

# **Predicting no return to sports after three months in patients with traumatic knee complaints in general practice by combining patient characteristics, trauma characteristics and knee complaints**

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*Eur J Gen Pract* 2019. <https://doi.org/10.1080/13814788.2019.1646241>

## ABSTRACT

**Background:** It remains unclear to what extent patients with traumatic knee complaints aged 18-45 years seen in general practice experience difficulties with return to sports.

**Objectives:** This study aims to determine the proportion of patients with a knee trauma that return to sports at 6-weeks and 3-months follow-up. Also examined were associations between no return to sports and baseline patient/trauma characteristics, knee complaints and MR findings, as well as the additive value of MR findings.

**Methods:** Included were patients with traumatic knee complaints participating in a randomised controlled trial assessing the cost-effectiveness of an MR scan in general practice. Patients were classified as 'no return to sports' or 'return to sports' (sports on pre-injury or adapted level). Potential baseline predictors for no return to sports were assessed using logistic regression analyses. The area under the curves (AUC) were compared.

**Results:** At 6-weeks and 3-months follow-up, 147 (59%) and 175 (74%) patients, respectively, reported return to sports. Combining patient characteristics, trauma characteristics and knee complaints predicted no return to sports with an AUC of 0.86 (95%CI:0.81-0.90) at 6-weeks and of 0.82 (95%CI:0.76-0.88) at 3-months follow-up. After adding MR findings, the AUC was 0.79 (95%CI:0.71-0.87) at 6-weeks and 0.79 (95%CI:0.70-0.88) at 3-months follow-up.

**Conclusions:** Three out of four patients with a knee trauma in general practice reported return to sports at 3-months follow-up. A combination of patient/trauma characteristics and knee complaints predicted no return to sports, whereas MR findings had no additive value.

## INTRODUCTION

An injury of the knee due to a trauma during sports or leisure is a common indication for which patients visit their general practitioner (GP).<sup>1</sup> Patients with traumatic knee complaints regularly ask when they can resume sports activities. To help address this, the GP's tools for diagnosis and management of these complaints are described in the Dutch guideline for traumatic knee complaints.<sup>2</sup> In the acute phase, the diagnosis is mainly based on history taking, whereas physical examination adds little diagnostic value.<sup>3,4,5</sup> Studies have shown the potential diagnostic value of a magnetic resonance scan (MR scan) in traumatic knee complaints (requested by the GP) by improving patients knee related quality of life and reducing medical costs.<sup>6,7,8</sup> In most patients with traumatic knee complaints in general practice, full recovery or major improvement is reported after one year.<sup>9</sup> However, the return to sports after traumatic knee complaints remains precarious and most active young patients with traumatic knee complaints demand to return to sports as soon as possible. Currently, in patients aged 18-45 years visiting a GP, the impact of a knee trauma on their return to sports activities remains unclear. Therefore, the aim of this study is to assess at 6-weeks and 3-months follow-up:

- the proportion of patients returning to sports after a knee trauma
- which patient characteristics, trauma characteristics, severity of knee complaints and MR findings, all measured at baseline, are associated with no return to sports
- whether MR findings have an additive value in predicting no return to sports.

## METHODS

### Design and setting

The present study included patients with traumatic knee complaints participating in a randomised controlled trial (RCT) that aimed to assess the (cost)effectiveness of an MR scan in general practice for patients with knee complaints due to a trauma (TACKLE Trial).<sup>10</sup> In the TACKLE trial, patients from 150 participating general practitioners were randomised to an MR scan or usual care. The recruitment for the TACKLE Trial took place from November 2012 to December 2015. The usual care group was treated according to the guideline of the Dutch College of General Practitioners for traumatic knee complaints, i.e. no MR scan.<sup>2</sup> The study was approved by the Medical Ethics Committee of the Erasmus Medical Centre (Dutch Trial Registration: NTR3689).<sup>11</sup>

### Study population

Patients visiting their GP with knee complaints due to a trauma in the preceding 6 months were eligible for the TACKLE Trial. Patients had to be 18-45 years old; the restriction of 45 years was chosen to exclude patients with osteoarthritis as much as possible. Excluded from the study were patients with: i) an indication for direct referral to an orthopaedic surgeon (e.g. fracture, locked knee or severe complaints after patella dislocation), ii) knee complaints already treated in secondary care,

iii) previous surgical intervention of the affected knee, iv) knee osteoarthritis diagnosed by a medical specialist, v) other non-traumatic arthropathy (i.e. isolated patellofemoral joint pain), vi) a previous MR scan for current knee complaints, or vii) a contra-indication for an MR scan. For the present study, also excluded were patients: i) who did not participate in sports before the knee trauma, and ii) who did not return to sports after the knee trauma due to reasons other than knee complaints.

