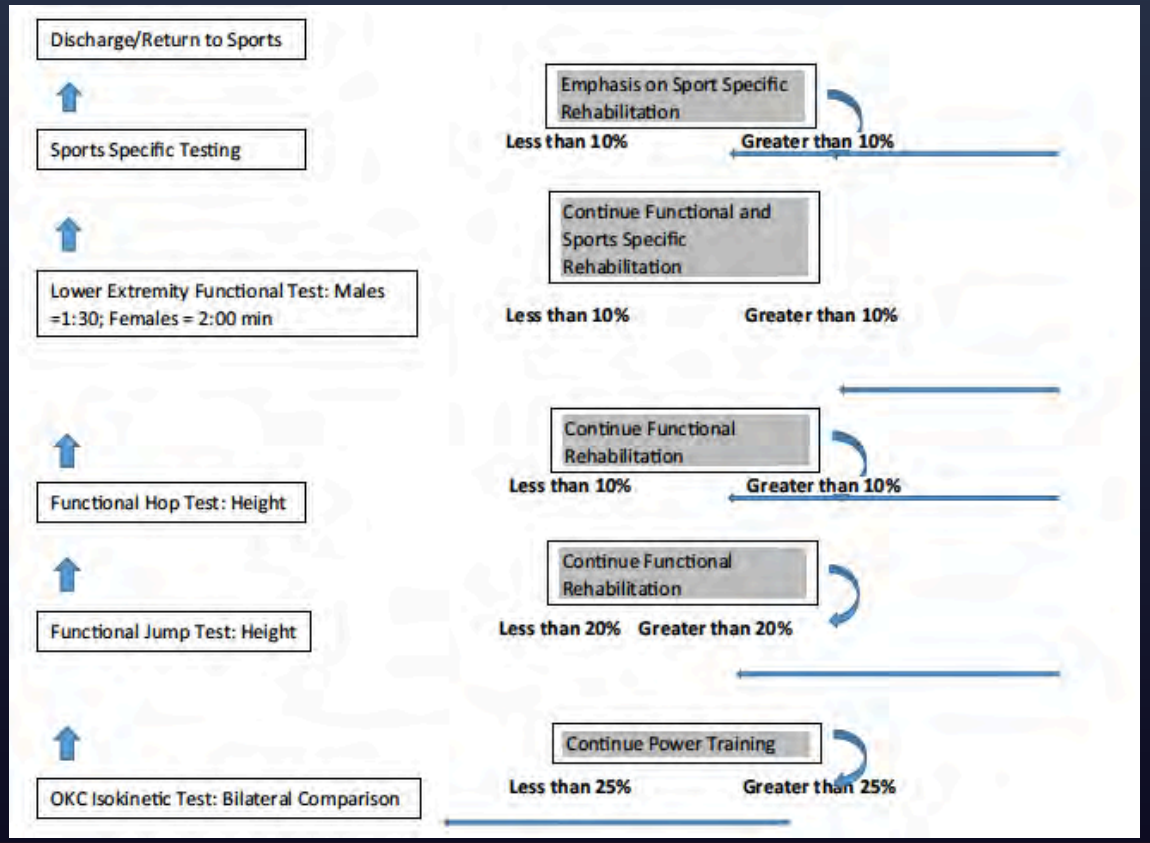
What SHOULD we be using for RTP Testing?

Davies et al 2017

Functional Testing Algorithm (FTA)





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RTS Testing Criteria

Burgi et al 2019

- Criteria categorization with ICF Framework

Table 2 Return to sport criteria categorisation and associated International Classification of Functioning, Disability and Health (ICF)[17] framework classification

Return to sport criteria categorisation	Corresponding ICF[17] framework classification
Time	N/A
Strength	Impairments
Clinical examination	Impairments
Hop testing	Activity (limitations)
Performance-based criteria	Participation (restrictions)
Patient report	Contextual factors

General Criteria Pool

- Basic Measures: Knee P/AROM, Effusion, Knee stability (KT)
- Impairments: Muscle strength (Isokinetic, Isometric, Isotonic), Neuromuscular control (Movement Quality)
- Activities: Hop Testing
- Performance: LEFT, Sport Specific
- Patient Report: IKDC, KOS-ADL(Function), TSK (Kines), ACL-RSI

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WHOA…

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Let's Go Back

Grindem et al 2016

Prognostic factors for RTS Level I

- Greater than 9 mo from ACL
  - Every mo after 50% dec risk re-injury

Quadriceps Strength Symmetry

- Improved Hop Testing
- Reduced risk symptomatic OA
- RFD assist with NM control
- Improve Subj Pt Outcomes

Simple decision rules can reduce reinjury risk by 84% after ACL reconstruction: the Delaware-Oslo ACL cohort study

Hege Grindem,[1] Lynn Snyder-Mackler,[2] Håvard Moksnes,[3] Lars Engebretsen,[3,4] May Arna Risberg[1,4]

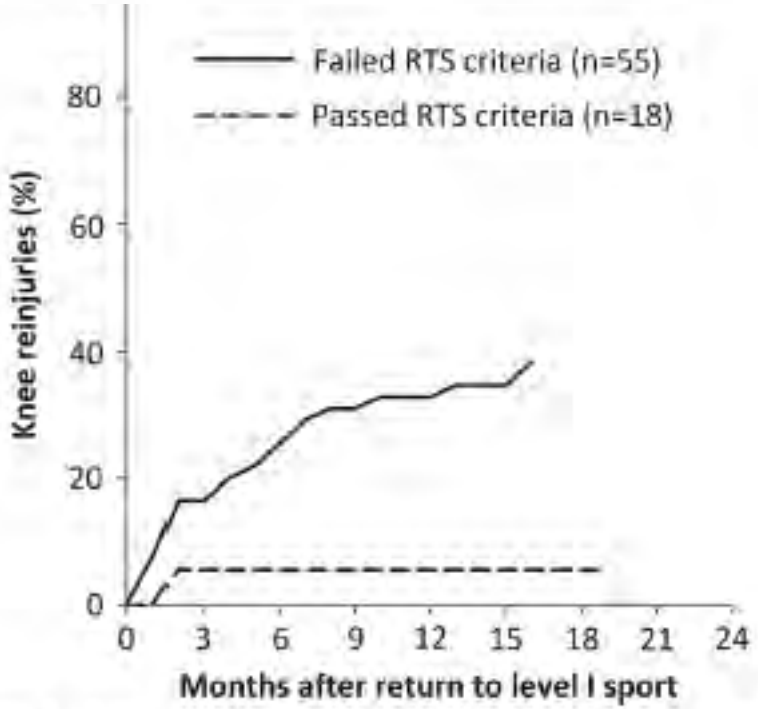

Figure 2 Knee reinjuries after return to level I sports in those who failed and those who passed return to sport (RTS) criteria prior to return.

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Grindem et al 2016

BUT you said…..

@ 1 yr post = 50% passed >90% Quad strength Symmetry

@ 2 yr post = 66% passed >90% Quad strength Symmetry

Nobody will pass the RTP for Quad Strength!!!

We will discuss a little later but it goes back to…

REHAB, REHAB, REHAB

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RTS Components

**** Pre-entry Components >> Basic Measurements (continue to monitor)**

1) Thigh Strength/Force Development
2) Neuromuscular Control
3) Hop Testing
4) Lower Extremity Functional Testing (LEFT)
5) Sport Specific
6) Patient Reported Outcomes/Kinesiophobia/Confidence

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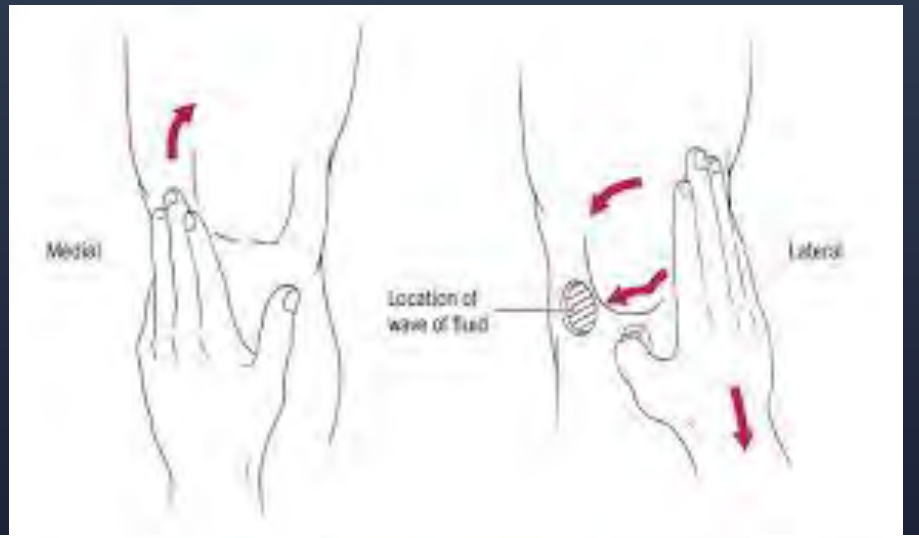
Basic Measurements

1) Full AROM Knee Extension and Flexion

2) Quiet Knee (no Effusion to 1+)

3) Patellar Mobility norm

4) Stability Testing (KT Arth, Lachman)



[RESEARCH REPORT]

LYNNE PATTERSON STURGILL, PT, DPT, OCS[1] • LYNN SNYDER-MACKLER, PT, ScD, SCS, FAPTA[2]
TARA JO MANAL, PT, DPT, OCS, SCS[3] • MICHAEL J. AXE, MD[4]

Interrater Reliability of a Clinical Scale to Assess Knee Joint Effusion

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RTS Components

** Pre-entry Components >> Basic Measurements (continue to monitor)

1)Thigh Strength/Force Development

2) Neuromuscular Control
3) Hop Testing
4) Lower Extremity Functional Testing (LEFT)
5) Sport Specific
6) Patient Reported Outcomes/Kinesiophobia/Confidence

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Do we NEED Quad Strength measures?

Significant Asymmetry Post ACLR

HERE

Quadriceps Strength Asymmetry After Anterior Cruciate Ligament Reconstruction Alters Knee Joint Biomechanics and Functional Performance at Time of Return to Activity

Riann M. Palmieri-Smith,*†‡ PhD, ATC, and Lindsey K. Lepley,†§ PhD, ATC
Investigation performed at University of Michigan, Ann Arbor, Michigan, USA

HERE

[RESEARCH REPORT]

LAURA C. SCHMITT, PT, PhD[1] • MARK V. PATERNO, PT, PhD, SCS, ATC[2] • TIMOTHY E. HEWETT, PhD[3]

The Impact of Quadriceps Femoris Strength Asymmetry on Functional Performance at Return to Sport Following Anterior Cruciate Ligament Reconstruction

HERE

The effect of insufficient quadriceps strength on gait after anterior cruciate ligament reconstruction

Michael Lewek [a], Katherine Rudolph [a], Michael Axe [a,b], Lynn Snyder-Mackler [a,*]
[a] *Department of Physical Therapy, 301 McKinly Lab, University of Delaware, Newark, DE 19716, USA*
[b] *First State Orthopedics, 4745 Ogletown-Stanton Road, Suite 225, Newark, DE, USA*
Received 16 October 2000; accepted 8 October 2001

HERE

Strength of the Quadriceps Femoris Muscle and Functional Recovery after Reconstruction of the Anterior Cruciate Ligament

A Prospective, Randomized Clinical Trial of Electrical Stimulation*

BY LYNN SNYDER-MACKLER, P.T., SC.D.†, NEWARK, DELAWARE,
ANTHONY DELITTO, P.T., PH.D.‡, PITTSBURGH, PENNSYLVANIA, SHERRI L. BAILEY, M.S.P.T.§, ST. LOUIS, MISSOURI,
AND SUSAN W. STRALKA, P.T.¶, GERMANTOWN, TENNESSEE

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MORE…..

[RESEARCH REPORT]

LAURA C. SCHMITT, PT, PhD[1] • MARK V. PATERNO, PT, PhD, SCS, ATC[2] • TIMOTHY E. HEWETT, PhD[3]

The Impact of Quadriceps Femoris Strength Asymmetry on Functional Performance at Re to Sport Following Anterior Cruc Ligament Reconstruction

Young Athletes With Quadriceps Femoris Strength Asymmetry at Return to Sport After Anterior Cruciate Ligament Reconstruction Demonstrate Asymmetric Single-Leg Drop-Landing Mechanics

Matthew P. Ithurburn,*† PT, DPT, OCS, Mark V. Paterno,‡§‖¶ PT, PhD, SCS, ATC, Kevin R. Ford,# PhD, FACSM, Timothy E. Hewett,†‡‖¶**†††‡‡ PhD, FACSM, and Laura C. Schmitt,*‡§§‖‖ PT, PhD
Investigation performed at the Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA

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Isokinetics – Gold Standard

Wilk et al 1994

- Look at ACLR Quad strength with additional measures **(>85%)**

(+) Correlation: Knee Extensor Peak Torque AND Subjective Knee function

(+) Correlation: Knee Extensor Peak AND Hop Tests (not Knee Flexion)

RESEARCH STUDY

The Relationship Between Subjective Knee Scores, Isokinetic Testing, and Functional Testing in the ACL-Reconstructed Knee[1]

Kevin E. Wilk, PT[2]
William T. Romaniello, ATC[3]
Susan M. Soscia, PT, ATC[4]
Christopher A. Arrigo, MS, PT, ATC[5]
James R. Andrews, MD[6]

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Isokinetics and Hop Tests

[RESEARCH REPORT]

SOFIA A. XERGIA, PT[1] • EVANGELOS PAPPAS, PT, PhD, OCS[2] • FRANCESKA ZAMPELI, MD[1] • SPYROS GEORGIOU, PT[1] • ANASTASIOS D. GEORGOULIS, MD[1]

Asymmetries in Functional Hop Tests, Lower Extremity Kinematics, and Isokinetic Strength Persist 6 to 9 Months Following Anterior Cruciate Ligament Reconstruction

Knee extensor strength and hop test performance following anterior cruciate ligament reconstruction

Kristoffer W. Barfod [a,b], Julian A. Feller [a], Taylor Hartwig [a], Brian M. Devitt [a], Kate E. Webster [c,*]

[a] OrthoSport Victoria Research Unit, Epworth HealthCare, Level 5, 89 Bridge Rd, Richmond 3121, Australia
[b] Afdelingslæge Artroskopisk Center, Hvidovre Hospital, Denmark
[c] School of Allied Health, College of Science, Health & Engineering, La Trobe University, Bundoora, Melbourne, VIC 3086, Australia

Quadriceps strength and functional performance after anterior cruciate ligament reconstruction in professional soccer players at time of return to sport

