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### RUNNING PATTERN ASYMMETRY EVALUATION AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION COULD BE A WAY TO DETECT RE-INJURIES

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**Background** A test battery is recommended after anterior cruciate ligament reconstruction (ACLR) to help decision-making of return to sport (RTS). Running is important in RTS continuum, but it is currently not included in the usual test batteries. Could running pattern asymmetry, which can be observed after ACLR, be considered as a risk factor of ACL re-injuries?

**Objective** To analyse the interest of adding running pattern evaluation in test battery after ACLR.

**Design** Prospective cohort study.

**Setting** Patient with ACLR with Tegner score >6 and Marx Scale score >8 before first ACL injury.

**Patients (or Participants)** 21 patients (12 women) with primary ACLR (graft type: Patellar (n=4) or Hamstring tendon (n=17)) without major chondral and/or meniscal lesion.

**Interventions (or Assessment of Risk Factors)** Running pattern evaluation was performed on a motorised instrumented treadmill in addition to recommended tests (questionnaires, knee laxity, Hop Tests and isokinetic evaluation) at 6 months after ACLR. ACL re-injuries were prospectively collected during the two years after ACLR, and comparisons between parameters were performed between ACLR patients who presented or not an ACL re-injury

**Main Outcome Measurements** Limb symmetry Index (LSI=operated leg/healthy leg x100) were calculated for running variables (Stride Length, Loading Rate, Leg Stiffness) and other parameters of test battery. Means were compared between groups.

**Results** Five patients had a re-injury (3 W/ 2 M), without significant differences in baseline characteristics (sport level, training frequency) with un-re-injured patients. For running variables, there was a significant difference for LSIs of Stride Length (Re-injury group  $95.8 \pm 2.3\%$  vs  $99.0\% \pm 1.8\%$ ,  $p=0.003$ ), Loading Rate ( $86.9 \pm 13.3\%$  vs  $98.3 \pm 9.6\%$ ,  $p=0.025$ ), and Leg Stiffness ( $112.6 \pm 7.3\%$  vs  $103.7 \pm 8.0\%$ ,  $p=0.035$ ), while there were no statistical differences for LSIs of other parameters of test battery.

**Conclusions** As greater running pattern asymmetry was reported in patients with ACL re-injury, this approach could be of interest for secondary prevention.

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### RESPONSIVENESS OF THE ANTERIOR CRUCIATE LIGAMENT – RETURN TO SPORTS AFTER INJURY (ACL-RSI) AND INJURY – PSYCHOLOGICAL READINESS TO RETURN TO SPORT (I-PRRS) SCALES

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**Background** Both physical and psychological readiness are important for a successful return to sport (RTS) and secondary prevention. The ACL-Return to Sport after Injury (ACL-RSI) and Injury-Psychological Readiness to Return to Sport (I-PRRS) scales were developed to assess psychological factors associated with RTS. Validity and reliability have been determined but responsiveness of both scales has not been examined yet.

**Objective** To investigate the responsiveness of the Dutch ACL-RSI and I-PRRS scales.

**Design** Prospective, cohort study.

**Setting** Patients from a university and regional hospital.

**Patients** Seventy athletes with ACL reconstruction 3–9 month previous to the start of the study completed both scales twice two months apart, plus a Global Rating of Change (GRC) questionnaire.

**Main Outcome Measurements** Distribution and logistic regression-based methods were used to study responsiveness.

**Results** The Standardized Response Mean (SRM) for the ACL-RSI was 0.3 and for the I-PRRS 0.1. The minimally important change (MIC) for ACL-RSI was 2.6 and for the I-PRRS 0.9. Since the smallest detectable change (SDC) was larger than MIC in individual patients, it does not seem possible to distinguish minimally important changes from measurement error in individual patients with either scale. At group level responsiveness of both scales seemed sufficient.

**Conclusions** In individual patients the responsiveness of the ACL-RSI and I-PRRS scales seems to be insufficient to detect changes in confidence over time with regard to return to sport after ACLR. Neither scale is able to distinguish minimally important changes from measurement error in individual patients. The scales are therefore less suitable for monitoring the effectiveness of individual interventions and to judge whether a patient has reached a change of importance. At the group level responsiveness seems sufficient, so the two scales can be used to investigate the effectiveness of an intervention at the group level.

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### CHALLENGING ACL RECONSTRUCTED ATHLETES AND THEIR SENSORIMOTOR SYSTEM AT RETURN-TO-SPORT: A VITAL STEP TOWARDS EXPOSING THE ROOTS OF THEIR NEUROMUSCULAR DEFICITS

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**Background** Evidence increasingly suggests that neuromuscular alterations in ACL reconstructed (ACLR) patients are rooted in neurocognitive and proprioceptive deficits.

**Objective** The aim of this study was to reveal how neurocognitive and proprioceptive deficits determine neuromuscular control alterations seen in ACLR athletes.