## Data collection and variables

### *Questionnaire*

The following question about sports participation was included in the questionnaires filled in at baseline, and at 6-weeks and 3-months follow-up: *'Are you able to participate in sports with your knee at this moment?'* The answers were categorised to: 'yes, on the same level as before the knee trauma', 'yes, on an adapted level', 'no, not able to participate in sports because of the knee complaints', 'no, not able to participate in sports because of another reason', and 'not applicable, I do not sport'. Afterwards, the answers were dichotomised to 'No return to sports' (not able to participate in sports because of the knee complaints) or 'Return to sports' (sports at the same level as before the knee trauma, or at an adapted level).

### *Baseline variables*

At baseline information on the following characteristics were collected: age, gender, height, weight, educational level (low/high), musculoskeletal co-morbidity (yes/no) previous knee complaints (yes/no), symptom side (right/left), paid job (yes/no), and hours spent on the paid job per week. Also, information on the date, occasion (sport/job/home/traffic/other) and the mechanism (fall/rotation/bump/squatting) of the knee trauma were assessed and dichotomised to: trauma during sport (yes/no) and rotational trauma (yes/no). In addition, the following were also assessed: the type of sport (ball sport: yes/no), hours of sport per week, and whether the sport was played in competition before knee trauma (yes/no).

### *Baseline scores of outcome measures*

The baseline scores of the following outcome measures were used to assess the severity of knee complaints:

- i) the numeric pain rating scale (NPRS; scores ranging from 0 (no pain) to 10 (unbearable pain)), for the average severity of knee pain during the previous 48 hours and the previous week<sup>12</sup>
- ii) the Lysholm scale (primary outcome measure of the TACKLE Trial) comprising 8 items on symptoms and limitations in activities (scores ranging from 0-100, with higher scores indicating better knee function<sup>13</sup>
- iii) a modified Tegner score to measure work load and sport participation, ranging from 0 (not able to work/sport due to knee complaints) to 10 (complete return to work/sports)<sup>13</sup>
- iv) the five dimensions of the Knee Injury and Osteoarthritis Outcome Score (KOOS) to measure disability due to knee complaints<sup>14</sup>; the KOOS consists of five dimensions (pain, symptoms,

function in daily living, function in sport and recreation, and knee-related quality of life) rated on a scale from 0-4: for every dimension, a score is calculated on a scale from 0-100 with a higher score indicating better knee function

- v) the shortened version of the Tampa scale that measures fear of pain, movement and injury (TSK-11), scored from 1 (strongly disagree) to 4 (strongly agree)<sup>15,16</sup>; the total score ranges from 11-44, with a higher score indicating more fear regarding pain, movement and injury.

### *MR findings*

MR findings were scored by one of the 12 participating (experienced) radiologists at a median of 13 (IQR 8, 20) days after inclusion. The following items were scored: the amount of synovial fluid (effusion), abnormalities in soft tissues, meniscal injuries, anterior and posterior cruciate ligament ruptures, medial and lateral collateral ligament distortions and bone and cartilage injuries. The MR findings were dichotomised to the presence or absence of effusion, a bone bruise of the femorotibial joint (FTJ), fracture, traumatic meniscal tear (longitudinal, radial or complex meniscal tear), grade I-III distortion of the medial or lateral collateral ligament (MCL/LCL), partial or complete anterior or posterior cruciate ligament tear (ACL/PCL) and cartilage damage grade I-IV.

### **Statistical analyses**

Descriptive statistics were used to describe the participants. Data were tested on a normal distribution with the Kolmogorov-Smirnov test. The mean and standard deviation (SD) were reported in case of normal distributed data and median and inter quartile range (IQR) in case of skewed data. The baseline associations of patient characteristics, trauma characteristics, severity of knee complaints and MR findings with return to sports (1=no, 0=yes) were assessed with logistic regression analyses, adjusted for the time from trauma to study inclusion and return to sports at baseline. Candidate predictors for the logistic regression analyses were selected based on expert consensus (PL, SBZ, NS). The number of selected candidate predictors was based on the number of patients in the smallest group (return to sports group, or no return to sports group).<sup>17</sup> Separate models were built for patient characteristics, trauma characteristics, baseline severity of knee complaints and MR findings. Candidate predictors with a univariate association of  $p < 0.2$  were all entered into a multivariable logistic regression analysis in one block (Enter method). In case of multicollinearity ( $r > 0.5$ ) of the candidate predictors the variable with the strongest association (odds ratio) with no return to sports was selected for the multivariable logistic regression analysis. In the latter analyses, variables with  $p > 0.2$  were removed.

Variables with an association of  $p < 0.2$  in the multivariable logistic regression analysis of the separate models were selected for a final multivariable logistic regression analysis (Enter method) with a combination of patient characteristics, trauma characteristics and baseline severity of knee complaints. Finally, the MR findings were added to the combined model to assess the additive value of an MR scan. A receiver operating characteristic curve was created and the area under the curve (AUC) was calculated to compare the separate models.<sup>18</sup> SPSS version 21.0 was used for all analyses.