Herrington, LC, Hussain, G and Comfort, P

http://dx.doi.org/10.1519/JSC.0000000000002749

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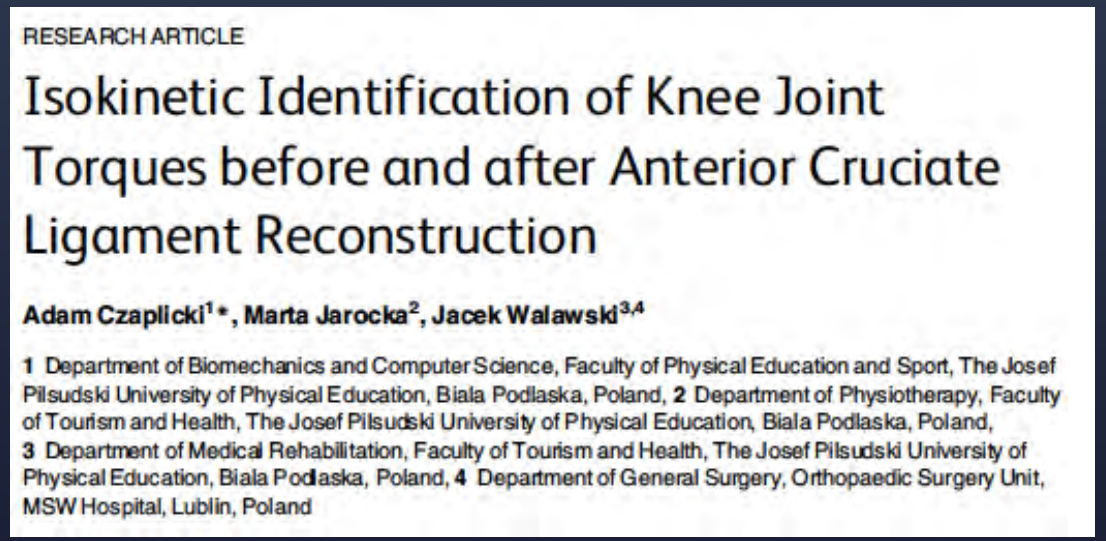
Isokinetics and RTP

[RESEARCH REPORT]

LAURA C. SCHMITT, PT, PhD[1] • MARK V. PATERNO, PT, PhD, SCS, ATC[2] • TIMOTHY E. HEWETT, PhD[3]

The Impact of Quadriceps Femoris Strength Asymmetry on Functional Performance at Return to Sport Following Anterior Cruciate Ligament Reconstruction



RESEARCH ARTICLE

Isokinetic Identification of Knee Joint Torques before and after Anterior Cruciate Ligament Reconstruction

Adam Czaplicki[1]*, Marta Jarocka[2], Jacek Walawski[3,4]

1 Department of Biomechanics and Computer Science, Faculty of Physical Education and Sport, The Josef Pilsudski University of Physical Education, Biala Podlaska, Poland, **2** Department of Physiotherapy, Faculty of Tourism and Health, The Josef Pilsudski University of Physical Education, Biala Podlaska, Poland, **3** Department of Medical Rehabilitation, Faculty of Tourism and Health, The Josef Pilsudski University of Physical Education, Biala Podlaska, Poland, **4** Department of General Surgery, Orthopaedic Surgery Unit, MSW Hospital, Lublin, Poland

Limitations in Literature: ***Undheim et al 2015***

- No standard protocol
- Standard for % passing lacking and inconsistent

Exactly WHY we are discussing! Helpful but HOW?

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I Can Just Use MMT!

Muscular strength relationship between normal grade manual muscle testing and isokinetic measurement of the shoulder internal and external rotators

Todd S. Ellenbecker*

Physiotherapy Associates, Scottsdale Sports Clinic, 9449 N. 90th Street, Suite 100, Scottsdale, AZ 85258, USA

Ellenbecker 1996

- 11-28% range difference!!!

ON SMALL MUSCLES!

Influence of Method on Estimates of Normal Knee Extensor Force among Normal and Postpolio Children

Willis C. Beasley, Ph.D.

Physical Therapy, Volume 36, Issue 1, 1 January 1956, Pages 21–41,
https://doi.org/10.1093/ptj/36.1.21

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What about Squat Testing?

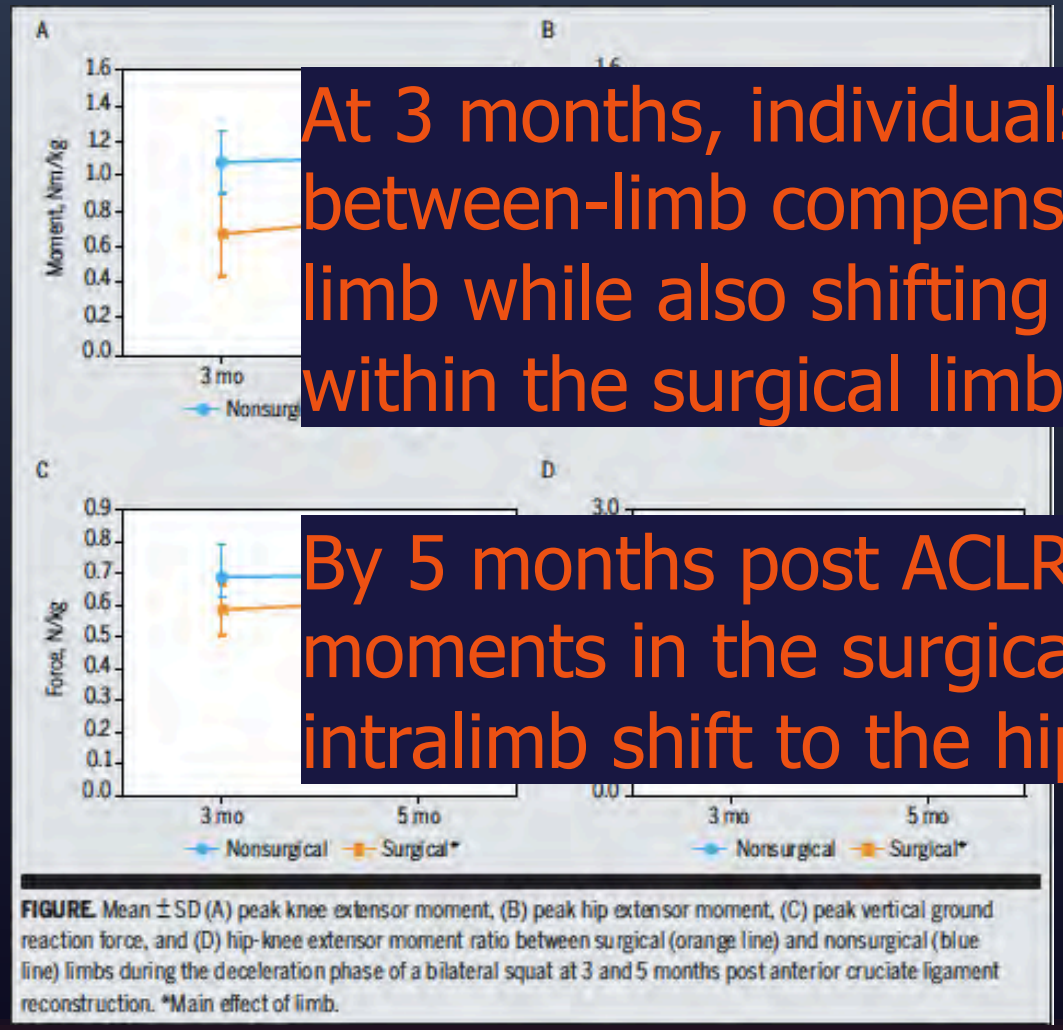


FIGURE. Mean ± SD (A) peak knee extensor moment, (B) peak hip extensor moment, (C) peak vertical ground reaction force, and (D) hip-knee extensor moment ratio between surgical (orange line) and nonsurgical (blue line) limbs during the deceleration phase of a bilateral squat at 3 and 5 months post anterior cruciate ligament reconstruction. *Main effect of limb.

At 3 months, individuals relied more heavily on a between-limb compensation, shifting weight to the other limb while also shifting the demand to the hip extensors within the surgical limb.

[RESEARCH REPORT]

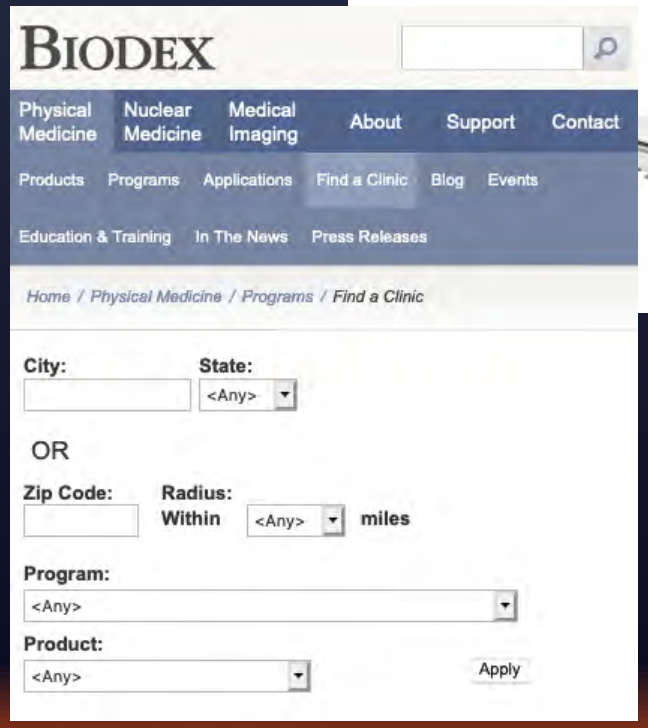
NG M. CHAN, PhD[1] • PAIGE E. LIN, PhD[1]
MARIE A. PRATT, PhD, MEng[1,2]

hat
d During
m 3 to 5
Months Following Anterior Cruciate Ligament Reconstruction

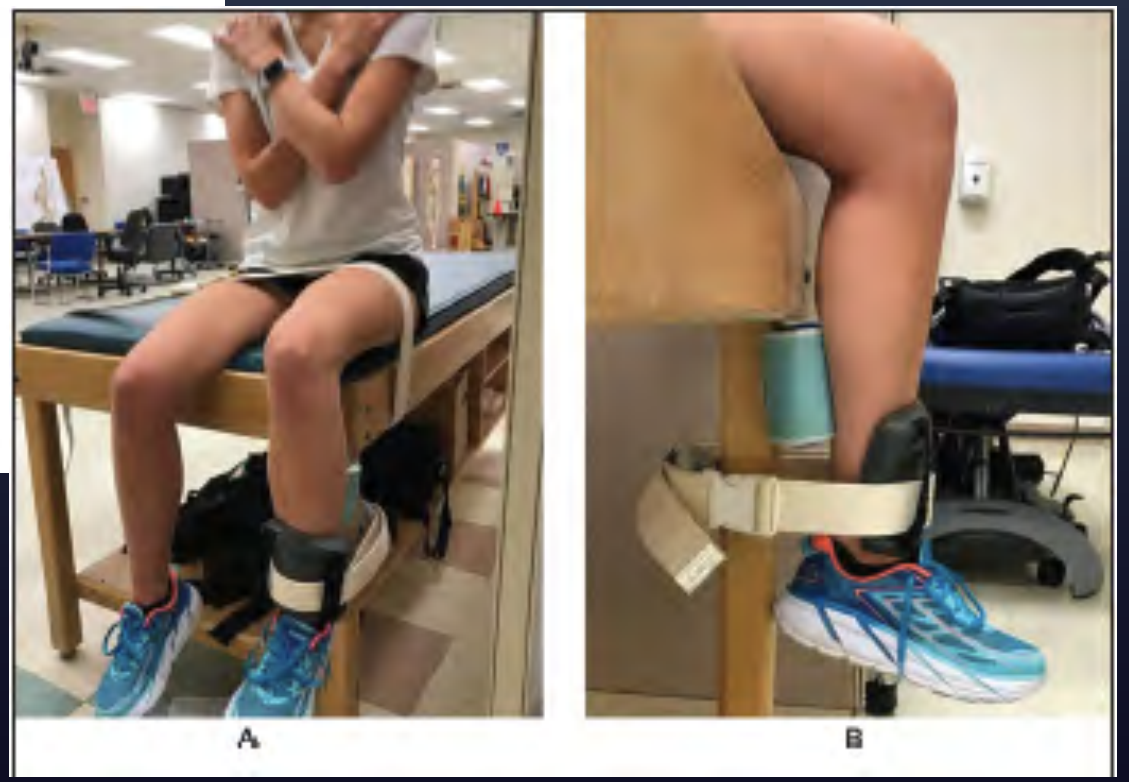
By 5 months post ACLR, decreased knee extensor moments in the surgical limb were primarily driven by an intralimb shift to the hip extensors.

http://www.quickmeme.com/meme/3v7pgl

Isokinetic Dynamometers: These things are expensive!



https://m.biodex.com/clinic-search



Lesnak et al 2019

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Hand-Held Dynamometry

Stark et al 2011 – SR of Isokinetic Compared to HHD

Conclusions: Considering hand-held dynamometry's ease of use, portability, cost, and compact size, compared with isokinetic devices this instrument can be regarded as a reliable and valid instrument for muscle strength assessment in a clinical setting.

IJSPT

ORIGINAL RESEARCH

VALIDITY OF HAND-HELD DYNAMOMETRY IN MEASURING QUADRICEPS STRENGTH AND RATE OF TORQUE DEVELOPMENT

Joseph Lesnak, PT, DPT[1]
Dillon Anderson, SPT[1]
Brooke Farmer, MS, ATC[1]
Dimitrios Katsavelis, PhD[2]
Terry L. Grindstaff, PT, PhD, ATC[1]

Can get reliable data BUT….

HHD and 1 RM - Analogs

HHD can OVERESTIMATE
- BUT good alternatives if you don't have Isokinetic access
Proceed with caution!

**Caution with HHD position

Figure 2. *A) Standard belt-stabilized HHD configuration B) Modified belt-stabilized HHD configuration.*

Hansen et al 2015
https://physiopraxis.co/testing-knee-extension-torque/

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Quad Strength Symmetry & Pt Reported Outcomes

Logerstedt et al 2013

Di Stasi et al 2013

Lepley, Palmieri-Smith 2015

Grindem et al 2016

Piussi et al 2020

> Med Sci Sports Exerc. 2016 Sep;48(9):1671-7. doi: 10.1249/MSS.0000000000000946.

Quadriceps Strength Predicts Self-reported Function Post-ACL Reconstruction

Brian Pietrosimone [1], Adam S Lepley, Matthew S Harkey, Brittney A Luc-Harkey, J Troy Blackburn, Phillip A Gribble, Jeffrey T Spang, David H Sohn

*****All re-iterate the same thing >>***

STRONG = Better Outcomes!

