

# Knienetwerk Noord-Limburg

Vakinhoudelijke bijeenkomst Vie Curie

Igor Tak PhD, MScPT, MPTS



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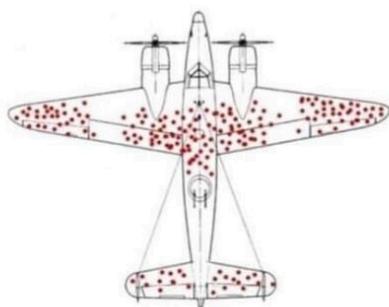


(1) Blood flow restriction training –  
what how and why?

(2) Return to sport decision making –  
time for a big hop forward

## Survivorship bias

This is a picture tracking bullet holes on Allied planes that encountered Nazi anti-aircraft fire in WW2.



At first, the military wanted to reinforce those areas, because obviously that's where the ground crews observed the most damage on returning planes. Until Hungarian-born Jewish mathematician Abraham Wald pointed out that this was the damage on the planes that *made it home*, and the Allies should armor the areas where there are no dots at all, because those are the places where the planes won't survive when hit. This phenomenon is called survivorship bias, a logic error where you focus on things that survived when you should really be looking at things that didn't.

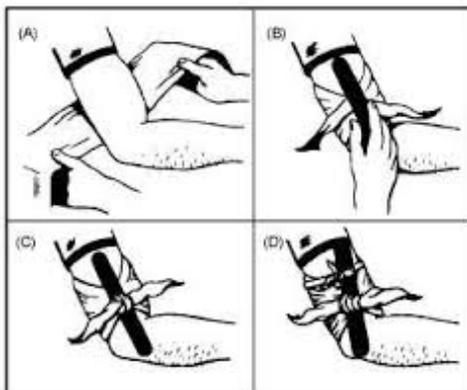
# Blood flow restriction training after ACL reconstruction – What how and why ?

Knienetwerk - Vie Curie

Igor Tak PhD, MScPT, MPTS



## Blood flow restriction training (history)



### REVIEW ARTICLE

#### The history and future of KAATSU Training

Y. Sato

*Int. J. Kaatsu Training Res.* 2005; 1: 1-5

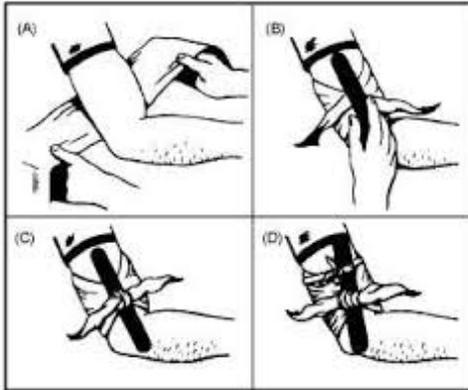
Yoshiaki Sato (1966)

Numbness and swelling after sustained sitting in a knee bended position on a Buddhist festival. Feelings pretty similar to those after heavy weight training.

He developed KAATSU (reduced blood flow) training.



## Blood flow restriction training (BFR)



Review

### Blood flow restricted exercise for athletes: A review of available evidence

Brendan R. Scott<sup>a,\*</sup>, Jeremy P. Loenneke<sup>b</sup>, Katie M. Slattery<sup>a,c</sup>, Ben J. Dascombe<sup>a</sup>

**Results:** Twelve papers were identified from 11 separate investigations that had assessed acute and adaptive responses to BFR in athletic cohorts. Of these, 7 papers observed enhanced hypertrophic and/or strength responses and 2 reported alterations in the acute responses to low-load resistance exercise when combined with BFR. One paper had examined the adaptive responses to moderate-load resistance training with BFR, 1 noted improved training responses to low-work rate BFR cardiovascular exercise, and 1 reported on a case of injury following BFR exercise in an athlete.

**Conclusions:** Current evidence suggests that low-load resistance training with BFR can enhance muscle hypertrophy and strength in well-trained athletes, who would not normally benefit from using light loads. For healthy athletes, low-load BFR resistance training performed in conjunction with normal high-load training may provide an additional stimulus for muscular development. As low-load BFR resistance exercise does not appear to cause measureable muscle damage, supplementing normal high-load training using this novel strategy may elicit beneficial muscular responses in healthy athletes.