## RESULTS

### Patient inclusion

Figure 1 is a flow chart of the process. Eight hundred and thirty-six patients were invited to participate in the TACKLE trial. Of the 356 patients included in the RCT, 282 (79%) participated in sports before the knee trauma and were included in the present study. At 6-weeks and 3-months follow-up, 250 (89%) and 235 (83%) patients, respectively, were available for analysis.

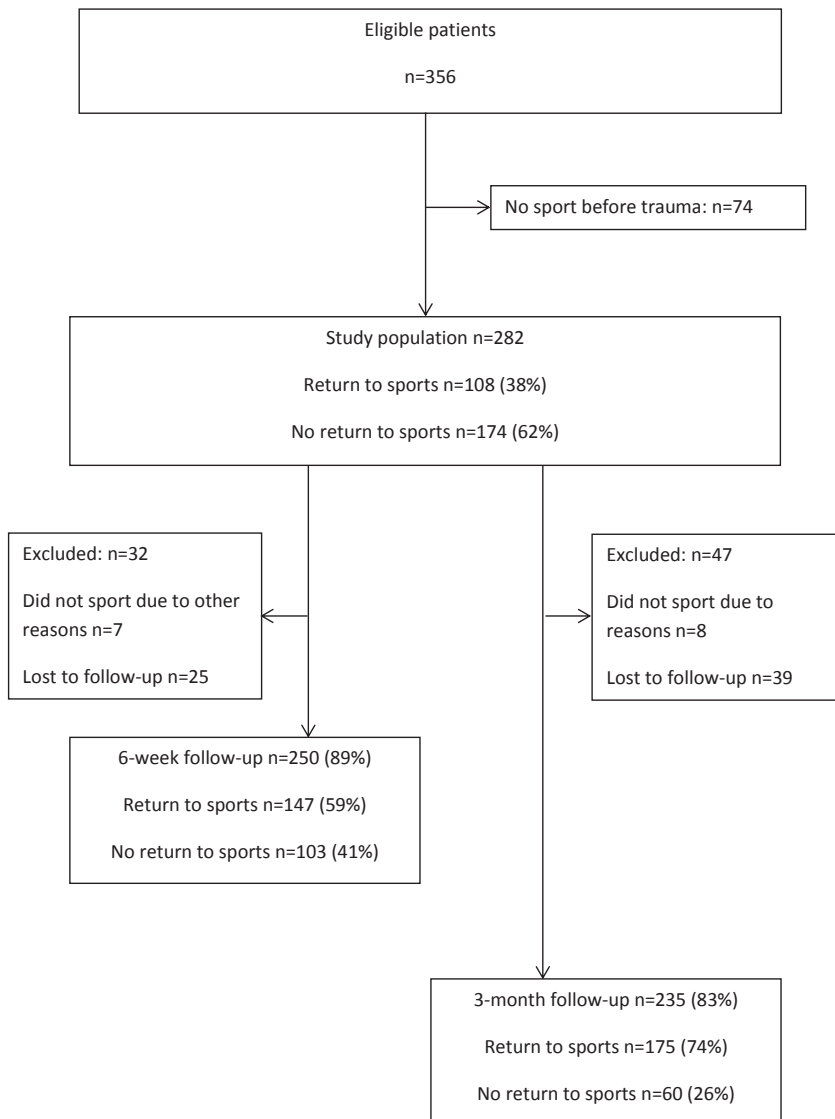


Figure 1 Flowchart of the process

## Baseline characteristics

Baseline characteristics are presented in Table 1. Median age was 32 (IQR 26, 39) years and 63% of the patients was male. Median time from trauma to study inclusion was 39 (IQR 13, 80) days. The four most commonly performed sports before trauma were: i) soccer, ii) fitness training or aerobics, iii) athletics or running, and iv) combat sport with 99 (35%), 60 (21%), 40 (14%) and 16 (6%) patients, respectively. For 188 (67%) patients the trauma occurred during sports, and in total, 114 (40%) patients experienced a rotational trauma.