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SL Squat and Patient Outcomes

Culvenor et al 2015

>22 SL sit to stand from chair = better outcomes on KOOS

*****Only noted functional predictor***

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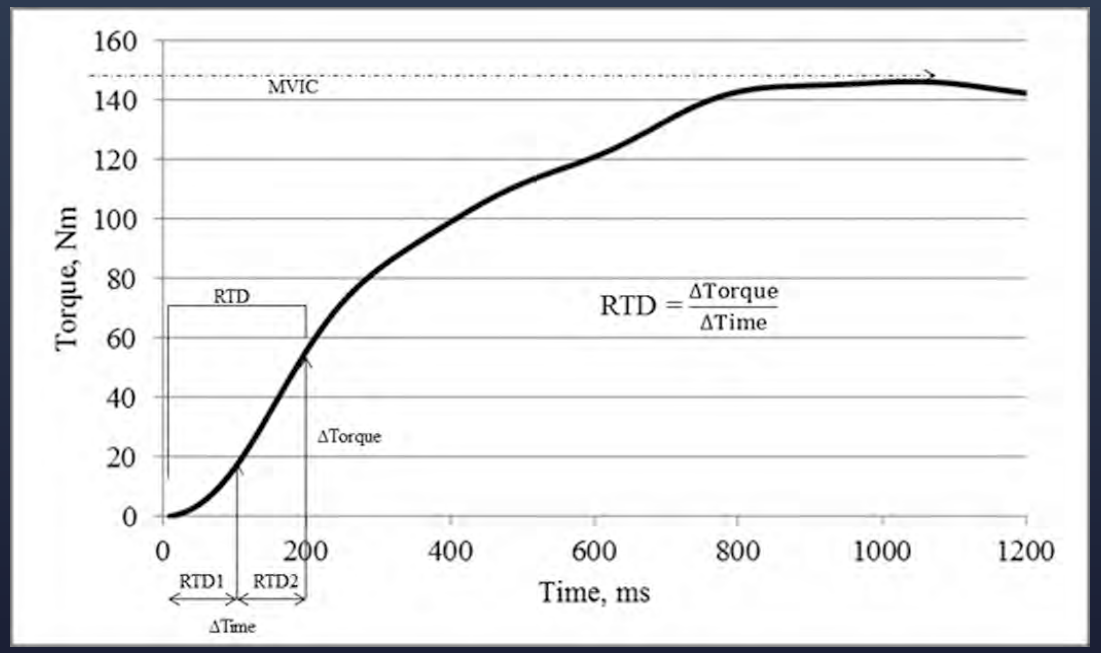
Other Considerations

Isokinetic/Isometric Testing

- Rate of Force Development (RFD)
- consider for NM control
- Goal is similar torque curves



Peak Torque (classically used ~3,000 articles)

- Additional Factors (H:Q ratio, Angle specific torque, Total work, Avg power)
- 2.5 to 3 N/m x kg BW (*Risberg et al 2018, Kuenze et al 2015, Harbo et al 2012*)

Kline et al 2015

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RTS Components

** Pre-entry Components >> Basic Measurements (continue to monitor)

1) Thigh Strength/Force Development
2) **Neuromuscular Control**
3) Hop Testing
4) Lower Extremity Functional Testing (LEFT)
5) Sport Specific
6) Patient Reported Outcomes/Kinesiophobia/Confidence

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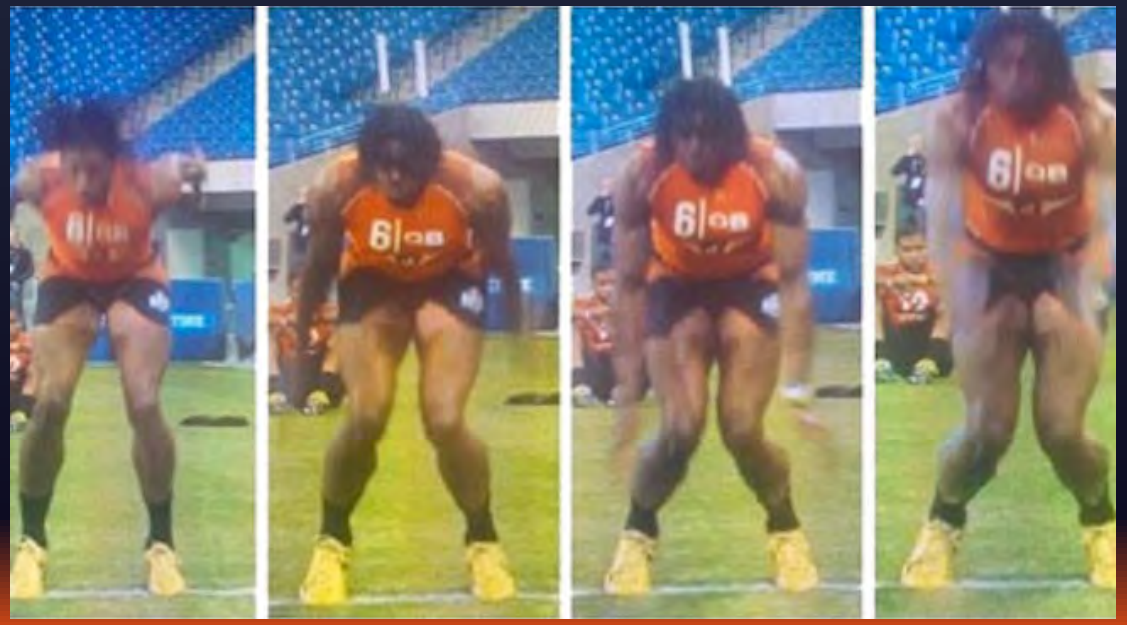
Neuromuscular Control

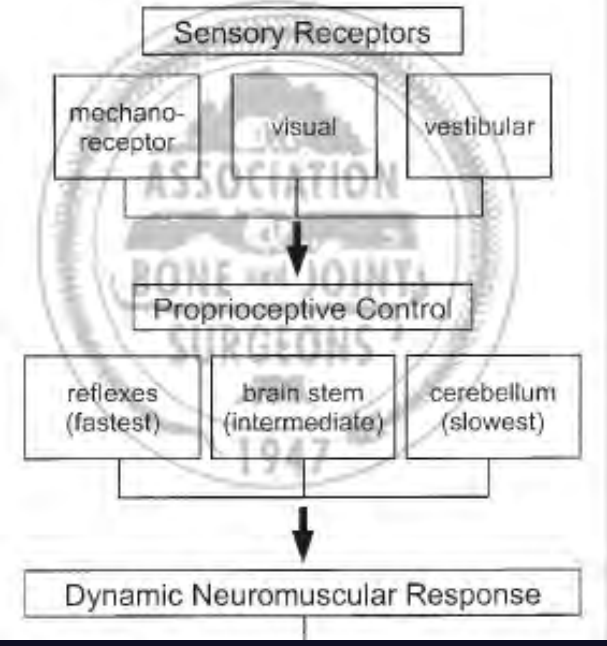
Push for examining Dynamic Knee Valgus

- Maybe not the WHOLE story but part of it
- Do they have the basic CAPACITY 1st >> then NM Control



Strategies for Enhancing Proprioception and Neuromuscular Control of the Knee

Timothy E. Hewett, PhD; Mark V. Paterno, MS, PT, ATC; and Gregory D. Myer, MS



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ACL Injury Mechanism

Koga et al 2010

- ACL Injury around 40ms after Initial contact (IC) with ground

Mechanisms for Noncontact Anterior Cruciate Ligament Injuries

Knee Joint Kinematics in 10 Injury Situations From Female Team Handball and Basketball

Hideyuki Koga,* MD, PhD, Atsuo Nakamae, MD, PhD, Yosuke Shima, MD, PhD, Junji Iwasa, MD, PhD, Grethe Myklebust, PT, PhD, Lars Engebretsen, MD, PhD, Roald Bahr, MD, PhD, and Tron Krosshaug, PhD
From Oslo Sports Trauma Research Center, Norwegian School of Sport Sciences, Oslo, Norway

Myer et al 2011

- Females with increased Knee Abduction Moment (KAM) and decreased knee flexion ROM = increased risk ACL injury

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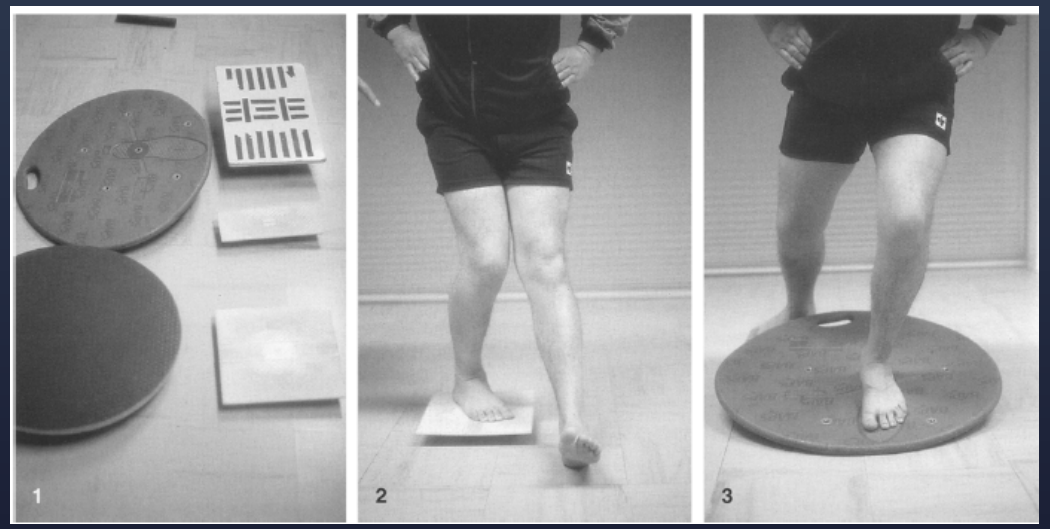
ACL Injury Prevention Programs

Carraffa et al 1996

- Reduction 7x ACL injury male soccer



Mechanisms, Prediction, and Prevention of ACL Injuries: Cut Risk With Three Sharpened and Validated Tools

Timothy E. Hewett,[1,2] Gregory D. Myer,[3,4,5,6,7,8] Kevin R. Ford,[9] Mark V. Paterno,[7,10] Carmen E. Quatman[1,7]

** There is evidence to modify biomechanical risk factors with neuromuscular training

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Fitzgerald et al 2000

Non-Operative ACL

Copers vs Non-Copers

10 sessions, 2-3x/week

	Successful Rehabilitation	Unsuccessful Rehabilitation	Total
Pertubation group	11	1	12
Standard group	7	7	14
Total	18	8	26

The Efficacy of Perturbation Training in Nonoperative Anterior Cruciate Ligament Rehabilitation Programs for Physically Active Individuals

Figure 1.
Roller board perturbation technique. Reprinted with permission of the Orthopaedic and Sports Physical Therapy Sections of the American Physical Therapy Association from Fitzgerald GK, Axe MJ, Snyder-Mackler L. Proposed practice guidelines for nonoperative anterior cruciate ligament rehabilitation of physically active individuals. *J Orthop Sports Phys Ther*. In press.

Figure 2.
Tiltboard perturbation technique. Reprinted with permission of the Orthopaedic and Sports Physical Therapy Sections of the American Physical Therapy Association from Fitzgerald GK, Axe MJ, Snyder-Mackler L. Proposed practice guidelines for nonoperative anterior cruciate ligament rehabilitation of physically active individuals. *J Orthop Sports Phys Ther*. In press.

tions (usually in 4 or 5 sessions), the motorized force platform was replaced with a roller board. The roller board was a 35- × 38-cm platform supported by 4 swivel rollers, with a roller placed on each corner of the platform's underside. Each subject stood on the roller board in single-limb support while the therapist manually perturbed the roller board randomly in multiple directions, at varying speeds (Fig. 1). The displacement of the board during the perturbations varied between approximately 2.5 to 5 cm (1–2 in). The speed of the perturbations varied from quick displacements to slow, gradual displacements. A training bout lasted approximately 1 to 1.5 minutes. The activity was initially performed in parallel bars so that the subject would have

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Neuroplasticity

Cortico-cerebellar Pathway

(correct sensory errors)

1 deg proprio loss = potential injury

Depressed Cortical Motor Excitement

SHIFT

Proprio >> Visual

Overlooked Considerations Pertaining to ACL Injury Risk and Impact on Protracted Recovery

1. Recovery of muscle strength alone is not always protective against reinjury (though is required!)
2. Injuries often occur during high attentionally demanding situations during periods of high cognitive stress (games)
3. During the time of injury, visual attention is often distracted within 1 meter onto a ball or other visual target
4. Reduced neurocognitive processing, especially visuospatial ability may contribute to primary ACL injury
5. Deficits in neurocognitive abilities can manifest as injury-risk biomechanics when challenged to move when reacting to visual stimuli
6. Previous history of concussive events (isolated brain perturbations) may increase risk of ACL injury
7. Brain connectivity may contribute to primary ACL injury risk
8. Despite return to play after ACL injury, visuospatial-motor deficits remain.
9. Patients with ACLR require increased neural activity to maintain motor control.

Table 1: Summary of overlooked considerations pertaining to ACL injury and recovery

RESEARCH REPORT

DUSTIN R. GROOMS, PhD, ATC[1,2] • STEPHEN J. PAGE, PhD, OTR/L[3] • DEBORAH S. NICHOLS-LARSEN, PT, PhD[4]
AJIT M.W. CHAUDHARI, PhD[5] • SUSAN E. WHITE, PhD[4] • JAMES A. ONATE, PhD[6]

Neuroplasticity Associated With Anterior Cruciate Ligament Reconstruction

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Cognitive Loading

Cognitive Function	Example Intervention
Motor Planning	Using PowerPoint, when a red slide is displayed perform a squat, when a blue slide is displayed perform a lunge.
Reaction time/Inhibition	Assign three exercises to numbers one to three, flash one to three fingers in the air, complete the intended exercise. Clinician then cycles through numbers on hand randomly. Can also be automated with a timed PowerPoint
Working Memory	*Serial 7 subtraction* continuously while performing 20 second squat-jumps

Table 2: Examples of cognitive functions and clinical interventions to target these functions

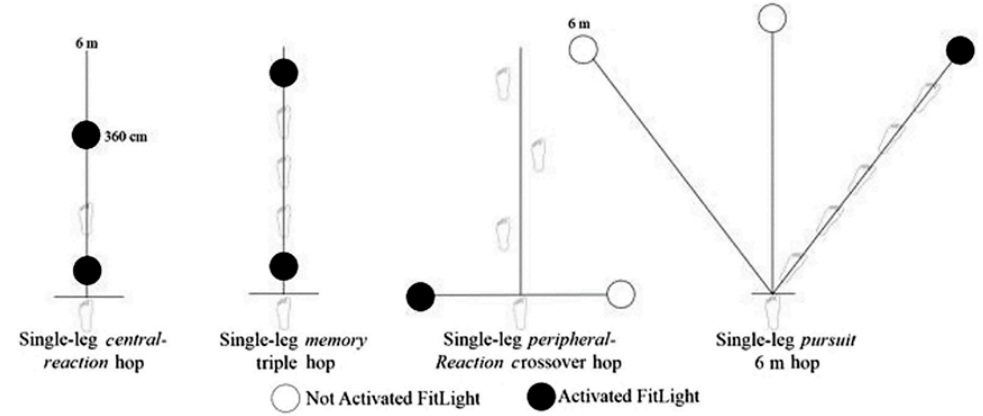

Figure 1: Schematic representation of neurocognitive hop tests. Image from Millikan N, Grooms DR, Hoffman B, Simon JE. The Development and Reliability of 4 Clinical Neurocognitive Single-Leg Hop Tests: Implications for Return to Activity Decision-Making. Journal of sport rehabilitation. 2019 Jul 1;28(5).