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## Is BFR effective ?

J Appl Physiol  
88: 2097-2106, 2000

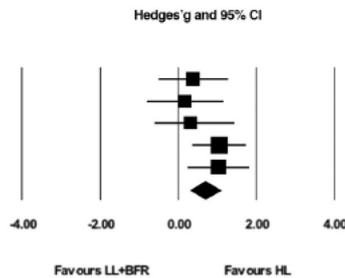
### Effects of resistance exercise combined with moderate vascular occlusion on muscular function in humans

YUDAI TAKARADA,<sup>1</sup> HARUO TAKAZAWA,<sup>1</sup> YOSHIKI SATO,<sup>2</sup> SHIGEO TAKEBAYASHI,<sup>2</sup> YASUHIRO TANAKA,<sup>4</sup> AND NAOKATA ISHII<sup>1</sup>

### Blood flow restriction training in clinical musculoskeletal rehabilitation: a systematic review and meta-analysis

Luke Hughes,<sup>1</sup> Bruce Paton,<sup>2</sup> Ben Rosenblatt,<sup>3</sup> Conor Gissane,<sup>1</sup> Stephen David Patterson<sup>1</sup>

**Results** Twenty studies were eligible, including ACL reconstruction (n=3), knee osteoarthritis (n=3), older adults at risk of sarcopenia (n=13) and patients with sporadic inclusion body myositis (n=1). Analysis of pooled data indicated low-load BFR training had a moderate effect on increasing strength (Hedges'  $g=0.523$ , 95% CI 0.263 to 0.784,  $p<0.001$ ), but was less effective than heavy-load training (Hedges'  $g=0.674$ , 95% CI 0.296 to 1.052,  $p<0.001$ ).



## Why BFR after ACL-R?

Low loads applied allow for desired training effects while not being able to fulfill 1RM prerequisites for adequate training responses.

Period between 2 wks and 15 wks.

62 Acta Orthop Scand 2003; 74 (1): 62-68

Low-load resistance muscular training with moderate restriction of blood flow after anterior cruciate ligament reconstruction

Haruyasu Ohta<sup>1</sup>, Hisashi Kurosawa<sup>1</sup>, Hiroshi Ikeda<sup>1</sup>, Yoshiyuki Iwase<sup>1</sup>, Naohiro Satou<sup>1</sup> and Shinji Nakamura<sup>2</sup>

Review > J Sport Rehabil. 2019 Nov 1;28(8):897-901. doi: 10.1123/jsr.2018-0062.

Blood Flow Restriction Therapy Versus Standard Care for Reducing Quadriceps Atrophy After Anterior Cruciate Ligament Reconstruction

Lauren Anne Lipker, Caitlyn Rae Persinger, Bradley Steven Michalko, Christopher J Durall



## BFR training is simple



BFR just do it?



SUGGESTED CLINICAL REASONING FOR THE APPLICATION OF LOW-LOAD BLOOD FLOW RESTRICTION TRAINING*	
Parameters	Description
Indications	• Hypertrophy required and heavy resistance training not clinically indicated
Contraindications	• Vascular compromise, clotting disorders or other elevated risk of embolism, renal compromise, hypertension (systolic blood pressure of 140 mmHg or greater)
Warnings	• Bruising is relatively common (in the upper limb especially). The exercise is very uncomfortable
Applications	<ul style="list-style-type: none"> <li>• Measure limb occlusion pressure in the body position in which the exercise will be undertaken</li> <li>• Set training pressure (40% to 80% of limb occlusion pressure for leg, 30% to 60% for upper limb). Note that higher pressures are associated with more discomfort but likely superior clinical outcomes</li> <li>• First set: aim for voluntary failure at 30 repetitions at a rate of approximately 1 repetition every 2 to 4 seconds</li> <li>• Second to fourth sets: same weight as first set, 15 repetitions, 30 seconds of recovery between sets. Adjust weight up or down depending on performance in first set: harder if failure wasn't achieved, easier if patient could not reach 30 repetitions</li> <li>• Initially, alternate days; training can ultimately be performed twice daily</li> <li>• Expect to see meaningful results after at least 4 weeks of training</li> <li>• When clinically appropriate, shift to regular resistance training</li> </ul>