**Table 1** Baseline characteristics of included patients (n=282)

| Patient characteristics                                   | Study population  |
|---|-------------------|
| Age in years, median (IQR)                                | 32 (26, 39)       |
| Male gender   | 178 (63%)         |
| Body mass index, median (IQR)                             | 24.6 (22.7, 26.9) |
| High educational level                                    | 117 (41%)         |
| Musculoskeletal comorbidities                             | 63 (22%)          |
| Previous knee complaints                                  | 116 (41%)         |
| Time from trauma to study inclusion in days, median (IQR) | 39 (13, 80)       |
| Symptom on the right knee                                 | 128 (45%)         |
| Sports before trauma                                      | 282 (100%)        |
| Hours spent on sport per week, median (IQR)               | 3 (2, 5)          |
| Ball sport  | 126 (45%)         |
| Sport in competition                                      | 124 (44%)         |
| Soccer  | 99 (35%)          |
| Fitness training/aerobics                                 | 60 (21%)          |
| Athletics/running   | 40 (14%)          |
| Combat sport  | 16 (6%)           |
| Paid job before trauma                                    | 252 (89%)         |
| Hours spent on paid job per week, median (IQR)            | 38 (30, 40)       |
| Trauma characteristics                                    |                   |
| Occasion of trauma  |                   |
| During sports   | 188 (67%)         |
| During work   | 18 (6%)           |
| At home   | 12 (4%)           |
| During traffic  | 24 (9%)           |
| Other   | 40 (14%)          |
| Mechanism of trauma                                       |                   |
| Fall  | 72 (26%)          |
| Rotation  | 114 (40%)         |
| Bump  | 19 (7%)           |
| Squatting   | 24 (9%)           |
| Other   | 51 (18%)          |

**Table 1** Baseline characteristics of included patients (n=282) (continued)

| Patient characteristics  | Study population  |
|--|-------------------|
| Immediate pain   | 208 (74%)         |
| Immediate effusion   | 72 (26%)          |
| Continuation activity impossible                               | 196 (70%)         |
| Popping sensation during trauma                                | 89 (35%)          |
| Severity of knee complaints                                    |                   |
| Severity of knee pain (NPRS previous 48h), median (IQR)        | 3 (5, 7)          |
| Symptoms and limitations in activities (Lysholm), median (IQR) | 73 (56, 85)       |
| Work load and sport participation (Tegner), median (IQR)       | 3 (2, 4)          |
| Fear of pain, movement and injury (TSK-11), median (IQR)       | 26 (22, 30)       |
| KOOS pain, median (IQR)  | 58.3 (44.4, 75)   |
| KOOS symptoms, median (IQR)                                    | 64.3 (46.4, 78.6) |
| KOOS function in daily living, median (IQR)                    | 69.1 (50, 85.7)   |
| KOOS sport and recreation, median (IQR)                        | 30 (15, 55)       |
| KOOS quality of life, median (IQR)                             | 43.8 (37.5, 50)   |

Data are presented as numbers (percentages), unless otherwise stated. Missing values ranged up to 0.7%. IQR: inter-quartile range. NPRS: Numeric Pain Rating Scale with scores from 0-10, with a higher score indicating more pain. Lysholm scale scored from 0-100, with a higher score indicating less problems. TSK-11: Shortened version of the Tampa scale for kinesiophobia scored from 11-44, with a higher score indicating more kinesiophobia. KOOS: Knee injury and Osteoarthritis Outcome Score ranging from 0-100, with a higher score indicating less problems.

Of the 282 patients included at baseline, 138 (49%) had received an MR scan (Table 2). Median time from trauma to MR scan was 48 (IQR 23, 88) days. In 114 (83%) patients one or more abnormalities were detected on the MR scan. In 50 (36%) patients there was a bone bruise of the FTJ and in 11 (8%) there was a (micro) fracture; also 25 (18%) patients had a traumatic (not horizontal) meniscal tear, 24 (17%) had an MCL/LCL distortion, 34 (25%) had an ACL/PCL tear, and 31 (22%) patients had cartilage defect.

### Return to sports

At baseline, 108 (38%) patients returned to sport on the pre-injury level or an adapted level). At 6-weeks and 3-months follow-up 147 (59%) and 175 (74%) patients, respectively, returned to sports.

### Associations with no return to sports

The results of the bivariate logistic regression analyses for return to sports are presented in the Appendix. The results of the multivariable logistic regression analyses for no return to sports are shown in Table 3.



**Table 2** Knee Magnetic Resonance findings of the 138 patients with the MR scan

| Findings on Magnetic Resonance scan               | Study population |
|---|------------------|
| Time from trauma to MR-scan in days, median (IQR) | 48 (23, 88)      |
| Abnormalities present                             | 114 (83%)        |
| Effusion  | 58 (42%)         |
| Bone bruise FTJ                                   | 50 (36%)         |
| (Micro) fracture                                  | 11 (8%)          |
| Traumatic meniscal tear <sup>1</sup>              | 25 (18%)         |
| MCL/LCL distortion <sup>2</sup>                   | 24 (17%)         |
| ACL/PCL tear <sup>3</sup>                         | 34 (25%)         |
| Cartilage damage <sup>4</sup>                     | 31 (22%)         |
| Combinations                                      |                  |
| ACL/PCL tear and bone bruise FTJ                  | 24 (17%)         |
| Traumatic meniscal tear and bone bruise FTJ       | 13 (9%)          |
| Traumatic meniscal tear and ACL/PCL tear          | 12 (9%)          |
| MCL/LCL distortion and bone bruise FTJ            | 11 (8%)          |

Data are presented as numbers (percentages), unless otherwise stated. Missing values ranged up to 1.4%. MR: magnetic resonance. IQR: inter quartile range. FTJ: femorotibial joint. MCL: medial collateral ligament. LCL: lateral collateral ligament. ACL: anterior cruciate ligament. PCL: posterior cruciate ligament. <sup>1</sup>Longitudinal, radial or complex meniscal tear. <sup>2</sup>Grade I-III. <sup>3</sup>Partial or complete tear. <sup>4</sup>grade I-IV.