DUSTIN GROOMS, MEd, ATC, CSCS[1] • GREGORY APPELBAUM, PhD[2]
JAMES ONATE, PhD, ATC, FNATA[1]

Neuroplasticity Following Anterior Cruciate Ligament Injury: A Framework for Visual-Motor Training Approaches in Rehabilitation

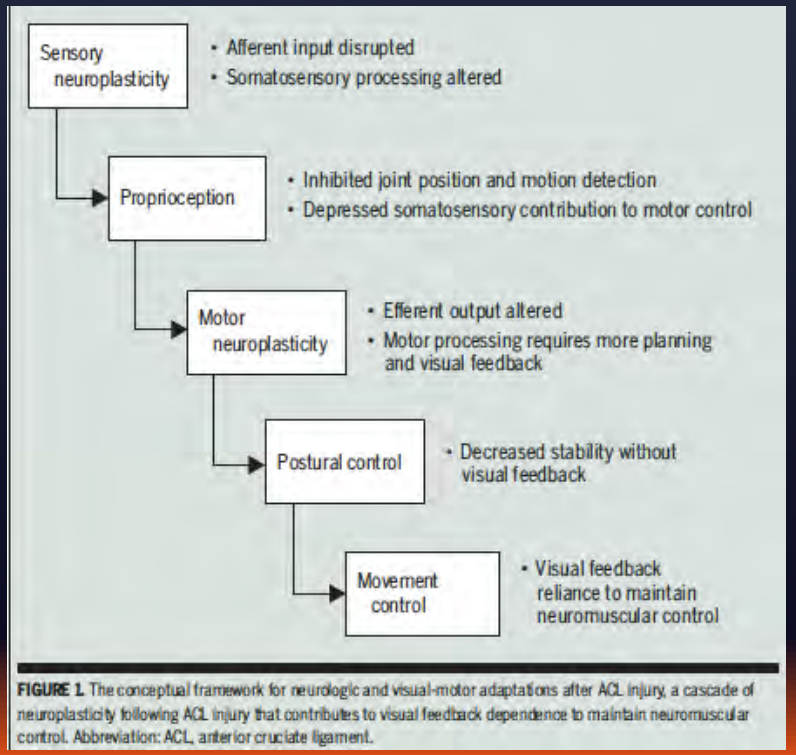

FIGURE 1. The conceptual framework for neurologic and visual-motor adaptations after ACL injury, a cascade of neuroplasticity following ACL injury that contributes to visual feedback dependence to maintain neuromuscular control. Abbreviation: ACL, anterior cruciate ligament.

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Prevention/Neuromuscular Training

Benjaminse et al 2015 >>>>>>>>>>>>>>>>

Paterno et al 2004, Johnson et al 2018 - reduced firing rate, need NM to help with RFD

Nagai et al 2018 - proprioception analysis with TTPM

** FIFA 11+, Sportsmetrics, PEP

FIGURE 2. Comparison of instructions to reduce knee valgus motion during a single-leg squat, with (A) an internal focus ("Keep your knee over your foot") and (B) an external focus ("Reach toward the cone with your knee").

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NM Control Assessment: Recommended and Alternative

Paterno et al 2004 and Davies et al 2017

- Biodex Stabilometer testing

Athl Ther Today. 2008 September 1; 13(5): 39–44.

Tuck Jump Assessment for Reducing Anterior Cruciate Ligament Injury Risk

Gregory D. Myer, MS, CSCS, Kevin R. Ford, MS, and **Timothy E. Hewett, PhD**
Cincinnati Children's Hospital

Figure 9. Tuck jumps are an example of an exercise used to train the athlete to increase lower body power. The tuck jump can also be used as an assessment to grade improvement in technique. To perform the tuck jump, athletes starts in the athletic position with their feet shoulder-width apart. They initiate the jump with a slight crouch downward while they extend their arms behind them. They then swing their arms forward as they simultaneously jump straight up and pulls the knees up as high as possible. At the highest point of the jump, athletes are in the air with the thighs parallel to the ground. When landing, athletes should immediately begin the next tuck jump. Encourage the athletes to land softly, using a toe to mid-foot rocker landing. The athletes should not continue this jump if they cannot control the high landing force or if they demonstrate a knock-kneed landing. Reprinted from G.D. Myer, K.R. Ford, et al. Rationale and clinical techniques for anterior cruciate ligament injury prevention among female athletes. *J Athl Train* 39: 352–364, 2004 with permission from the editor.

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Tuck Jump Assessment

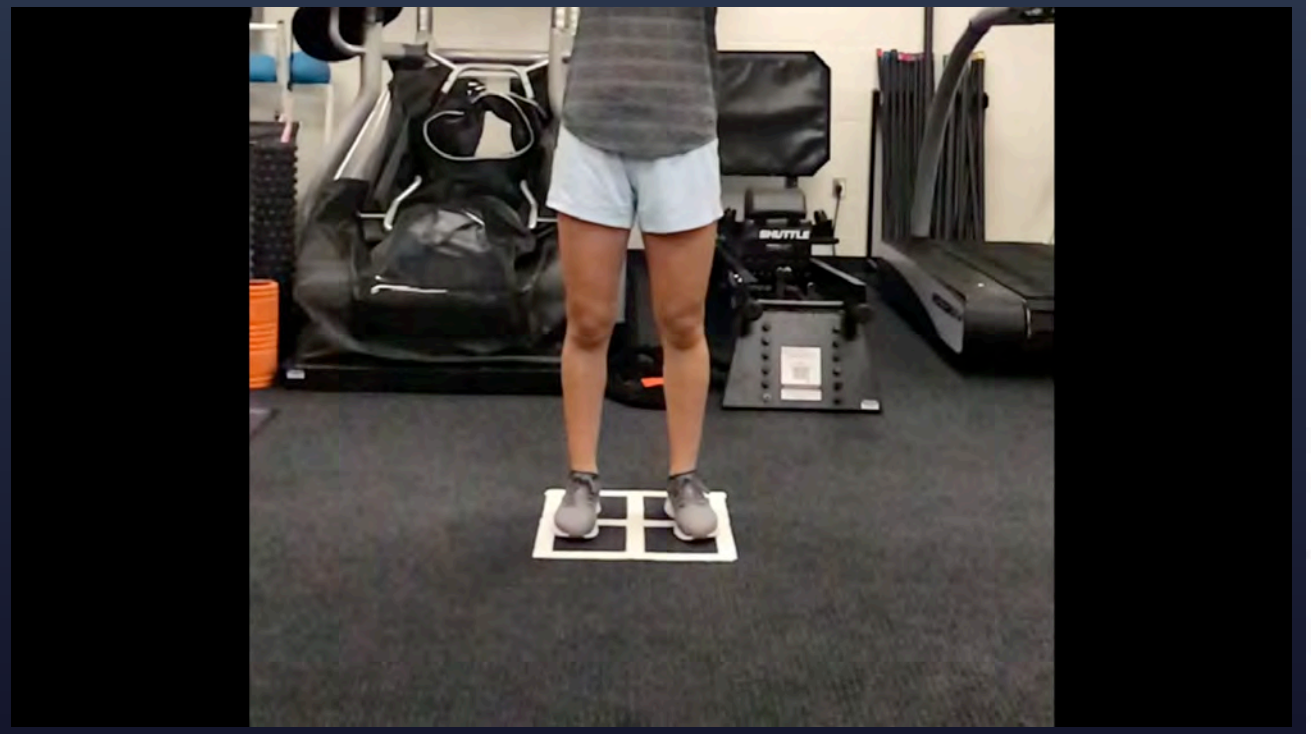

Table 2. Scoring criteria for each item of the Modified Tuck Jump Assessment.

Phase of jump	Criterion	View	None (0)	Small (1)	Large (2)
Knee and Thigh motion	1. Lower Extremity valgus at landing	Frontal (F)	No valgus	Slight Valgus	Obvious valgus: Both knees touch
	2. Thighs do not reach parallel (peak of jump)	Lateral (L)	The knees are higher or at the same level as the hips	The middle of the knees are at a lower level than the middle of the hips	The whole knees are under the entire hips
	3. Thighs not equal side-to-side during flight	F	Thighs equal side-to-side	Thighs slightly unequal side-to-side	Thighs completely unequal side-to-side (one knee is over the other)
Foot Position During Landing	4. Foot placement not shoulder width apart	F	Foot placement exactly shoulder width apart	Foot placement mostly shoulder width apart	Both feet fully together and touch at landing
	5. Foot placement not parallel (front to back)	L	Foot (the end of the feet) placement parallel	Foot placement mostly parallel	Foot placement obviously unparalleled (one foot is over half the distance of the other foot/leg)
	6. Foot contact timing not equal (Asymmetrical landing)	F	Foot contact timing equal side-to-side	Foot contact timing slightly unequal	Foot contact timing completely unequal
	7. Excessive landing contact noise	F/L	Subtle noise at landing (landing on the balls of their feet)	Audible noise at landing (heels almost touch the ground at landing)	Loud and pronounced noise at landing (contact of the entire foot and heel on the ground between jumps)
Plyometric Technique	8. Pause between jumps	F/L	Reactive and reflex jumps	Small pause between jumps	Large pause between jumps (or double contact between jumps)
	9. Technique declines prior 10 seconds	F/L	No decline in technique.	Technique declines after five seconds	Technique declines before five seconds
	10. Does not land in same foot print (Consistent point of landing)	F/L	Lands in same footprint	Does not land in same footprint, but inside the shape	Lands outside the shape

Some meaningfulness in question with ***Arundale et al 2020***


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ORIGINAL RESEARCH
TUCK JUMP SCORE IS NOT RELATED TO HOPPING PERFORMANCE OR PATIENT-REPORTED OUTCOME MEASURES IN FEMALE SOCCER PLAYERS
Amelia J.H. Arundale, PT, PhD, DPT[1]
Joanna Kvist, PT, PhD[1,2]
Martin Hägglund, PT, PhD[1]
Anne Fältström, PT, PhD[1,3]

Original and Modified 0,1,2 scoring; Interrater Reliability

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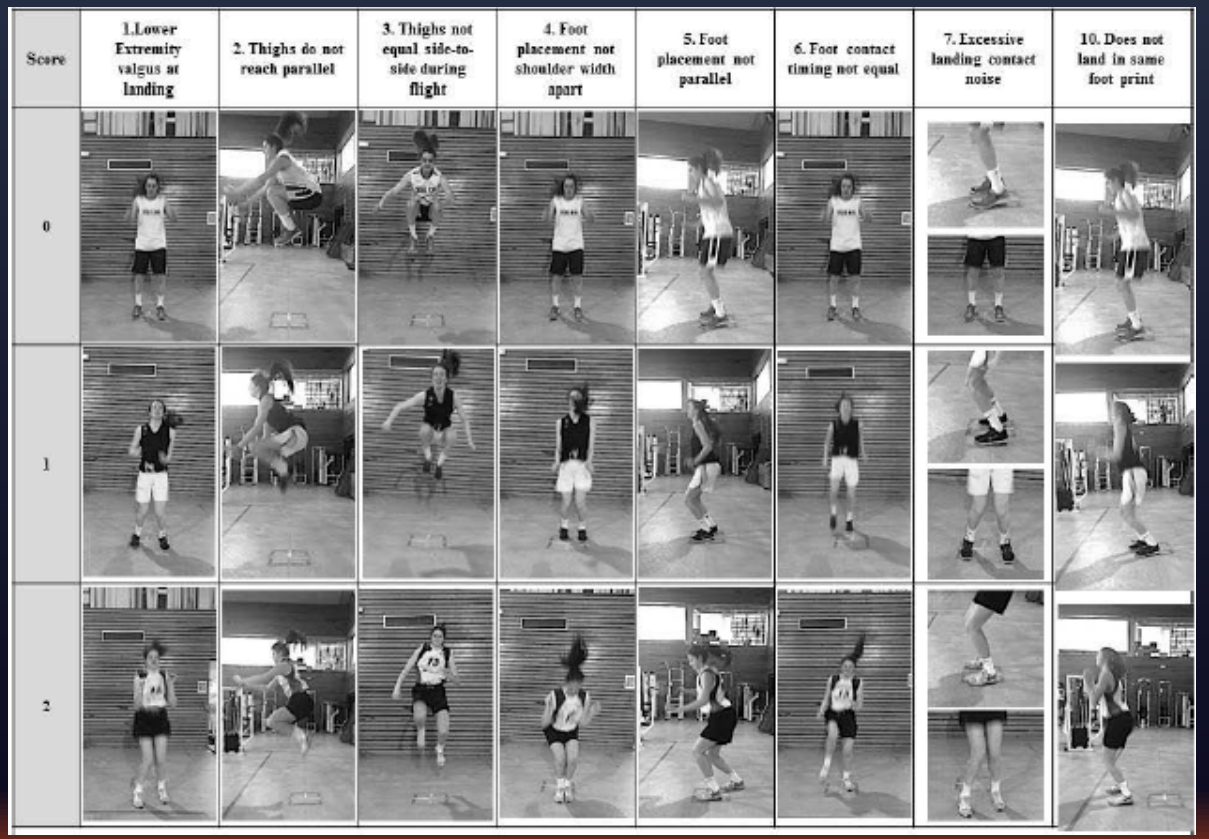
Tuck Jump Assessment

Tuck Jump Assessment	Pre	Mid	Post	Comments
Knee and Thigh Motion				
1 Lower extremity valgus at landing	❑	❑	❑	
2 Thighs do not reach parallel (peak of jump)	❑	❑	❑	
3 Thighs not equal side-to-side (during flight)	❑	❑	❑	
Foot Position During Landing				
4 Foot placement not shoulder width apart	❑	❑	❑	
5 Foot placement not parallel (front to back)	❑	❑	❑	
6 Foot contact timing not equal	❑	❑	❑	
7. Excessive landing contact noise	❑	❑	❑	
Plyometric Technique				
8. Pause between jumps	❑	❑	❑	
9. Technique declines prior to 10 seconds	❑	❑	❑	
10. Does not land in same footprint (excessive in-flight motion)	❑	❑	❑	
	Total _____	Total _____	Total _____	



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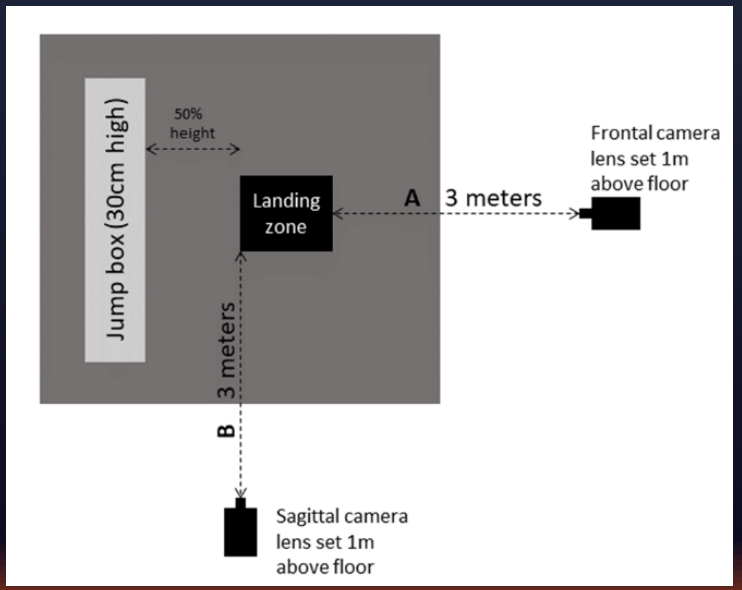
Landing Error Scoring System (LESS)

Padua et al 2009 & Smith et al 2012

- Able to identify high-risk movement patterns (Padua)
- Use as predictor for ACL injury remains to be seen with score (Smith)

Score = <5
"High Risk"

Frontal-Plane Motion	Sagittal-Plane Motion
1. Stance width	**6. Initial landing of feet**
☐ Normal (0)	☐ Toe to heel (0)
☐ Wide (1)	☐ Heel to toe (1)
☐ Narrow (1)	☐ Flat (1)
2. Maximum foot-rotation position	**7. Amount of knee-flexion displacement**
☐ Normal (0)	☐ Large (0)
☐ Externally rotated (1)	☐ Average (1)
☐ Internally rotated (1)	☐ Small (2)
3. Initial foot contact	**8. Amount of trunk-flexion displacement**
☐ Symmetric (0)	☐ Large (0)
☐ Not symmetric (1)	☐ Average (1)
	☐ Small (2)
	9. Total joint displacement in the sagittal plane
4. Maximum knee-valgus angle	☐ Soft (0)
☐ None (0)	☐ Average (1)
☐ Small (1)	☐ Stiff (2)
☐ Large (2)	
5. Amount of lateral trunk flexion	**10. Overall impression**
☐ None (0)	☐ Excellent (0)
☐ Small to moderate (1)	☐ Average (1)
	☐ Poor (2)



