Additional perspectives on 'ACL rupture is a single leg injury but a double leg problem…'

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Additional perspectives on Commentary bjsports-2017-098502: 'ACL rupture is a single leg injury but a double leg problem: too much focus on "symmetry" alone and that's not enough!'[1]

In the Commentary 'ACL rupture is a single leg injury but a double leg problem…', the authors argue that measurements of limb symmetry underestimate deficits. I mainly agree with the authors, but reason for *when and how symmetry measurements* should be used and also for the use of *versatile test batteries*. To choose adequate functional tests in the clinic and to design new test-batteries and rehabilitation programmes for individuals with ACL injury, I propose to look for answers and solutions in the extensive literature on motor control. Therefore, *basics of motor control* are *recapitulated*.

LIMB SYMMETRY INDEX (LSI) IS NOT PERFECT BUT CAN BE RELEVANT: WHEN AND HOW?

No consensus exists on how to decide when to return to sports.[2] Often, strength and hop tests are used, calculating an LSI (the ratio of injured/non-injured sides), and LSI >90% is frequently suggested as a cut-off criteria.[3] However, individuals with ACL reconstruction rarely reach 90% symmetry.[4] Moreover, impaired capacity on both sides after ACL injury is well known, underestimating deficits measured as LSI. Therefore, measurements of preinjury capacity or normative data of non-injured controls have been suggested, since they may be more sensitive in predicting second ACL injuries.[5] Therefore, to meet the concerns of the double leg problem I argue for that *when LSI* is used, it should be interpreted *in combination with applicable normative data of controls or of preinjury capacity*.

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Underlying sensorimotor deficits that might have led to the initial injury can be found when studying initial risk factors for ACL injury. Indeed, risk factors for injury are multifactorial,[6] but several authors conclude that one important sensorimotor risk factor is altered movement patterns (in specific increased frontal plane knee motion, poor trunk positioning or landing techniques).[7] Therefore, *quantification of altered movement patterns* should be included in test batteries. One such quantifiable measurement, reliable and valid for individuals with ACL injury, is the Test for Substitution Patterns. This is an observation test measuring predefined, unfavourable movements/alignment in ankle–knee–hip and trunk regions and can be used before, during and after rehabilitation.[8] It should be kept in mind that when measuring movement patterns, *considerable interindividual variations* exist, and the individual has to be his or her own control. In these situations, *symmetry measurements are of great value*.

IN FOCUS WHEN DESIGNING FUTURE TEST BATTERIES AND REHABILITATION PROGRAMMES: MOTOR CONTROL RECAPITULATED

To optimise test batteries, the included tests should reflect the complexity of movement and stabilisation—motor control.[9–11] In short, in the non-injured situation, sensorimotor control in posture and movement comprise a complex integration of neural and muscular mechanisms coordinated by the central nervous system, CNS, and takes into account soft tissue restraints, articular mechanics and joint loads to create appropriate movements and stabilisation. To maintain and modify posture during movements, the CNS coordinates visual, vestibular and proprioceptive information into automatic, continuous muscular activation in *muscular synergies*. Feed-forward control (anticipatory actions) and feedback control (corrective response to tasks/perturbation, also involved in motor learning) contribute to the continuous corrections in functional/*dynamic joint stabilisation* (the ability to remain stable in single joints and in kinematic chains).[10 11]

After knee injury, side-to-side differences are described as deficits in biomechanical stability and in dynamic joint stabilisation.[10 11] The sensorimotor deficits that can follow joint injury relates to alterations and adaptations demonstrated as: altered somatosensory input from the injured side to the spinal cord and the brain, altered central information processing in the brain resulting in erroneous efferent motor commands to the muscles, resulting in (altered) movements that in turn provide new afferent stimuli. *Manifestations of sensorimotor deficits* can, for example, be delayed or altered muscular activation, reduced muscle strength and/or altered movement patterns[12]; characteristics so complex that they have to be measured separately and with different tests. This implicates the use of *more versatile test batteries* to measure sensorimotor deficits that include strength- , hop- and movement-quality tests and measurements of, for example, muscle activation, joint stabilisation and motor learning aspects. For a more complete review of return-to-sport testing, see ref [2].

WHAT TO DO BEFORE RETURN TO SPORTS? IMPLICATIONS FOR REHABILITATION TO PREVENT FURTHER COMPLICATIONS

Rehabilitation programmes integrating strength and sensorimotor control training have been found effective in ACL injury rehabilitation, but the exact content is under debate.[13] Importantly, commonly used strength training alone does not efficiently train the central control responsible for timely muscular responses resulting in dynamic joint stabilisation. I therefore suggest that training programmes are studied aiming to optimise dynamic joint stabilisation by training muscular *synergies*, balanced in *time* and *magnitude* through the *relearning of motor control* to create *appropriate*, automatic and generalised *movements, without unfavourable altered movements*. Examples of this are exercises where voluntary movements of the contralateral leg, trunk or arms generate compensating, postural and stabilising reactions on injured side[14] (figure 1A–D). Patients with non-reconstructed ACL injury and activity modification, trained with such exercises, were found to have good knee function, acceptable activity level and favourable