### *Patient characteristics*

At 6-weeks follow-up, 'age', 'musculoskeletal comorbidities' and 'ball sport before trauma' predicted no return to sports with an AUC of 0.85 (95%CI:0.80-0.89). At 3-months follow-up only 'age' predicted no return to sports with an AUC of 0.73 (95%CI:0.66-0.80).

### *Trauma characteristics*

At 6-weeks follow-up, 'trauma during sport', 'rotational trauma' and 'popping sensation' predicted no return to sports with an AUC of 0.84 (95%CI:0.79-0.89). At 3-months follow-up, 'trauma during sport', 'rotational trauma' and 'popping sensation' predicted no return to sports with an AUC of 0.78 (95%CI:0.71-0.85).

### *Baseline severity of knee complaints*

At 6-weeks follow-up, 'effusion during previous week', 'NPRS previous 48h' and the 'Tegner score' predicted no return to sports with an AUC of 0.83 (95%CI:0.78-0.88). At 3-months follow-up 'effusion during previous week', 'NPRS previous 48h' and 'KOOS QoL' predicted no return to sports with an AUC of 0.81 (95%CI:0.75-0.87).

**Table 3** Multivariable logistic regression analysis for return to sports

| 6-week follow-up (n=250)                            |      |             | 3-month follow-up (n=235)                           |      |             |
|---|------|-------------|---|------|-------------|
|   | OR   | 95% CI      |   | OR   | 95% CI      |
| Patient characteristics                             |      |             | Patient characteristics                             |      |             |
| Time from trauma to inclusion                       | 1.00 | 0.99-1.01   | Time from trauma to inclusion                       | 1.00 | 0.99-1.01   |
| Return to sports at baseline                        | 0.04 | 0.01-0.10*  | Return to sports at baseline                        | 0.12 | 0.04-0.31*  |
| Age   | 1.10 | 1.05-1.15*  | Age   | 1.04 | 1.00-1.08** |
| MSK comorbidities                                   | 2.04 | 0.91-4.57** |   |      |             |
| Ball sport before trauma                            | 2.23 | 1.14-4.33*  |   |      |             |
| AUC = 0.85 (95% CI 0.80-0.89). R <sup>2</sup> =0.46 |      |             | AUC = 0.73 (95% CI 0.66-0.80). R <sup>2</sup> =0.20 |      |             |
| Trauma characteristics                              |      |             | Trauma characteristics                              |      |             |
| Time from trauma to inclusion                       | 1.01 | 1.00-1.01   | Time from trauma to inclusion                       | 1.00 | 0.99-1.01   |
| Return to sports at baseline                        | 0.04 | 0.02-0.11*  | Return to sports at baseline                        | 0.12 | 0.04-0.33*  |
| Trauma during sport                                 | 1.89 | 0.96-3.72** | Trauma during sport                                 | 2.50 | 1.16-5.39*  |
| Rotational trauma                                   | 1.64 | 0.85-3.16** | Rotational trauma                                   | 1.84 | 0.92-3.69** |
| Popping sensation                                   | 2.11 | 1.07-4.14*  | Popping sensation                                   | 1.97 | 1.00-3.91*  |
| AUC = 0.84 (95% CI 0.79-0.89). R <sup>2</sup> =0.43 |      |             | AUC = 0.78 (95% CI 0.71-0.84). R <sup>2</sup> =0.27 |      |             |
| Baseline severity of knee complaints <sup>1</sup>   |      |             | Baseline severity of knee complaints <sup>2</sup>   |      |             |
| Time from trauma to inclusion                       | 1.00 | 1.00-1.01   | Time from trauma to inclusion                       | 1.00 | 0.99-1.01   |
| Return to sports at baseline                        | 0.09 | 0.04-0.24*  | Return to sports at baseline                        | 0.25 | 0.09-0.68*  |
| Effusion previous week                              | 1.83 | 0.93-3.62** | Effusion previous week                              | 2.49 | 1.14-5.41*  |
| NPRS previous 48h                                   | 1.26 | 1.08-1.48*  | NPRS previous 48h                                   | 1.30 | 1.09-1.55*  |
| Tegner score  | 0.89 | 0.76-1.05** | KOOS QoL  | 0.97 | 0.94-1.00** |
| AUC = 0.83 (95% CI 0.78-0.89). R <sup>2</sup> =0.44 |      |             | AUC = 0.81 (95% CI 0.75-0.87). R <sup>2</sup> =0.32 |      |             |
| Magnetic Resonance subgroup (n=128)                 |      |             | Magnetic Resonance subgroup (n=121)                 |      |             |
| Findings on Magnetic Resonance scan <sup>3</sup>    |      |             | Findings on Magnetic Resonance scan <sup>4</sup>    |      |             |
| Time from trauma to inclusion                       | 1.00 | 0.99-1.01   | Time from trauma to inclusion                       | 1.01 | 1.00-1.02   |
| Return to sports at baseline                        | 0.08 | 0.02-0.27*  | Return to sports at baseline                        | 0.14 | 0.04-0.53*  |
| Effusion  | 2.55 | 1.07-6.09*  | Effusion  | 2.71 | 1.02-7.21*  |
| Traumatic meniscal tear                             | 2.17 | 0.71-6.66** | Traumatic meniscal tear                             | 3.10 | 1.01-9.49*  |
|   |      |             | MCL/LCL distortion                                  | 0.35 | 0.10-1.26** |
| AUC = 0.80 (95% CI 0.72-0.87). R <sup>2</sup> =0.37 |      |             | AUC = 0.79 (95% CI 0.70-0.88). R <sup>2</sup> =0.29 |      |             |