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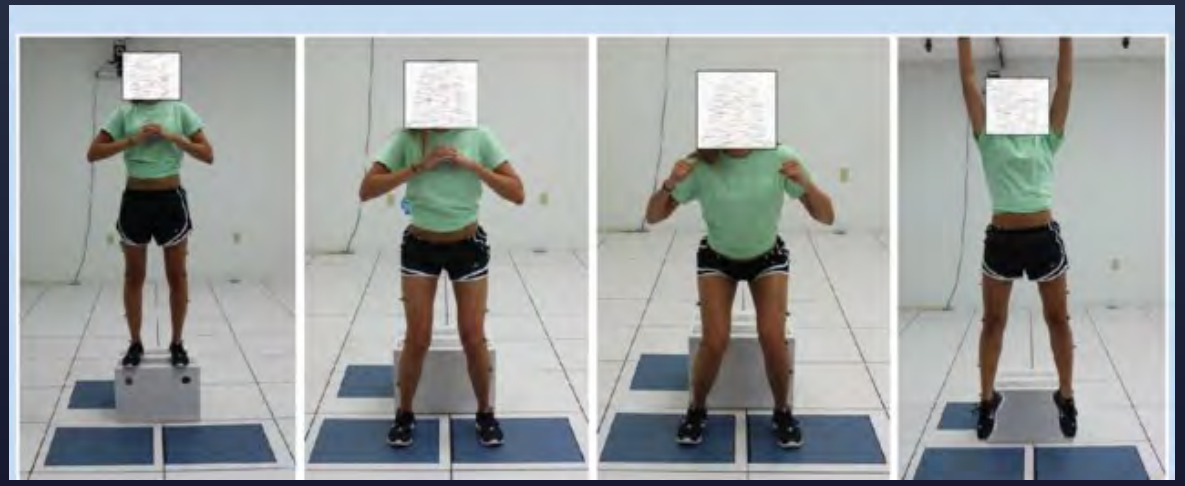
Drop Vertical Jump (DVJ)

Evidence in lab with force plate and Camera (Hewett)



Biomechanical Measures of Neuromuscular Control and Valgus Loading of the Knee Predict Anterior Cruciate Ligament Injury Risk in Female Athletes

Timothy E. Hewett
Cincinnati Children's Hospital Medical Center, tim.hewett@chmcc.org

Gregory D. Myer
Cincinnati Children's Hospital Medical Center

Kevin R. Ford
Cincinnati Children's Hospital Medical Center

Robert S. Heidt Jr.
Wellington Orthopaedic and Sports Medicine

The Vertical Drop Jump Is a Poor Screening Test for ACL Injuries in Female Elite Soccer and Handball Players

A Prospective Cohort Study of 710 Athletes

Tron Krosshaug,*† PhD, Kathrin Steffen,† PhD, Eirik Kristianslund,† MD, PhD, Agnethe Nilstad,† PT, PhD, Kam-Ming Mok,† MSc, Grethe Myklebust,† PT, PhD, Thor Einar Andersen,† MD, PhD, Ingar Holme,† PhD, Lars Engebretsen,† MD, PhD, and Roald Bahr,† MD, PhD

Reliability of a Field-Based Drop Vertical Jump Screening Test for ACL Injury Risk Assessment

Lauren H. Redler MD, Jonathan P. Watling MD, Elizabeth R. Dennis MD, Eric Swart MD & Christopher S. Ahmad MD

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Y Balance

Anterior Reach – less than 4cm

Can be used early in monitoring prior to jumping

Combined strength and control

players with an anterior right/left reach distance difference greater than 4 cm were 2.5 times more likely to sustain a lower extremity injury (P<.05). Girls with a composite reach distance less than 94.0% of their limb length were 6.5 times more likely to have a lower extremity injury (P<.05)

Star Excursion Balance Test as a Predictor of Lower Extremity Injury in High School Basketball Players

Phillip J. Plisky, PT, DSc, OCS, ATC/L, CSCS[1]
Mitchell J. Rauh, PT, PhD, MPH[2]
Thomas W. Kaminski, PhD, ATC, FACSM[3]
Frank B. Underwood, PT, PhD, FCS[4]

Overview: NM Control

Testing Something is Better Than Nothing….

**It is all information you put together to make a Clinical Decision

RTS Components

** Pre-entry Components >> Basic Measurements (continue to monitor)

1) Thigh Strength/Force Development
2) Neuromuscular Control
3) **Hop Testing**
4) Lower Extremity Functional Testing (LEFT)
5) Sport Specific
6) Patient Reported Outcomes/Kinesiophobia/Confidence

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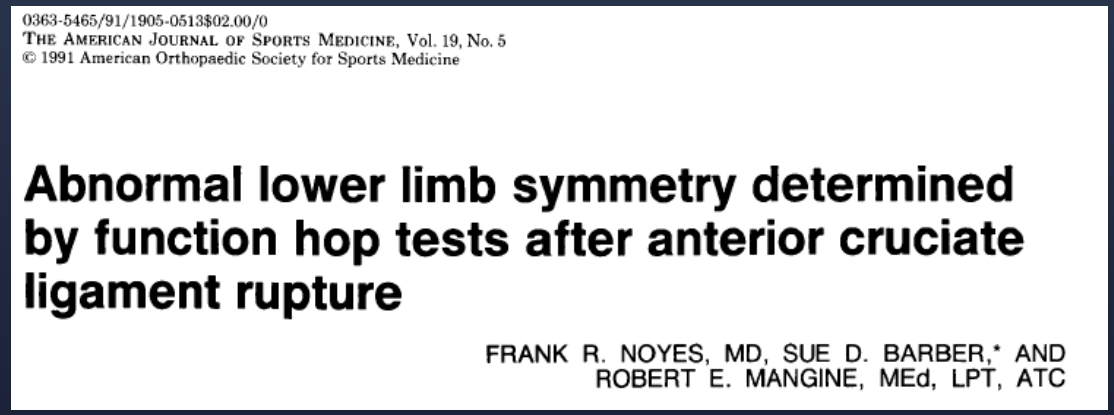
Original Development

Noyes et al 1991

- 4 Hop Tests developed for function after ACL injury and ACLR


0363-5465/91/1905-0513$02.00/0
THE AMERICAN JOURNAL OF SPORTS MEDICINE, Vol. 19, No. 5

Abnormal lower limb symmetry determined by function hop tests after anterior cruciate ligament rupture

FRANK R. NOYES, MD, SUE D. BARBER,* AND ROBERT E. MANGINE, MEd, LPT, ATC

Recently, Hop tests have been used increasingly as a sole predictor of function

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Hop Tests: Predictors of Function ACLR

Logerstedt et al 2012

- N = 120 patients performing 4 sagittal plane hop tests
- 85 performed hop tests 6 mo post, 68 normal self report knee function @ 1 year (*6 m timed, Cross over hop*)

Gustavsson et al 2006

- High discriminative ability
- 1/10 passed at 6 mo ACLR

Vertical jump (cm)
Hop for distance (cm)
Drop jump followed by
a double hop for distance (cm)
Square hop (jumps)
Side hop (jumps)

Br J Sports Med. 2018 March ; 52(6): 375. doi:10.1136/bjsports-2016-097095.

Functional performance 6 months after ACL reconstruction predict return to participation in the same preinjury activity 12 and 24 months after surgery

Zakariya Nawasreh[1,2], **David Logerstedt**[3,4], **Kathleen Cummer**[1], **Michael Axe**[5,6], **May Risberg**[7], and **Lynn Snyder-Mackler**[1,4,5]

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Not Just Sagittal Plane

Dingenen et al 2019

- Concentration around multiple planes of hop testing
- More information on stability and control with various force vectors

Test–retest reliability and discriminative ability of forward, medial and rotational single-leg hop tests

Bart Dingenen [a,*], Jan Truijen [b,c], Johan Bellemans [d,c], Alli Gokeler [e,f]

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SPORTS MEDICINE

However….

Recent studies over last 2 years bring discussion on OVERESTIMATION of function with hop Limb Symmetry Index (LSI)

Hop tests can result in higher limb symmetry index values than isokinetic strength and leg press tests in patients following ACL reconstruction

Takashi Nagai[1,2] · Nathan D. Schilaty[1,2,3] · Edward R. Laskowski[1,4] · Timothy E. Hewett[1,2,3,4]

J Orthop Sports Phys Ther. 2017 May ; 47(5): 334–338. doi:10.2519/jospt.2017.7285.

Limb Symmetry Indexes Can Overestimate Knee Function After ACL Injury

E Wellsandt, DPT, PhD[1,2], MJ Failla, PT, PhD[3,2], and L Snyder-Mackler, PT, ScD[2]

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Hop Tests: Confounding Factors

FATIGUE & DUAL TASKS

Davies et al 2017

- Even notes contribution and lower amount of patients passing tests

Fatigued vs non-fatigued


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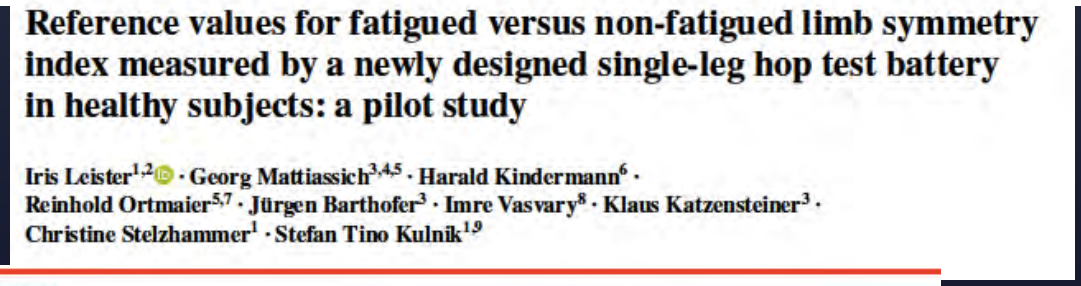
ORIGINAL RESEARCH

COMPARISON OF CLINICAL FATIGUE PROTOCOLS TO DECREASE SINGLE-LEG FORWARD HOP PERFORMANCE IN HEALTHY INDIVIDUALS

Allison K. White[1]
Chelsea J. Klemetson[1]
Brooke Farmer[1]
Dimitrios Katsavelis[2]
Jennifer J. Bagwell[1]


Reference values for fatigued versus non-fatigued limb symmetry index measured by a newly designed single-leg hop test battery in healthy subjects: a pilot study

Iris Leister[1,2] · Georg Mattiassich[3,4,5] · Harald Kindermann[6] · Reinhold Ortmaier[5,7] · Jürgen Barthofer[3] · Imre Vasvary[8] · Klaus Katzensteiner[3] · Christine Stelzhammer[1] · Stefan Tino Kulnik[1,9]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ORIGINAL RESEARCH

INCORPORATING A DUAL-TASK ASSESSMENT PROTOCOL WITH FUNCTIONAL HOP TESTING

Brandon M. Ness, PT, DPT, PhD[1]
Kory Zimney, PT, DPT[1]
Thomas Kernozek, PhD[2],
William E. Schweinle, PhD[3]
Amy Schweinle, PhD[4]

RTS Components

** Pre-entry Components >> Basic Measurements (continue to monitor)

1) Thigh Strength/Force Development
2) Neuromuscular Control
3) Hop Testing
4) **Lower Extremity Functional Testing (LEFT)**
5) Sport Specific
6) Patient Reported Outcomes/Kinesiophobia/Confidence

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Lower Extremity Functional Test (LEFT)

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ORIGINAL RESEARCH

LOWER EXTREMITY FUNCTIONAL TESTS AND RISK OF INJURY IN DIVISION III COLLEGIATE ATHLETES

Jason Brumitt, PT, PhD, SCS, ATC, CSCS[1]
Bryan C. Heiderscheit, PT, PhD[2]
Robert C. Manske, DPT, MEd, SCS, ATC[3]
Paul E. Niemuth, PT, DSc, SCS, OCS, ATC[4]
Mitchell J. Rauh, PT, PhD, MPH, FACSM[5]

Female athletes with slower LEFT times were found to have a 6-fold increase in thigh or knee injury

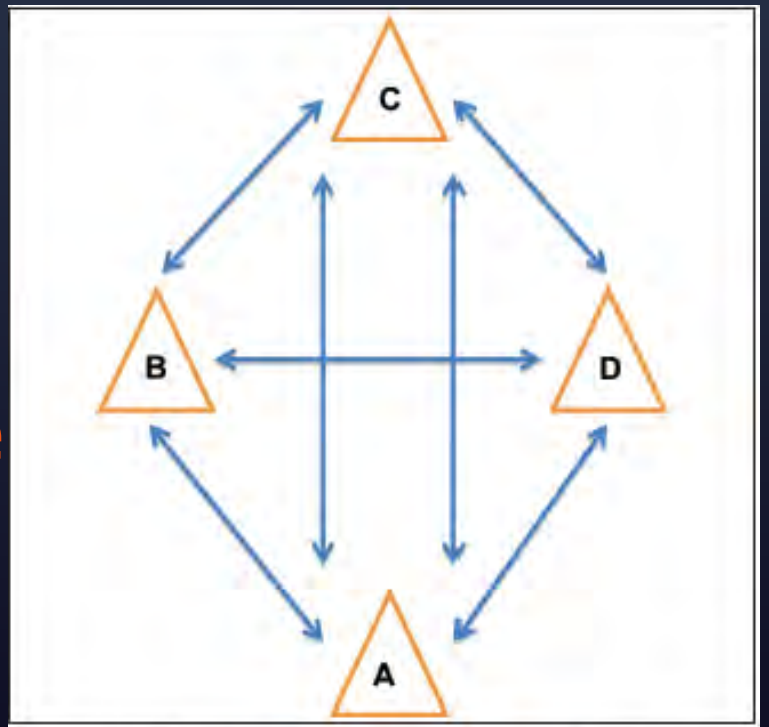

Figure 1. *The LEFT Test. Distance between marker A and marker C is 9.14 meters, and distance between marker B and marker D is 3.05 meters. The athlete completes a series of 16 maneuvers in this course, as described the Appendix.*

RTS Components

** Pre-entry Components >> Basic Measurements (continue to monitor)

1) Thigh Strength/Force Development
2) Neuromuscular Control
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5) **Sport Specific**
6) Patient Reported Outcomes/Kinesiophobia/Confidence

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What about…Return to Run

Criteria for return to run begin

Plyo progression and foot contacts

SL quad strength to blunt force

Running Progression (requires trace or less effusion, 80% or greater strength, understand soreness rules)*

Level	Treadmill	Track
Level 1	0.1-mi† walk/0.1-mi jog, repeat 10 times	Jog straights/walk curves (2 mi)
Level 2	Alternate 0.1-mi walk/0.2-mi jog (2 mi)	Jog straights/jog 1 curve every other lap (2 mi)
Level 3	Alternate 0.1-mi walk/0.3-mi jog (2 mi)	Jog straights/jog 1 curve every lap (2 mi)
Level 4	Alternate 0.1-mi walk/0.4-mi jog (2 mi)	Jog 1.75 laps/walk curve (2 mi)
		Jog all laps (2 mi)
		Increase workout to 2.5 mi
		Increase workout to 3 mi
		Increase speed on straights/jog curves

orm activity for 2 mi without increased
1 week and no more frequently than every
7-day period.