\*The contraindications and warnings are those peculiar to blood flow restriction training, and are in addition to usual care and precautions taken when prescribing resistance training. The exercise parameters suggested are based on the most frequently reported regimens.<sup>12</sup>

## Blood Flow Restriction Training in Rehabilitation: A Useful Adjunct or Lucy's Latest Trick?

ROD WHITELEY, PT, PhD

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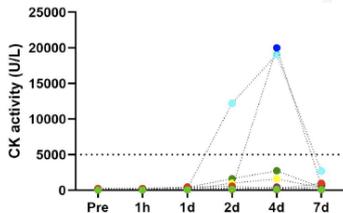
BFR how we do it

# BLOODFLOW RESTRICTION TRAINING

Spiermassatraining in de vroege fase na een knieoperatie.



# BFR SAE?



**FIGURE 1** | Responses in creatine kinase (CK) activity levels in serum before and 1 hour (1h), 1 day (1d), 2 days (2d), 4 days (4d), and 7 days (7d) after a damaging bout of low-load BFR-RE. Figure based on data from individuals in the study of Sijacki et al. (2016). Note the differences between individuals, and also in the time-course of the responses in the two participants who were "high-responders" (CK > 15,000 U/L). The upper detection limit for the CK assay in this study was 20,000 U/L, and one of these two individuals may have exceeded this limit. Serum myoglobin showed similarly high increases (data not shown).

## Commentary: Can Blood Flow Restricted Exercise Cause Muscle Damage? Commentary on Blood Flow Restriction Exercise: Considerations of Methodology, Application, and Safety

Mathias Wernbom<sup>1,2\*</sup>, Brad J. Schoenfeld<sup>1</sup>, Garon Paulsen<sup>1</sup>, Thomas Sjorssen<sup>1</sup>, Kristoffer T. Cumming<sup>1</sup>, Per Asgaard<sup>1</sup>, Brian C. Clark<sup>1,3</sup> and Truls Raastad<sup>1</sup>

It is not: the more the better!  
 Allow time to adapt to rep bout effect  
 Monitor especially 1st week after training  
 Not max occlusion needed



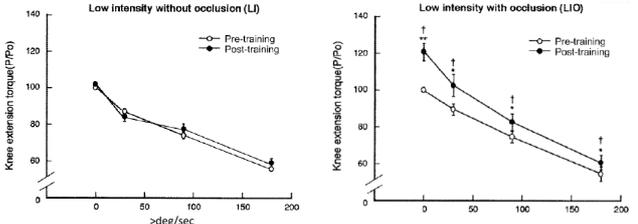
# BFR is is not all !

- Adjunct to rehab! Why?
- Period between 2 wks and 15 wks hypertrophy
- Recipe
- Use predefined sets and reps
- Keep BFR during exercise and rest
- Remove cuff immediately after the exercise

Eur J Appl Physiol (2002) 86: 308–314  
 DOI 10.1007/s00421-001-0561-5

### ORIGINAL ARTICLE

Yudai Takarada · Yoshiaki Sato · Naokata Ishii  
 Effects of resistance exercise combined with vascular occlusion on muscle function in athletes



Courtesy: S Patterson



# Return to sports decision making

## –

# It is time for a big hop forward

Knienetwerk - Vie Curie

Igor Tak PhD, MScPT, MPTS



## Rehabilitation progression decisions

RETURN TO  
PARTICIPATION

RETURN TO  
SPORT

RETURN TO  
PERFORMANCE

- Based on clinical features

- Symptoms (pain during/after, stiffness, fear, etc)
- Range of motion (how flexible? In **degrees**)
- Strength (how strong? In **N** or **Nm**)
- Coordination (how does it look qualitatively? In ..... ?)