Adjusted for time from trauma to inclusion and baseline return to sports. Missing values ranged up to 1.6%. MR: magnetic resonance. 95% CI; 95% confidence interval. OR: odds ratio. AUC: area under the curve. \*P<0.05. \*\*P<0.20. MSK: musculoskeletal. NPRS: Numeric Pain Rating Scale on a scale from 0-10, with a higher score indicating more pain. KOOS: Knee injury and Osteoarthritis Outcome Score ranging from 0-100, with a higher score indicating less problems. QoL: quality of life. Tegner score from 0-10, with a higher score indicating less problems. MCL/LCL distortion: distortion of the medial or lateral collateral ligament. <sup>1</sup>'KOOS QoL' removed because of p>0.2. <sup>2</sup>'TSK-11' removed because of p>0.2. <sup>3</sup>'BML FTJ' and 'fracture' removed because of p>0.2. <sup>4</sup>'ACL/PCL tear' removed because of p>0.2.

### MR findings

At 6-weeks follow-up, 'effusion' and 'traumatic meniscal tear' predicted no return to sports with an AUC of 0.80 (95%CI:0.72-0.87). At 3-months follow-up, 'effusion', 'traumatic meniscal tear' and 'MCL/LCL distortion' predicted no return to sports with an AUC of 0.79 (95%CI:0.70-0.87).

### Additive value of the Magnetic Resonance scan

The results of the multivariable logistic regression analyses for return to sports of the combined models and the additive value of the MR scan are shown in Table 4.

Combining the model of patient characteristics, trauma characteristics and baseline severity of knee complaints, the AUC was 0.86 (95%CI:0.81-0.90) at 6-weeks follow-up and 0.82 (95%CI:0.76-0.88) at 3-months follow-up. When adding the MR information, the AUC was 0.79 (95%CI:0.71-0.87) at 6-weeks follow-up and 0.79 (95%CI:0.70-0.88) at 3-months follow-up.

**Table 4** Multivariable logistic regression analysis of the combined models for return to sports

| 6-week follow-up (n=250)   |      |            | 3-month follow-up (n=235)  |      |             |
|--|------|------------|--|------|-------------|
|  | OR   | 95% CI     |  | OR   | 95% CI      |
| Patient characteristics, trauma characteristics and baseline severity of knee complaints <sup>1</sup>                              |      |            | Patient characteristics, trauma characteristics and baseline severity of knee complaints <sup>2</sup>                              |      |             |
| Time from trauma to inclusion  | 1.00 | 0.99-1.01  | Time from trauma to inclusion  | 1.01 | 1.00-1.02   |
| Return to sports at baseline   | 0.05 | 0.02-0.13* | Return to sports at baseline   | 0.19 | 0.07-0.52*  |
| Age  | 1.09 | 1.04-1.14* | Trauma during sport  | 2.58 | 1.17-5.72*  |
| NPRS previous 48 h   | 1.32 | 1.12-1.54* | Effusion previous week   | 2.77 | 1.27-6.05*  |
|  |      |            | NPRS previous 48 h   | 1.33 | 1.12-1.59*  |
| AUC = 0.86 (95% CI 0.81-0.90). R <sup>2</sup> =0.47  |      |            | AUC = 0.82 (95% CI 0.76-0.88). R <sup>2</sup> =0.33  |      |             |
| Magnetic Resonance subgroup (n=128)  |      |            | Magnetic Resonance subgroup (n=121)  |      |             |
| Patient characteristics, trauma characteristics, baseline severity of knee complaints and Magnetic Resonance findings <sup>3</sup> |      |            | Patient characteristics, trauma characteristics, baseline severity of knee complaints and Magnetic Resonance findings <sup>4</sup> |      |             |
| Time from trauma to inclusion  | 1.00 | 0.99-1.01  | Time from trauma to inclusion  | 1.01 | 0.99-1.02   |
| Return to sports at baseline   | 0.04 | 0.02-0.10* | Return to sports at baseline   | 0.23 | 0.06-0.83*  |
| Age  | 1.09 | 1.04-1.14* | NPRS previous 48 h   | 1.29 | 1.04-1.61*  |
|  |      |            | Traumatic meniscal tear  | 5.43 | 1.77-16.62* |
| AUC = 0.79 (95% CI 0.71-0.87). R <sup>2</sup> =0.36  |      |            | AUC = 0.79 (95% CI 0.70-0.88). R <sup>2</sup> =0.28  |      |             |