Sample Functional Hop Progression	
Double Leg	**Single Leg**
Hop in Place	Hop in Place
Forward Hop	Forward Hop
Backward Hop	Backward Hop
Triple Hop	Triple Hop
Side-to-Side Hop	Side-to-Side Hop
Crossover	Cross-over
Scissor Hops	Dot Drills
Dot Drills	Lateral Bounds/Skaters

Current Concepts for Anterior Cruciate Ligament Reconstruction: A Criterion–Based Rehabilitation Progr

DOUGLAS ADAMS, PT, DPT, SCS, CSCS[1], DAVID LOGERSTEDT, PT, PhD, MP
AIRELLE HUNTER-GIORDANO, PT, DPT, SCS, OCS, CSCS[3], MICHAEL J. AXE,
LYNN SNYDER-MACKLER, PT, ATC, ScD, SCS, FAPTA[5]

Basic Walk to Run Program	Walk	Run	Repetitions	Days
Phase 1	4 minutes	1 minute	3-6	2-3
Phase 2	3 minutes	2 minute	3-6	2-3
Phase 3	2 minutes	3 minutes	3-6	2-3
Phase 4	1 minute	4 minutes	3-6	2-3
Phase 5	0	30 minutes	1	3

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Let's Think Where Our Athlete is at

The three elements of the RTS continuum.

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Sport Specific

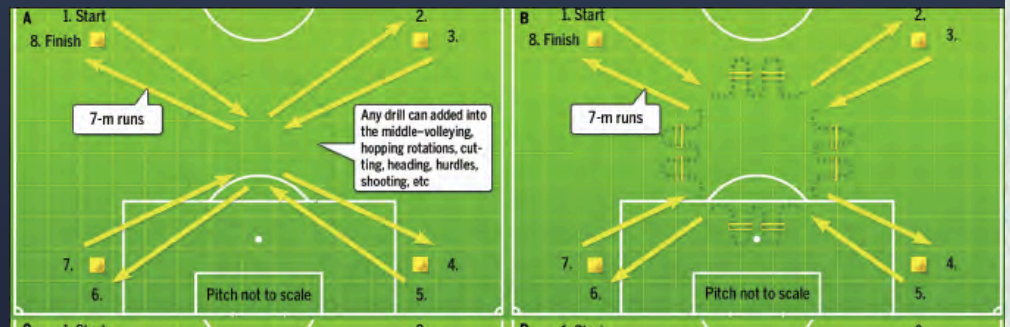


FIGURE 4. Star run drill. Basic setup and different drills: (A) star run outline, (B) star run with zigzag cutting drill, (C) star run with forward/backward ladder drills, (D) star run with running curves through poles.

TABLE 2 RETURN-TO-SKI PROGRAM

Each week, the athlete will perform progression 1 on days 1 and 4. Progression 2 is performed on days 6 and 7. On days 3 and 4, progressions 1 and 2 are performed. Day 2 and day 5 are off-days.

Progression 1: Directed Free Skiing

1. Free skiing, as outlined by level, focusing on basic athletic stance, balance, joint angles, turn shape
2. Free skiing should begin on groomed, flat to moderate terrain
3. Work to achieve even balance on both legs with trust and confidence on both skis
4. Free ski in sections, working up to longer/full-length runs
5. Nonarcing to arcing turns

Progression 2: Drills (Below Are Examples)

1. Skiing to be performed on groomed, flat to mild terrain
2. Sideslipping into smooth stop on fall line
3. Sideslipping into distinctive stop on fall line
4. Sideslipping diagonally across fall line and switching sides
5. Sideslipping to edge-set and carving across fall line
6. Diagonal skiing, carving
7. Diagonal skiing, carving with flattening of ski
8. Sliding turn in natural-stance position
9. Sliding turn in squat position
10. Sliding turn in squat position with squat pumps
11. Single-leg sliding turns, "heel lift" opposite ski
12. Single-leg sliding turns, "cross-hip" opposite ski
13. Sliding short to medium turns with pole plant
14. Sliding short to medium turns without pole plant
15. Turns with 1 leg lifted
16. Turns with 1000-ft stepping (stepping back and forth throughout the turn)
17. Turns with small hops

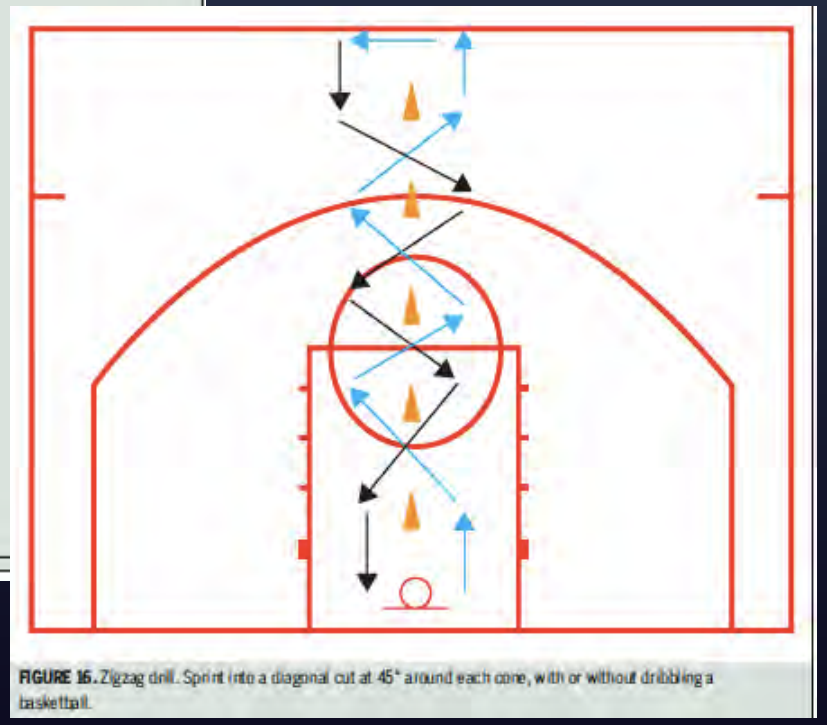
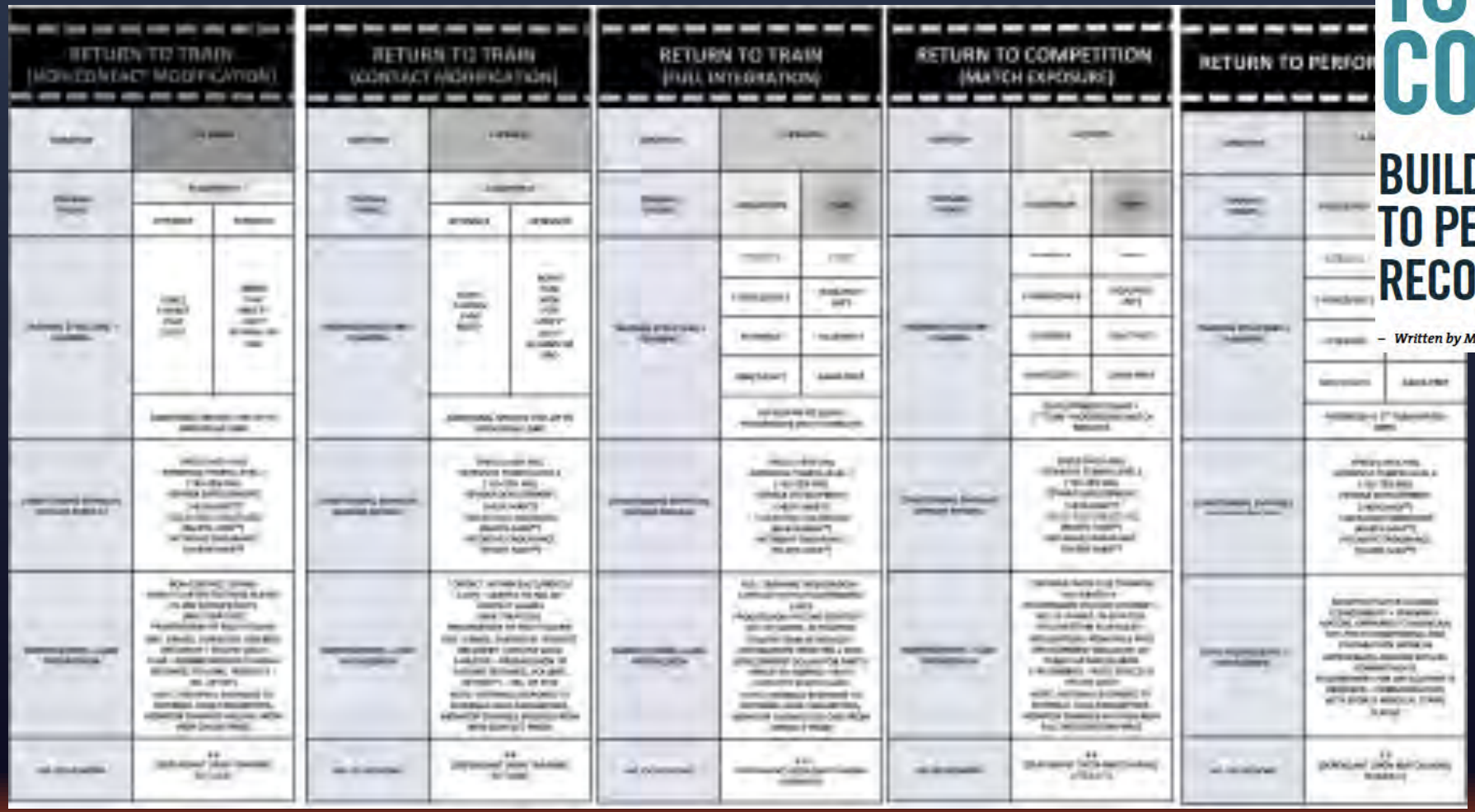


FIGURE 16. Zigzag drill. Sprint into a diagonal cut at 45° around each cone, with or without dribbling a basketball.

Bizzini et al 2012, Kokmeyer et al 2012, Waters et al 2012

ASPETAR – Taberner et al



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FROM CONTROL TO CHAOS TO COMPETITION

BUILDING A PATHWAY FOR RETURN TO PERFORMANCE FOLLOWING ACL RECONSTRUCTION

– *Written by Matt Taberner, Tom Allen, and Emma Constantine, UK and Daniel D Cohen, Colombia*

RTS Components

** Pre-entry Components >> Basic Measurements (continue to monitor)

1) Thigh Strength/Force Development
2) Neuromuscular Control
3) Hop Testing
4) Lower Extremity Functional Testing (LEFT)
5) Sport Specific
6) **Patient Reported Outcomes/Kinesiophobia/Confidence**

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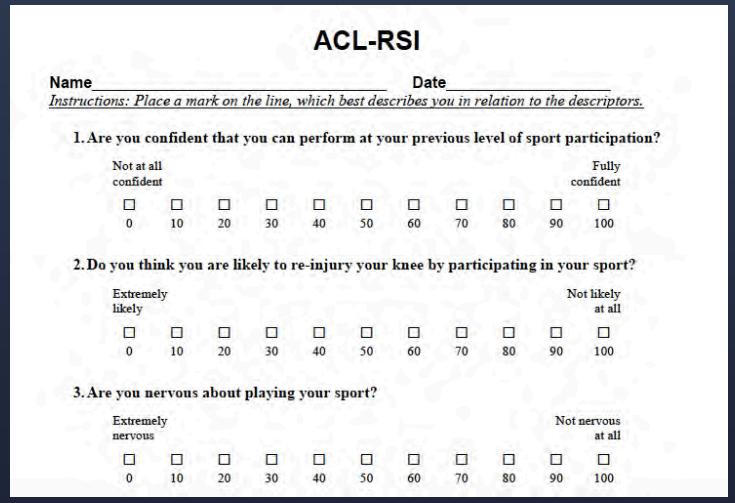
Subjective Outcome Measures

Knee Function:
IKDC, KOS, Cincinnati

Kinesiophobia:
TSK-11 – early ***(Paterno 2018)***
>17 = 4x decreased function
>19 = 13x more likely 2nd injury

Sport Confidence:
ACL-RSI – mid to later phase
(62/75 – full, 60 – short) 42 no RTP



ACL-RSI

Name_____ Date_____

Instructions: Place a mark on the line, which best describes you in relation to the descriptors.

1. Are you confident that you can perform at your previous level of sport participation?

Not at all confident — Fully confident

☐ 0 ☐ 10 ☐ 20 ☐ 30 ☐ 40 ☐ 50 ☐ 60 ☐ 70 ☐ 80 ☐ 90 ☐ 100

2. Do you think you are likely to re-injury your knee by participating in your sport?

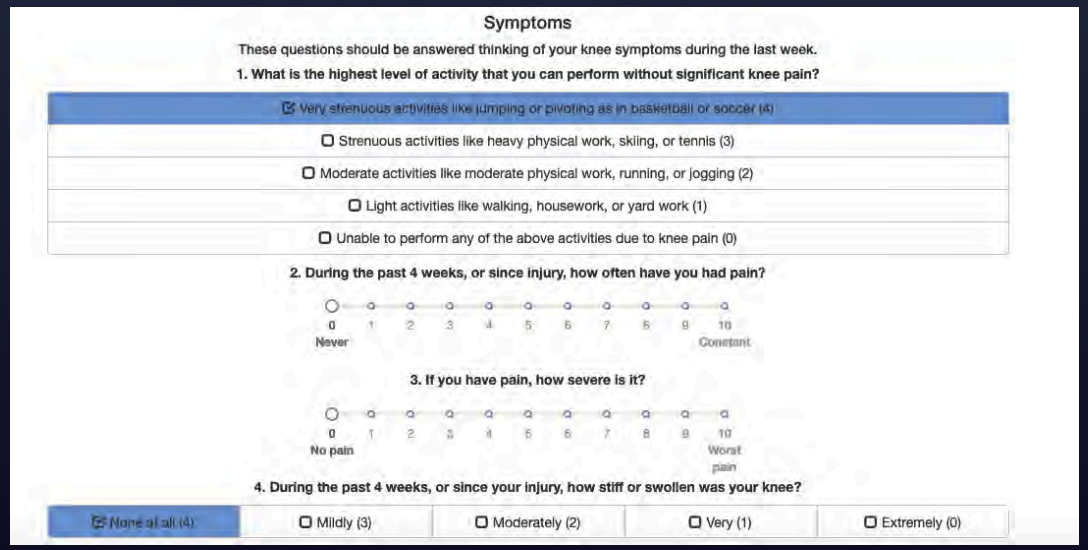
Extremely likely — Not likely at all

☐ 0 ☐ 10 ☐ 20 ☐ 30 ☐ 40 ☐ 50 ☐ 60 ☐ 70 ☐ 80 ☐ 90 ☐ 100

3. Are you nervous about playing your sport?

Extremely nervous — Not nervous at all

☐ 0 ☐ 10 ☐ 20 ☐ 30 ☐ 40 ☐ 50 ☐ 60 ☐ 70 ☐ 80 ☐ 90 ☐ 100



Symptoms

These questions should be answered thinking of your knee symptoms during the last week.