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Figure 1 Examples of exercises suggested to efficiently train the central control, with the aim to improve dynamic joint stabilisation. Voluntary movements of the contralateral leg, trunk or arms are used to generate compensating, postural, stabilising muscular reactions. Exercises in figure 1A–C have the aim to generate stabilising reactions mainly in the right leg, and the exercise in figure 1D in both legs. Arrows denote movements. Circles denote what is primarily in focus of the training. (A) Subject in supine position, right knee bent about 90°, right foot in line with knee and hip placed on a ball that is positioned in a corner. Seat is lifted from floor, and left leg is moved repeatedly up and down in rapidly hip flexion–extension. Arms aside body. (B) Subject standing on right leg with proper alignment in foot, knee, hip, trunk and neck. Left leg is repeatedly moving in hip flexion–extension with resistance from a pulley machine. The arms are moved in flexion–extension as in walking/running. (C) Subject standing on right leg with proper alignment in foot, knee, hip and trunk with support from hands. The subject is repeatedly flexing right knee and hip about 90°, moving left leg behind the body without support from floor and then moving left leg rapidly up towards abdomen on the same time as moving up on tiptoes on right leg. Left and right figures indicate end positions. (D) Subject standing on both legs with slight knee and hip flexion and proper alignment in foot, knee, hip, trunk and neck. A medicine ball is repeatedly and rapidly moved from right side to left side.

outcome concerning osteoarthritis 15 years after injury.[15]

SUGGESTIONS IN SUMMARY

- ► Use LSI measurements in combination with applicable normative or preinjury data of controls.
- ► Quantify movement patterns before, during and after rehabilitation.
- ► Use versatile test batteries reflecting also sensorimotor deficits.
- ► Rehabilitation aims: relearning of movements and dynamic joint stabilisation by, for example, using voluntary movements generating postural, stabilising, muscular activity in muscular synergies, performed without unfavourable alterations.

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REFERENCES

1 Benjaminse A, Holden S, Myer GD. ACL rupture is a single leg injury but a double leg problem: too much focus on 'symmetry' alone and that's not enough!. *Br J Sports Med* 2018:bjsports-2017-098502.
2 Dingenen B, Gokeler A. Optimization of the return-to-sport paradigm after anterior cruciate ligament reconstruction: a critical step back to move forward. *Sports Med* 2017;47:1487–500.
3 Barber-Westin SD, Noyes FR. Objective criteria for return to athletics after anterior cruciate ligament reconstruction and subsequent reinjury rates: a systematic review. *Phys Sportsmed* 2011;39:100–10.
4 Zwolski C, Schmitt LC, Thomas S, *et al*. The utility of limb symmetry indices in return-to-sport assessment in patients with bilateral anterior cruciate ligament reconstruction. *Am J Sports Med* 2016;44:2030–8.
5 Wellsandt E, Failla MJ, Snyder-Mackler L. Limb symmetry indexes can overestimate knee function after anterior cruciate ligament injury. *J Orthop Sports Phys Ther* 2017;47:334–8.
6 Griffin LY, Albohm MJ, Arendt EA, *et al*. Understanding and preventing noncontact anterior cruciate ligament injuries: a review of the Hunt Valley II meeting, January 2005. *Am J Sports Med* 2006;34:1512–32.
7 Nessler T, Denney L, Sampley J. ACL Injury Prevention: What Does Research Tell Us? *Curr Rev Musculoskelet Med* 2017;10:281–8.
8 Trulsson A. Test for substitution patterns. http://testforsubstitutionpatterns.pbworks.com.
9 Shumway-Cook A, Woollacott MH. Normal postural control. *Motor Control Translating Research into Clinical Practice*. Fourth edn. Baltimore, Philadelphia: Lippincott Williams & Wilkins, 2011:161–94.
10 Williams GN, Chmielewski T, Rudolph K, *et al*. Dynamic knee stability: current theory and implications for clinicians and scientists. *J Orthop Sports Phys Ther* 2001;31:546–66.

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11 Riemann BL, Lephart SM. The sensorimotor system, part I: the physiologic basis of functional joint stability. *J Athl Train* 2002;37:71–9.
12 Ingersoll CD, Grindstaff TL, Pietrosimone BG, *et al*. Neuromuscular consequences of anterior cruciate ligament injury. *Clin Sports Med* 2008;27:383–404.
13 van Melick N, van Cingel RE, Brooijmans F, *et al*. Evidence-based clinical practice update: practice guidelines for anterior cruciate ligament rehabilitation based on a systematic review and multidisciplinary consensus. *Br J Sports Med* 2016;50:1506–15.
14 Zätterström R, Fridén T, Lindstrand A, *et al*. Rehabilitation following acute anterior cruciate ligament injuries--a 12-month follow-up of a randomized clinical trial. *Scand J Med Sci Sports* 2000;10:156–63.
15 Neuman P, Englund M, Kostogiannis I, *et al*. Prevalence of tibiofemoral osteoarthritis 15 years after nonoperative treatment of anterior cruciate ligament injury: a prospective cohort study. *Am J Sports Med* 2008;36:1717–25.

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