Adjusted for time from trauma to inclusion and baseline return to sports. Missing values ranged up to 1.6%. MR: magnetic resonance. 95% CI; 95% confidence interval. OR: odds ratio. AUC: area under the curve.

\*p<0.05. NPRS: Numeric Pain Rating Scale on a scale from 0-10, with a higher score indicating more pain.

<sup>1</sup>'Ball sport before trauma', 'trauma during sports', 'rotational trauma', 'popping sensation' and 'Tegner score' removed because of p>0.05. <sup>2</sup>'Age', 'MSK comorbidities', 'effusion during previous week', 'rotational trauma', 'popping sensation' and 'KOOS QoL' removed because of p>0.05. <sup>3</sup>'NPRS previous 48h', 'effusion on MR scan' and 'traumatic meniscal tear' removed because of p>0.05. <sup>4</sup>'Trauma during sport', 'effusion previous week', 'effusion on MR scan' and 'MCL/LCL distortion' removed because of p>0.05.

## DISCUSSION

### Main findings

The results of this study show that, at 6-weeks follow-up 41% of the patients aged 18-45 years with traumatic knee complaints reported not to have returned to sports. After 3 months, one in four patients was still not able to return to sports.

Adding MR findings to the patient characteristics, trauma characteristics and baseline severity of knee complaints did not improve the prediction of no return to sports at 6-weeks or 3-months follow-up.

### Comparison with literature

We found no studies focusing on return to sports in patients with traumatic knee complaints seen in general practice. In secondary care, in a pair-matched comparison of conservatively treated patients with ACL injuries versus ACL reconstruction, a return to sports rate of 68% was seen after one year in the conservative group; this percentage was not significantly different between the groups.<sup>19</sup> The rate is lower than the 74% found in our study at 3-months follow-up. However, our population included patients with all types of intra/extra-articular damage due to a trauma, in which only 34 (34.5%) patients had an ACL/PCL tear. The return to sport percentages for patients with traumatic knee complaints after surgery are even lower: i.e. 55% of the patients returned to sports after ACL reconstruction<sup>20</sup> and 61% after arthroscopic lateral meniscectomy.<sup>21</sup>

In patients after ACL reconstruction, younger age, male gender, playing elite sport and having a positive psychological response favoured returning to the preinjury level of sport.<sup>20,22</sup> In our study, there was no association between the Tegner score and the TAMPA scale with no return to sports. Possibly, these factors play an important role in the return to pre-injury level of sports, but not in the return to an adapted level of sports.

In this study, an MR scan had no additive value to patient/trauma characteristics and severity of knee complaints in predicting no return to sports at 6-weeks and 3-months follow-up. Possibly, an MR scan can be additive in revealing information regarding the underlying cause of the knee complaints which can be important in a later stage, for example in predicting re-injury. Our finding is however in accordance with a recent study on the absence of an additive value of an MR scan in the prediction of recovery in patients with low back pain in general practice.<sup>23</sup>

### Strengths and limitations

In this study, the p-value for the selection of variables for the multivariable analysis was set at 0.2. This might have caused a type 1 error; however, the number of variables tested were limited in the ratio of one per 10 patients. The final model of patient characteristics, trauma characteristics and baseline severity of knee complaints was used in the subgroup of patients to assess the additive value of MR scan. Although we did not validate the model in the subgroup, the groups were based on randomisation and there were no differences in patient characteristics between

the groups (with exception of the time from trauma to study inclusion, for which the analyses were adjusted: data not shown).

However, to our knowledge, this is the first study on return to sports in patients with traumatic knee complaints in general practice. These results of our study emphasise the difficulty patients with traumatic knee complaints have with return to sports. Identification of important predictors for no return to sports may serve to improve the treatment of patients with traumatic knee complaints in general practice.

### Implications

Future research should focus on all potential biological, psychological and social factors influencing return to sports. A large observational cohort with long term follow-up is needed to be able to give insight into which factors are associated with no return to sports on a pre-injury level.