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

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



## Rehabilitation ingredients

- Clinical practice guidelines
  - Immediate mobilization
  - Neuromuscular training
  - Only 1 CPG criteria-based vs time based

Review

How should clinicians rehabilitate patients after ACL reconstruction? A systematic review of clinical practice guidelines (CPGs) with a focus on quality appraisal (AGREE II)

Renato Andrade <sup>1,2,3</sup>, Rogério Pereira, <sup>1,2,3,4</sup> Robert van Cingel, <sup>5,6</sup> J Bart Staal, <sup>5,7</sup> João Espregueira-Mendes <sup>1,2,8,9</sup>

Around 80% of ACL-reconstructed patients return to some kind of sporting activities, but only 65% return to their preinjury level and 55% to competitive level sports.<sup>4</sup> There are data that inadequate rehabilitation combined with an unprepared return to sports<sup>7-9</sup> may limit subsequent sporting performance and predispose to reinjury (ACL, other knee injuries and perhaps other injuries). Returning

## Return to sports criteria

- Different aspects
  - Chronobiological (gaft, tunnel, etc)
  - Clinical (IKDC, Tegner, ACL-RSI, etc)
  - Functional (strength, hoptests)

Review

How should clinicians rehabilitate patients after ACL reconstruction? A systematic review of clinical practice guidelines (CPGs) with a focus on quality appraisal (AGREE II)

Renato Andrade <sup>1,2,3</sup>, Rogério Pereira, <sup>1,2,3,4</sup> Robert van Cingel, <sup>5,6</sup> J Bart Staal, <sup>5,7</sup> João Espregueira-Mendes <sup>1,2,8,9</sup>

There are no clear criteria for 'highly likely to return to sport successfully' because data are lacking and the ideal study design (RCT that randomises patients to one set of criteria vs another) would be unethical.

“Facing uncertainty we need to take wise actions”

- William Osler (1849-1919) -

## RTP is multidimensional

- LSI >90% is highly questionable
- Delay RTS minimum 9 mo post OP



## When Is It Safe to Return to Sport After ACL Reconstruction? Reviewing the Criteria

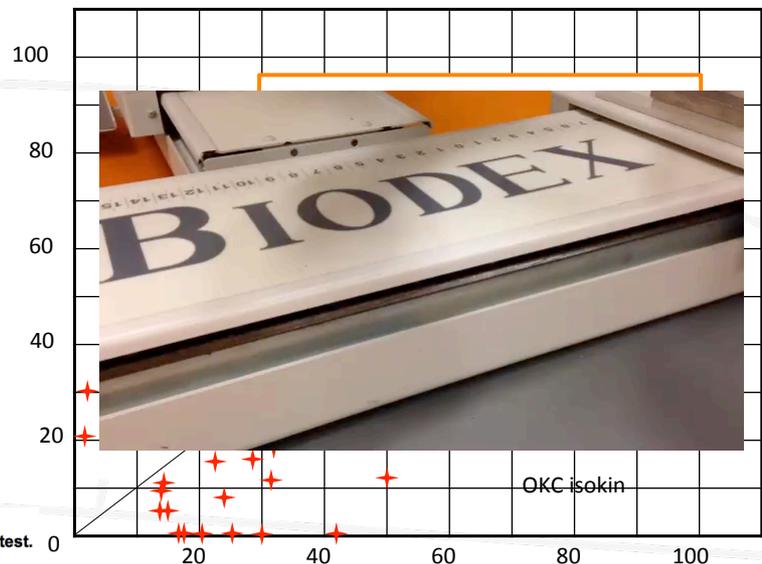
Yonatan Kaplan, PT, PhD,<sup>1\*</sup> and Erik Witvrouw, PT, PhD<sup>2</sup>

**Conclusion:** The psychological readiness of the player is a major factor in successful safe return to sport (SRTS) decision making. Although strength, performance, and functional tests presently form the mainstay of SRTS criteria, there exists very little scientific evidence for their validity. More protection should be provided to athletes with known risk factors. Movement quality is important, if not more important than the quantifiable measures. As a result of the significantly high rerupture rate in young individuals, delayed SRTS should be considered preferably beyond 9 months postsurgery.



## Test battery

- Isokinetics
- HDD
- Kinetic chain machine (leg press)
- Hoptests



*J Orthop Sports Phys Ther*, 2001 Oct;31(10):588-97.

**Hop tests as predictors of dynamic knee stability.**

Fitzgerald GK<sup>1</sup>, Lephart SM, Hwang JH, Wainner RS.

*J Strength Cond Res*, 2011 May;25(5):1470-7. doi: 10.1519/JSC.0b013e3181d83335.

**Between-session reliability of four hop tests and the agility T-test.**

Munro AG<sup>1</sup>, Herrington LC.