1. What is the highest level of activity that you can perform without significant knee pain?

- ☑ Very strenuous activities like jumping or pivoting as in basketball or soccer (4)
- ☐ Strenuous activities like heavy physical work, skiing, or tennis (3)
- ☐ Moderate activities like moderate physical work, running, or jogging (2)
- ☐ Light activities like walking, housework, or yard work (1)
- ☐ Unable to perform any of the above activities due to knee pain (0)

2. During the past 4 weeks, or since injury, how often have you had pain?

0 1 2 3 4 5 6 7 8 9 10
Never — Constant

3. If you have pain, how severe is it?

0 1 2 3 4 5 6 7 8 9 10
No pain — Worst pain

4. During the past 4 weeks, or since your injury, how stiff or swollen was your knee?

☑ None at all (4) ☐ Mildly (3) ☐ Moderately (2) ☐ Very (1) ☐ Extremely (0)

https://www.orthotoolkit.com/

Meierbachtol JOSPT 2018, Webster OJSM 2018

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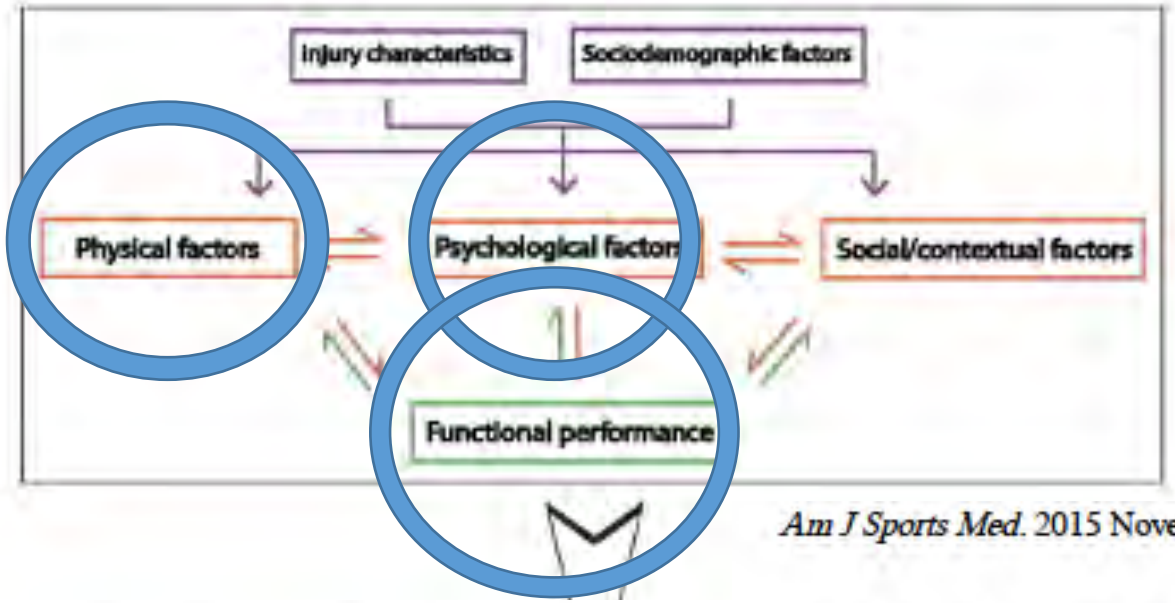
Putting it all together

DON'T FORGET!

Prevention/Risk Reduction Programs

50% to 67% Female noncontact!



Am J Sports Med. 2015 November ; 43(11): 2628–2637. doi:10.1177/0363546515602009.

A Training Program Neuromuscular and Female High School

Frank R. Noyes, Sue D. Barber-Westin,

Cincinnati Sportsmedicine Research and Education Fou

Anterior cru
female athle

Holly J. Silvers MPT, E

Efficacy of the FIFA 11+ Injury Prevention Program in the Collegiate Male Soccer Player

Holly Silvers-Granelli, MPT[*,†,‡,§], Bert Mandelbaum, MD[†,§], Ola Adeniji, MS[†], Stephanie Insler, BA[†], Mario Bizzini, PT, PhD[‖], Ryan Pohlig, PhD[¶], Astrid Junge, PhD[‖], Lynn Snyder-Mackler, PT, ATC, ScD[‡,#], and Jiri Dvorak, MD[‖]

Current Sports Medicine Reports 4, 341–343(2005) | Cite this article

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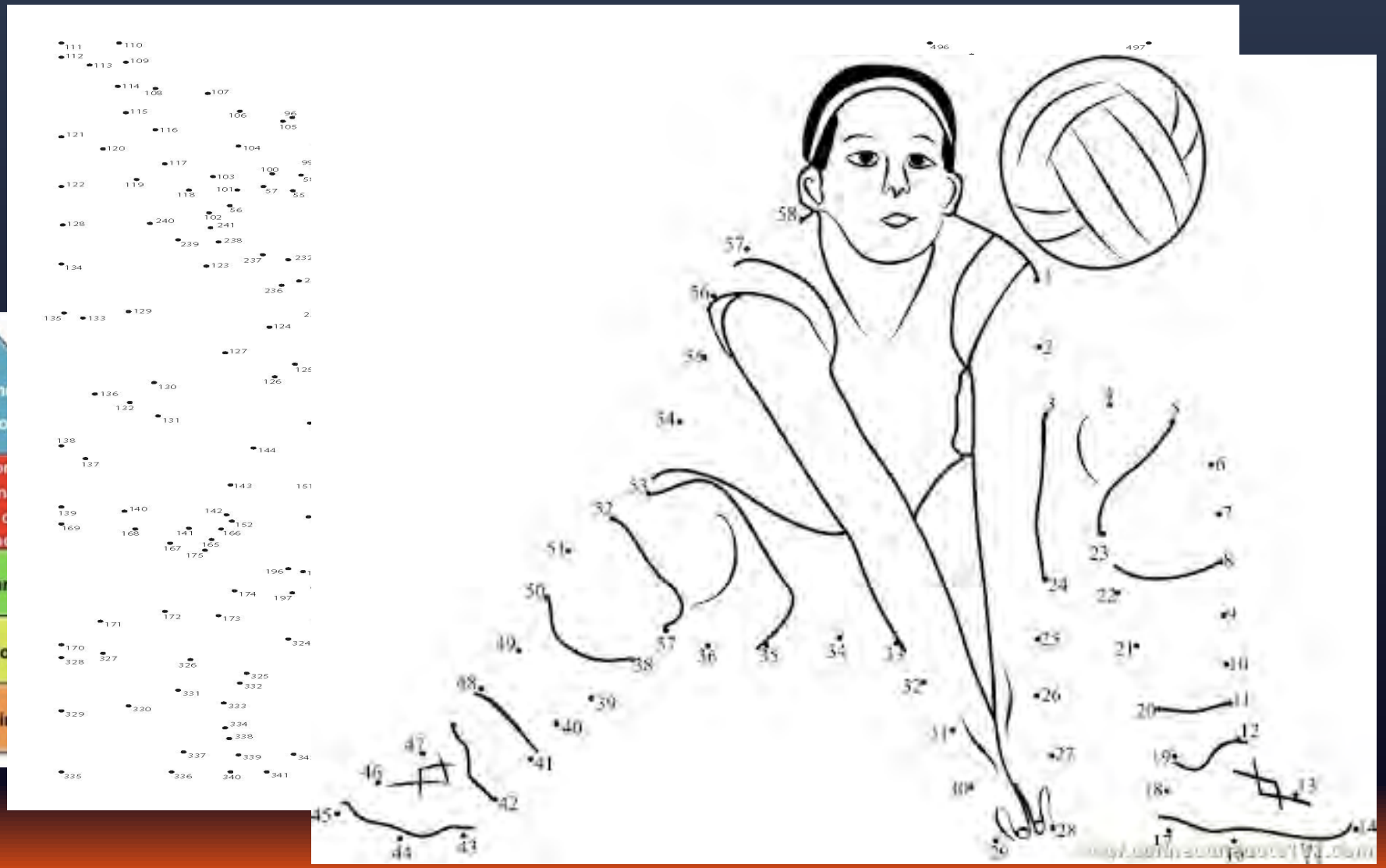
Connect the Dots



Buckthorpe and Roi 2018

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Clinical Pearl: Quad Deficit

WHY SO BAD ---- For SOOOOO Long?

Aversion to Knee Extension Loading!

Who's Afraid of the Big Bad Wolf? Open-Chain Exercises After Anterior Cruciate Ligament Reconstruction

AUTHORS

Brian Noehren, PT, PhD, FACSM[1], Lynn Snyder-Mackler, PT, ATC, ScD, SCS, FAPTA

Henning et al 1985 = increase shear OKC

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Escamilla et al 2012

If you can Walk…

You can do Knee Extensions!!!

Make sure to grade according to Ability starting with SLR + STIM!

TABLE 3 PEAK ANTERIOR SHEAR FORCE (ACL LOADING) AND CORRESPONDING KNEE ANGLE FOR NON–WEIGHT-BEARING AND WEIGHT-BEARING EXERCISES

Non-Weight-Bearing Exercises			
Author	**Exercise**	**Anterior Shear Force (N)**	**Knee Flexion Angle (°)**
Wilk and Andrews[6]	Dynamic seated knee extension (0°-90° of knee flexion) using 12 repetitions of maximum resistance*	248	14

Weight-Bearing Exercises			
Author	**Exercise**	**Anterior Shear Force (N)**	**Knee Flexion Angle (°)**
Wilk et al[6]	Barbell squat (0°-90° of knee flexion) using 12 repetitions of maximum resistance*	0	
	Leg press (0°-90° of knee flexion) using 12 repetitions of maximum resistance*	0	
Nagura et al[10]	Full squat (0°-140° of knee flexion) using no external resistance	66	10.9
			40.9
	Level-ground walking	355	16.8
			50.8
Pflum et al[14]	Double-foot drop landing	220	33 to 48

Abbreviation: ACL, anterior cruciate ligament.
**Heaviest resistance possible that allowed the performance of 12 consecutive repetitions with proper form and technique.*

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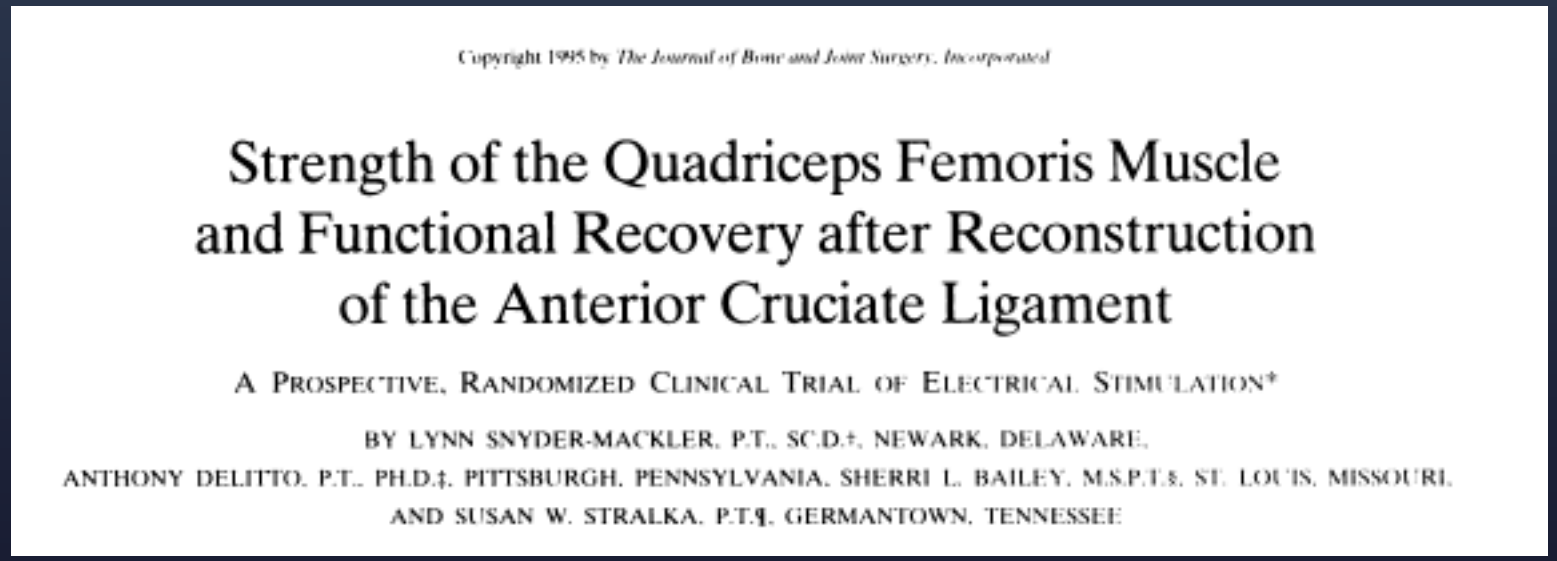
Quad Deficiency and NMES

- Use High Level Stim
- Knee Ext machine



Strength of the Quadriceps Femoris Muscle and Functional Recovery after Reconstruction of the Anterior Cruciate Ligament

A Prospective, Randomized Clinical Trial of Electrical Stimulation*

BY LYNN SNYDER-MACKLER, P.T., SC.D.†, NEWARK, DELAWARE, ANTHONY DELITTO, P.T., PH.D.‡, PITTSBURGH, PENNSYLVANIA, SHERRI L. BAILEY, M.S.P.T.§, ST. LOUIS, MISSOURI, AND SUSAN W. STRALKA, P.T.¶, GERMANTOWN, TENNESSEE

**If you are worried can lock for isometric @ 60 deg to start (Optimal Quadriceps L-T curve)

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New Trends around ACL and ACLR

Single-leg vertical jump test as a functional test after anterior cruciate ligament reconstruction☆

Dhong Won Lee [a], Sang Jin Yang [b], Seung Ik Cho [b], Jung Ho Lee [a], Jin Goo Kim [a,*]

[a] Department of Orthopaedic Surgery, KonKuk University Medical Center, Seoul, South Korea
[b] Sports Medical Center, KonKuk University Medical Center, Seoul, South Korea

Development of a test battery to enhance safe return to sports after anterior cruciate ligament reconstruction

Alli Gokeler[1] · Wouter Welling[1,2] · Stefano Zaffagnini[3] · Romain Seil[4] · Darin Padua[5]

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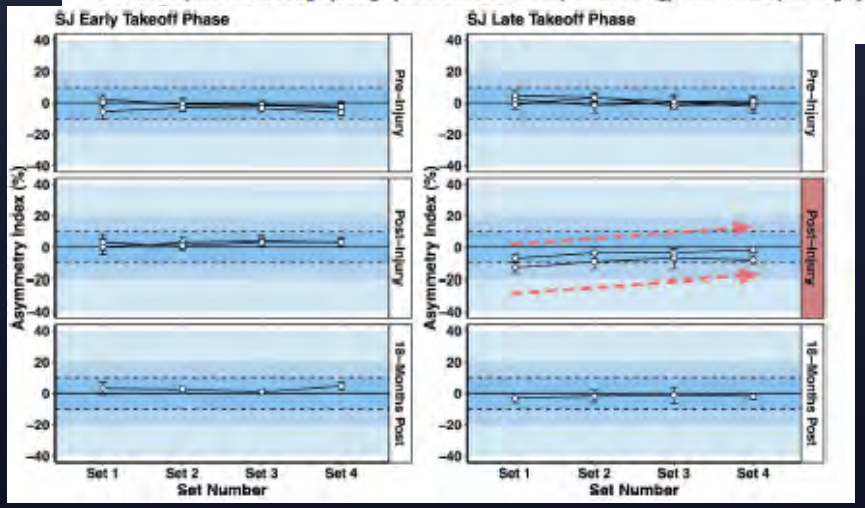
New Trends Cont'd