**Design** Cross-sectional study.

**Setting** Athletes who return to a cutting or pivoting sport after an ACL reconstruction.

**Patients** 20 athletes who had an ACL reconstruction and were cleared by the surgeon/physiotherapist to return to sport (RTS), were tested at time of RTS. A control group of 20

uninjured athletes, matched for gender and type of sport, was included.

**Assessment of Risk Factors** All participants performed a stepping-down task under 4 conditions: 1. no additional challenges (NORM), 2. whilst performing a cognitive dual-task (DUAL), 3. whilst undergoing unpredictable surface perturbations (PERT), 4. whilst performing a cognitive dual-task + undergoing unpredictable surface perturbations.

**Main Outcome Measurements** Muscle activations of the vastus medialis (VM), vastus lateralis, hamstrings medialis (HM), hamstrings lateralis were recorded with surface EMG. Integrals were calculated over the landing period (50–250 ms after initial contact) and normalized to maximal voluntary contractions.

**Results** The ACLR athletes showed an almost unadjusted strategy of increased HM (6.7% (ACL); 3.9% (control),  $F=5.07$ ,  $p=0.031$ ) and decreased VM activation across all tasks (6.8% (ACL); 12.9% (control),  $F=8.52$ ,  $p=0.006$ ), whilst the control group had a clear increase in HM activation (3.2% (NORM); 5.6% (PERT),  $t=4.06$ ,  $p=0.001$ ) and VM activation (9.0% (NORM); 16.9% (PERT),  $t=3.81$ ,  $p=0.001$ ) when unpredictable perturbations occurred. However, within the ACLR athletes HM activation decreased when a dual task was added (7.3% (NORM); 4.7% (DUAL),  $t=3.4$ ,  $p=0.003$ ).

**Conclusions** It seems that the neuromuscular strategy of the ACLR athlete is an overprotective strategy to improve knee stability. They use this strategy in every situation, potentially to compensate for the altered proprioceptive input. This overprotective strategy is jeopardized under cognitively challenging circumstances, confirming that underlying neurocognitive limitations contribute to altered neuromuscular control in ACLR athletes.

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#### GENDER DIFFERENCES IN LANDING MECHANICS AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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**Background** Studies have reported that females and males exhibit different landing techniques. However, few studies have examined the effect of gender on landing technique in athletes following ACLR.

**Objective** To compare landing technique between females and males following ACLR during landing from heading-jump (LHJ) and landing from long-jump (LLJ).

**Design** Cross-sectional study.

**Setting** Biomechanical laboratory.

**Patients (or Participants)** Eight female and 8 male recreational athletes.

**Interventions (or Assessment of Risk Factors)** LHJ included jumping forward to head a soccer ball and landing on the force plates, whereas LLJ included jumping forward and landing on the force plates.

**Main Outcome Measurements** A 2×2 ANOVA (gender × landing) was performed to evaluate kinematics, kinetics, and electromyography data.

**Results** A significant interaction was found only for knee flexion angles ( $F_{1,14}=12.67$ ,  $p=0.003$ ). Pairwise comparisons showed that males landed with decreased knee flexion compared with females during LLJ ( $p=0.01$ ). LHJ showed decreased knee flexion compared with LLJ in females ( $p<0.001$ ) and males ( $p=0.001$ ). Significant main effects of landing were found. LHJ showed decreased hip flexion angles ( $F_{1,14}=71.07$ ,  $p<0.001$ ), decreased knee flexion angles ( $F_{1,14}=95.17$ ,  $p<0.001$ ), decreased knee extension moments ( $F_{1,14}=20.12$ ,  $p=0.001$ ), and decreased plantar-flexion moments ( $F_{1,14}=34.71$ ,  $p<0.001$ ). Also, a significant main effect of gender for hip flexion was found showing that males landed with decreased hip flexion angles ( $F_{1,14}=7.17$ ,  $p=0.01$ ).

**Conclusions** LHJ showed greater injury predisposing factors compared with LLJ. Females and males following ACLR showed nearly similar landing biomechanics. However, males landed with smaller hip and knee flexion angles (stiff-landing); therefore, preventative training programs may focus on improving the use of hip and knee joints (soft-landing) during landing to decrease the risk of consequent injuries in males following ACLR.

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#### RELATIONSHIP BETWEEN POLE VAULT BIOMECHANICS AND PREVIOUS INJURIES

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**Background** During pole vault, a high level of energy is transferred from horizontal speed of athlete to the pole. Several ways of performing the pole vault exist, and could be associated with specific injury risk.

**Objective** To analyse the potential association between the biomechanical patterns of pole vault and the history of injuries.

**Design** Retrospective study.

**Setting** National elite indoor championship and youth national indoor championship (U17 and U20) of pole vault (athletics)

**Participants** 62 (70.5% of the eligible population participating in the championships) healthy national level male and female pole vaulters.

**Main Outcome Measurements** We prospectively collected the pole vault biomechanical data of the run-up and take-off phases of the vault, and we retrospectively collected the history of injuries during the 12 preceding months through an online questionnaire.

**Results** A total of 62 (70.5% of those participating in the championships) pole vaulters accepted to participate in this study, and benefited from pole vault biomechanical and injury