## Hop tests

- SLHop, SLTHop, VJump, DrJump, CrHop, SHop



## We know quite a lot

- Lowering the bar (threshold) of LSI results in increased numbers passing the criteria (like everywhere in life)
- Better hop test performance > better outcomes
- Caveat fatigue

Knee Surg Sports Traumatol Arthrosc. 2012 Jun;20(6):1143-51. doi: 10.1007/s00167-012-1912-y. Epub 2012 Feb 8.

**Variability in leg muscle power and hop performance after anterior cruciate ligament reconstruction.**

Thomé R<sup>1</sup>, Neeter C, Gustavsson A, Thomé P, Augustsson J, Eriksson B, Karlsson J.

Am J Sports Med. 2015 Jan 12. pii: 0363546514563282. [Epub ahead of print]

**Sports Participation 2 Years After Anterior Cruciate Ligament Reconstruction in Athletes Who Had Not Returned to Sport at 1 Year: A Prospective Follow-up of Physical Function and Psychological Factors in 122 Athletes.**

Ardem CL<sup>1</sup>, Taylor NF<sup>2</sup>, Feller JA<sup>3</sup>, Whitehead TS<sup>4</sup>, Webster KE<sup>2</sup>.

Knee Surg Sports Traumatol Arthrosc. 2019 Feb;27(2):549-555. doi: 10.1007/s00167-018-5149-2. Epub 2018 Sep 27.

**Fatigue affects quality of movement more in ACL-reconstructed soccer players than in healthy soccer players.**

van Melick N<sup>1,2</sup>, van Rijn L<sup>3</sup>, Nijhuis-van der Sanden MWG<sup>4</sup>, Hoogboom TJ<sup>4</sup>, van Cingel REH<sup>4,5</sup>.

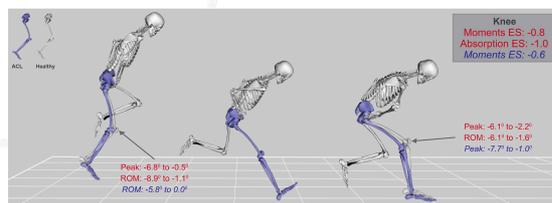
## Can we “see” movement quality?

- When hugely impaired: maybe yes/no
- When slightly different: likely not
- Even if so: what to assess ?
  - Angles
  - Angular velocity
  - Angular acceleration
  - Single joint or multi joint



## Enough is enough

- Then a 100% SLI is enough ?
- Likely not
  - Despite adequate single hop performance, even w/ healthy leg as reference, kinematic and kinetic differences exist



ELIZABETH WELLSANDT, DPT, PhD<sup>1</sup> • MATTHEW J. FALLA, PE, PhD<sup>1</sup> • LYNN SINDOER-MACKLER, PE, ScD<sup>1</sup>

### Limb Symmetry Indexes Can Overestimate Knee Function After Anterior Cruciate Ligament Injury

**Review**  
Measuring only hop distance during single leg hop testing is insufficient to detect deficits in knee function after ACL reconstruction: a systematic review and meta-analysis

Argyro Kotsifaki,<sup>1,2</sup> Vasileios Korakakis,<sup>1</sup> Rod Whiteley,<sup>1</sup> Sam Van Rossum,<sup>2</sup> Ilse Jonkers<sup>2</sup>

#### What is already known?

- ▶ The rate of reinjury after ACL reconstructed (ACLR) is high.
- ▶ Failure to achieve some simple functional tests are associated with elevated risk of reinjury.

#### What are the new findings?

- ▶ A symmetrical SLHD test does not indicate restoration of normal lower-limb kinematics or kinetics.
- ▶ ACLR patients tend to offload their reconstructed knee, landing with less knee flexion, less knee flexion moments and less knee energy absorption ('stiff landing' strategy).
- ▶ Achieving >90% hop distance for the ACLR leg compared with the uninjured leg is usually associated with compensatory movements at the hip, ankle and/or knee joints.