Monitoring the Return to Sport Transition After ACL Injury: An Alpine Ski Racing Case Study

Matthew J. Jordan[1,2], Nathaniel Morris[1,2], Mike Lane[1], Jeremiah Barnert[1], Katie MacGregor[1], Mark Heard[3], Sarah Robinson[1] and Walter Herzog[2]*

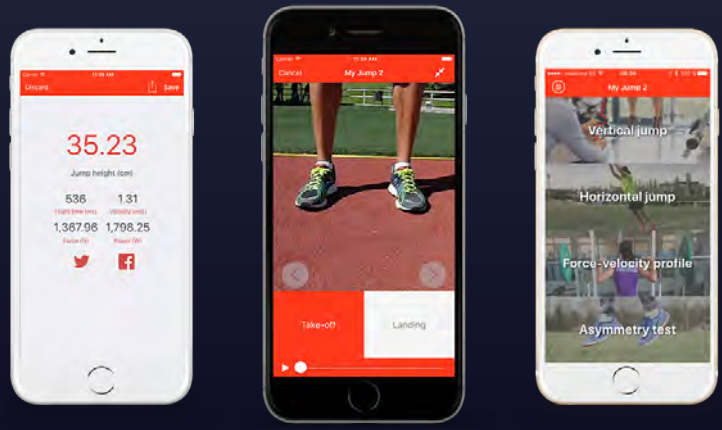
[1] Canadian Sport Institute Calgary, Calgary, AB, Canada, [2] Faculty of Kinesiology, The University of Calgary, Calgary, AB,



Return to sports after ACL reconstruction: a new functional test protocol

Gian Nicola Bisciotti[1]

Introduction



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My Jump2: SL Vertical Hop






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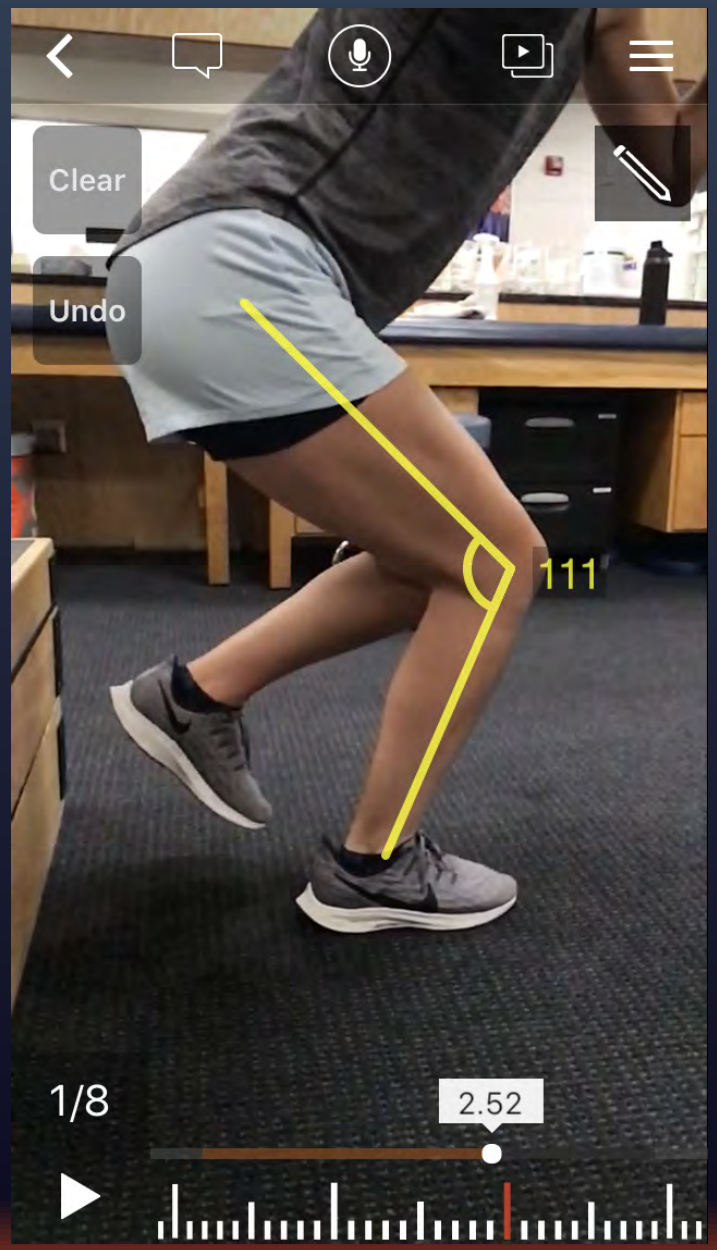

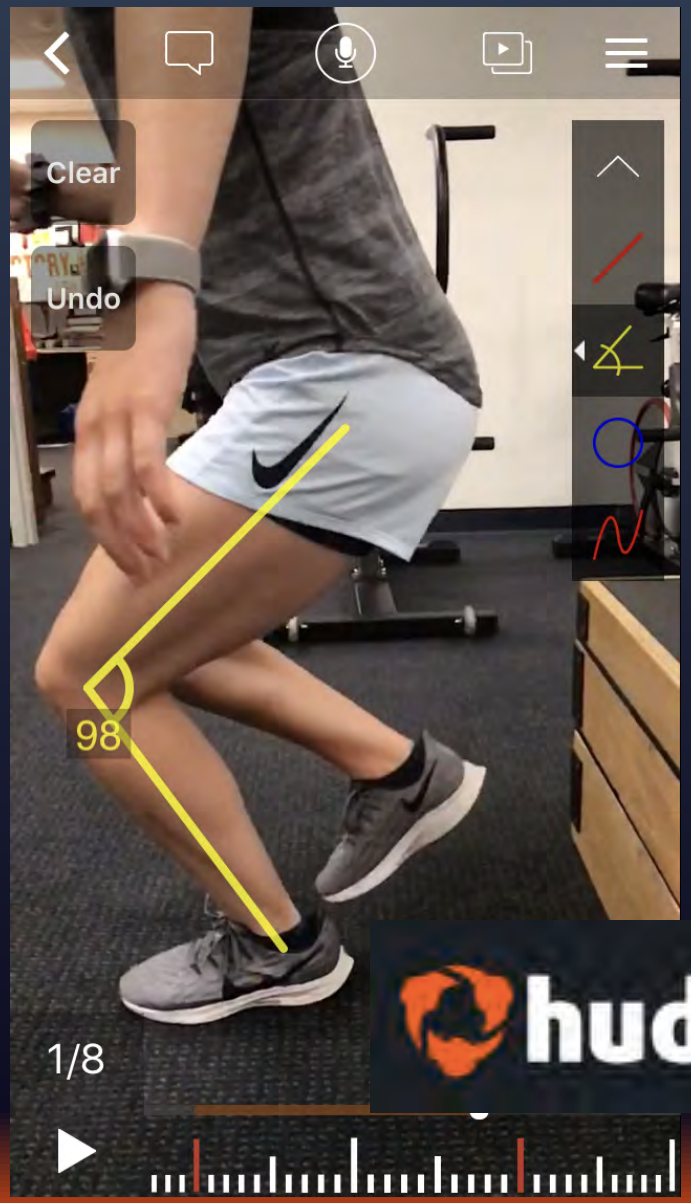

hudltechnique

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http://news.meyerpt.com/physical-therapists/viperform-knee-module/
https://twitter.com/IMeasureU/status/1029192918634909697/photo/1

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UE RTS Testing

Total Arc Motion (TAM)

Byram et al – 66% ER/IR ratio
HHD testing

Subjective – DASH, FAST
KJOC

> J Strength Cond Res. 2012 Nov;26(11):3043-8. doi: 10.1519/JSC.0b013e3182472fdb.

Upper Quarter Y Balance Test: Reliability and Performance Comparison Between Genders in Active Adults

Paul P Gorman [1], Robert J Butler, Phillip J Plisky, Kyle B Kiesel

IJSPT

ORIGINAL RESEARCH

EXPLORATION OF THE Y-BALANCE TEST FOR ASSESSMENT OF UPPER QUARTER CLOSED KINETIC CHAIN PERFORMANCE

Richard B. Westrick, PT, DPT, DSc, OCS, SCS[1]

Closed Kinetic Chain Upper Extremity Stability test (CKCUES test): a reliability study in persons with and without shoulder impingement syndrome

Helga Tatiana Tucci, Jaqueline Martins, Guilherme de Carvalho Sposito, Paula Maria Ferreira Camarini & Anamaria Siriani de Oliveira

BMC Mus

One-arm Hop Test: Reliability and Effects of Arm Dominance

Susan A Falsone [1], Michael T Gross, Kevin M Guskiewicz, Robert A Schneider

Affiliations + expand

PMID: 12168743 DOI: 10.2519/jospt.2002.32.3.98

https://johnsnyderdpt.com/for-clinicians/functional-testing/

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Take Home Message

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1) Respect Biology

>9 Mo over 18

>12 Mo under 18

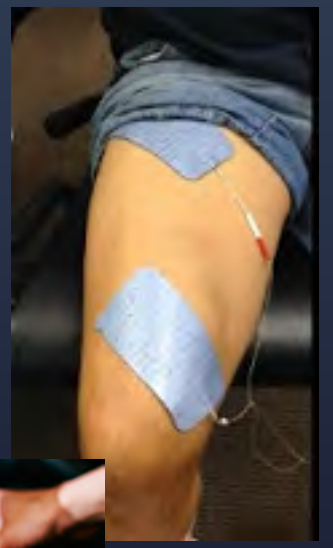
Should return to sport be delayed until two years after anterior cruciate ligament reconstruction? Biological and functional considerations

Christopher V. Nagelli[1,2,4,5] and Timothy E. Hewett[1,2,3,4,5]

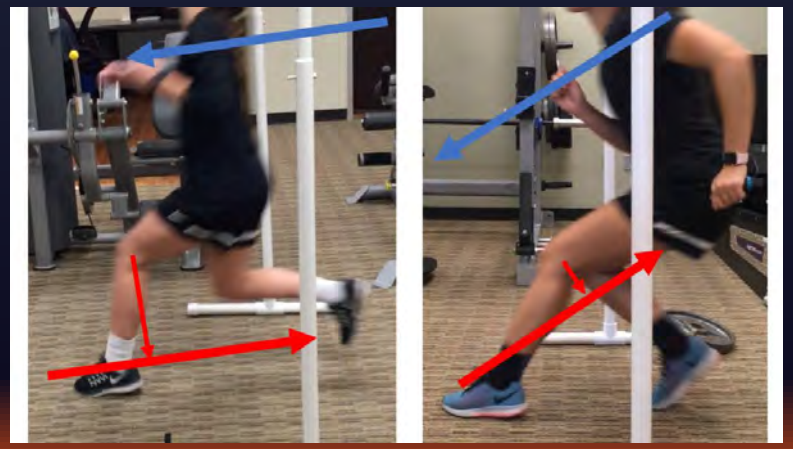
**Strength, NM, Sensory and Mechanoreceptor adaptation

2) Quad strength, Quad Strength, QUAD STRENGTH!

>>> If you didn't hear me in the back: QUADS!



Don't neglect contralateral and balance with hamstring work



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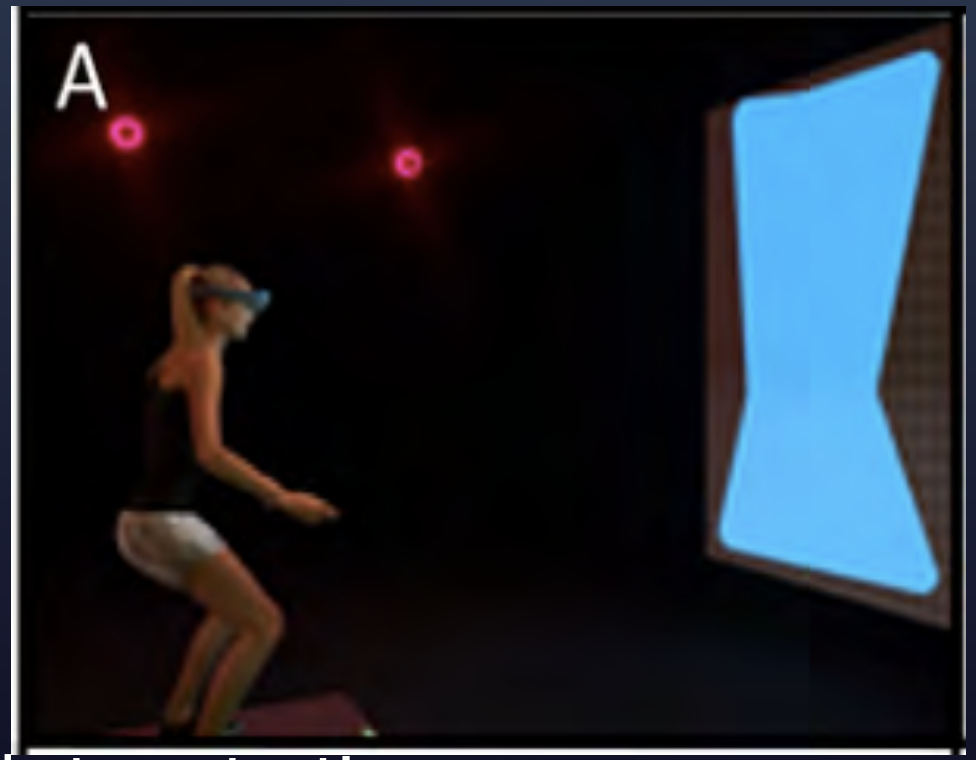
3) Incorporate serial monitoring

Quad and Hamstring
→ Strength, RFD, Torque @ ranges
Neuromuscular control
Hop Testing
Functional/Sport Specific
Outcome Measures



**These allow you to track progress vs end stage testing

Diekfuss JA, Grooms DR, Foss KB, et al. 2019

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4) Use Functional Testing

Continue monitoring previous criteria

LEFT

But also…

- Pro Agility (5-10-5)
- T test
- 3 cone drill

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5) Incorporate Sport Specific drills/prep/test

- Collaborate with sport coaches
- Think about force vectors/planes mvmt
- Utilize publications (JOSPT)
- Be Creative!

CONTINUE WITH RISK REDUCTION PROGRAMS!

6) Subjective Outcome Measures

Don’t FORGET!

- IKDC, KOS, Cincinnati Knee Score (Use 1)
- TSK-11
- ACL-RSI

** Important to incorporate with Objective Measures!

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Wrap Up and Take Home

1) Respect Biology (at least >9 mo over 18, >12 if under)
2) Quad strength, Quad Strength, QUAD STRENGTH!
3) Incorporate serial monitoring of
   - Quad Strength, Neuromuscular control, Hop Testing
4) Use functional tests WITH monitoring of previous testing
5) Incorporation of Sport specific drills/prep/test
6) Adjunct objective testing with Subjective Outcome Measures!

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OBJECTIVES

1) Appraise current literature regarding varying degrees of return to sport (RTS) criteria and testing procedures.
2) Identify inconsistencies in clinical practice patterns of RTS testing compared to current evidence.
3) Describe various methods of quadriceps testing and its importance to recovery post ACLR.
4) Identify limitations of hop testing and LSI calculation for RTS testing.
5) Describe how psychological testing (ACL-RSI, TSK-11) can adjunct rehab progression and RTS decision making.
6) Briefly describe use of UE RTS testing methods and directions for improvement.

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THANK YOU!

QUESTIONS?

Email: wsanks@gmail.com

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