## Data capturing but processing remains quite a thing

- Processing automation AI algorithms
- Reporting for stakeholders (PT, Sportsmed Ph, Orth AND Athlete)

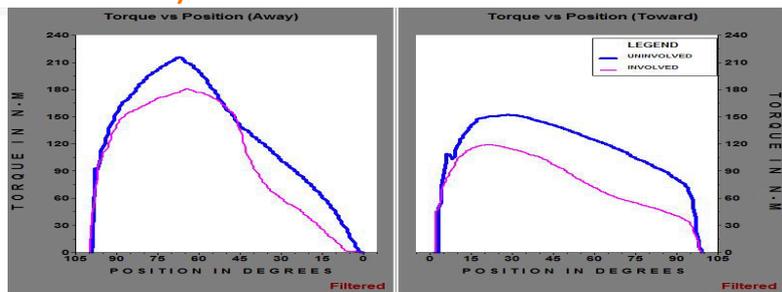


## Meet Adil Nabi (w/ permission)

Former Premiership now in Greece  
 Revision ACL surgery 8 ½ mo ago  
 Bone bruise delayed rehab b/o pain  
 "Feels good", "no fear" = subj ready

KT1000 ligament laxity  
 Right  
 Posterior 1 mm  
 Anterior 4.5 mm  
 IKDC grade A (likely post-ACL revision surgery).

Isokinetic test (30 deg/sec):  
 Peak torque: Extension deficit 21% Flexion deficit 21%  
 Total work: Extension deficit 21% Flexion deficit 26%  
 90 deg/sec:  
 Peak torque: Extension deficit 16% Flexion deficit 13%  
 Total work: Extension deficit 22% Flexion deficit 20%  
 180 deg/sec:  
 Peak torque: Extension deficit 15% Flexion deficit 21%  
 Total work: Extension deficit 6% Flexion deficit 14%



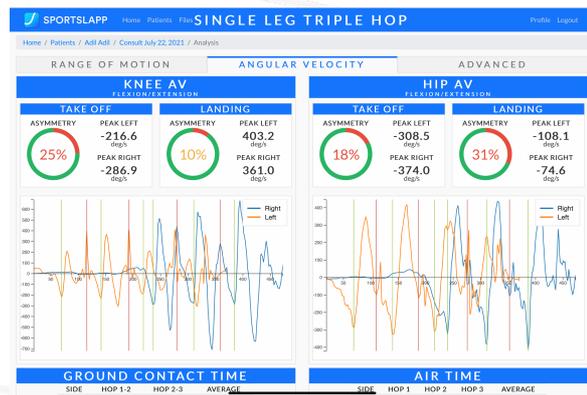
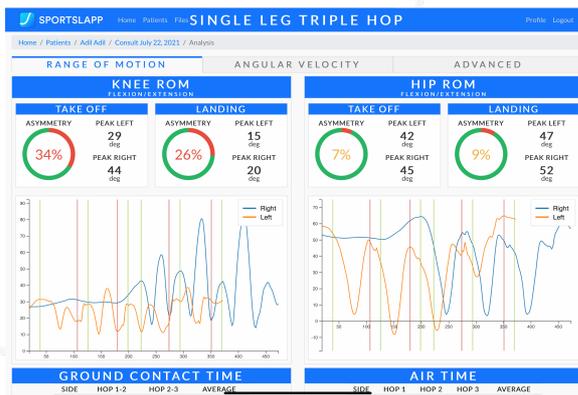
Hop testing:  
 Distance triple hop: Right 5.95 m Left 5.60 m. LSI 94%  
 Caveat: No pre-operative hopping performance available. Right leg score probably is underestimate of healthy situation so the LSI is likely an overestimate of healthy knee function.



# Hop test

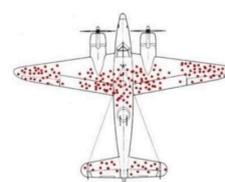


# Hop testing report – beyond the LSI for distance



## Data capturing but processing remains quite a thing

- Look at the right parameters (not just distance LSI)
- Get a better view on vital areas (function)
- New technology in clinic and pitch is required
- Let's master and develop ICT solutions
- Clinicians' input is imperative



## Take to work message

Let's face it, **we can and should** do better  
Open up to **learn from our failures**  
Put **all knowledge** in there is  
Talk to the IT boys & girls, **together we can make it happen**



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SAFETY IN  
SPORTS

 ACES | ACADEMIC CENTER  
FOR EVIDENCE-BASED  
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