Until then, based on the results of our study, the general practitioner can use the information gathered during history taking on patient characteristics, trauma characteristics, and the amount of pain to inform patients about the odds of returning to sports. Subsequently, the GP may consider to refer patients at high risk of no return to sports to physiotherapy. At 6-weeks, for patients who are older and have more pain the odds of return to sports decreases and at 3-months, for patients who experienced a trauma during sport, who had effusion during the previous week and in patients with more pain the odds of return to sports decreases. However, the general practitioner has to be aware that there may be other factors which we have not measured that may contribute to no return to sports.

### CONCLUSION

The results of this study show that 41% of the patients aged 18-45 years with traumatic knee complaints reported not to have returned to sports at 6-weeks follow-up and 26% of the patients reported not to have returned to sports at 3-months follow up. A combination of patient/trauma characteristics and knee complaints predicted no return to sports with an AUC of 0.86 at 6-weeks and of 0.82 at 3-months follow-up, whereas MR findings had no additive value (AUC 0.79 both at 6-weeks and 3-months follow-up).

#### Implications

- The odds of no return to sports at three months follow-up increases for patients who experienced a trauma during sport, for patients with more pain at baseline and for patients who reported effusion at baseline.
- Magnetic resonance findings has no additive value in predicting return to sports.

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**Appendix 1** Results of the bivariate logistic regression analysis for return to sports

|  | 6-weeks follow-up |                   |                    | 3-months follow-up |                   |                    |
|--|-------------------|-------------------|--------------------|--------------------|-------------------|--------------------|
|  | Return (n=147)    | No return (n=103) | OR (95% CI)        | Return (n=175)     | No return (n=60)  | OR (95% CI)        |
| <b>Patient characteristics<sup>1</sup></b>     |                   |                   |                    |                    |                   |                    |
| Age in years, median (IQR)                     | 32 (25, 39)       | 34 (27, 41)       | 1.09 (1.04-1.14)*  | 33 (25, 39)        | 32 (27, 40.8)     | 1.04 (1.00-1.08)** |
| Male gender                                    | 92 (62.6%)        | 66 (64.1%)        | 0.88 (0.47-1.65)   | 110 (62.9%)        | 39 (65%)          | 0.85 (0.44-1.64)   |
| BMI, median (IQR)                              | 24.7 (22.6, 26.9) | 24.7 (22.9, 27)   | 1.04 (0.96-1.14)   | 24.6 (22.8, 26.6)  | 24.2 (22.1, 26.9) | 1.01 (0.92-1.10)   |
| High educational level                         | 67 (45.6%)        | 41 (39.8%)        | 1.21 (0.65-2.25)   | 76 (43.4%)         | 28 (46.7%)        | 1.45 (0.77-2.75)   |
| MSK comorbidities                              | 29 (19.7%)        | 27 (26.2%)        | 1.80 (0.84-3.86)** | 40 (22.9%)         | 14 (23.3%)        | 1.01 (0.47-2.17)   |
| Previous knee complaints                       | 57 (38.8%)        | 47 (45.6%)        | 1.14 (0.77-2.69)   | 69 (39.4%)         | 29 (48.3%)        | 1.38 (0.72-2.61)   |
| Ball sport before trauma                       | 58 (39.5%)        | 56 (54.4%)        | 1.56 (0.85-2.87)** | 76 (43.4%)         | 33 (55%)          | 1.24 (0.65-2.35)   |
| Hours sport p/w, median (IQR)                  | 3 (2, 5)          | 3 (2, 5)          | 0.97 (0.87-1.10)   | 3 (2, 5)           | 4 (2, 5)          | 1.03 (0.93-1.15)   |
| Paid job before trauma                         | 130 (88.4%)       | 95 (92.2%)        | 0.78 (0.24-2.52)   | 157 (89.7%)        | 55 (91.7%)        | 0.84 (0.24-2.96)   |
| Hours spend on paid job p/w, median (IQR)      | 36 (30, 40)       | 40 (32, 40)       | 1.01 (0.98-1.04)   | 40 (32, 40)        | 38 (28, 40)       | 0.98 (0.95-1.02)   |
| <b>Trauma characteristics<sup>2</sup></b>      |                   |                   |                    |                    |                   |                    |
| Trauma during sport                            | 93 (63.3%)        | 74 (71.8%)        | 1.92 (1.00-3.71)*  | 110 (62.9%)        | 47 (78.3%)        | 2.45 (1.16-5.20)*  |
| Rotational trauma                              | 48 (32.7%)        | 56 (54.4%)        | 2.01 (1.08-3.74)*  | 64 (36.6%)         | 37 (61.7%)        | 2.15 (1.12-4.14)*  |
| Immediate pain                                 | 106 (71.8%)       | 78 (75.7%)        | 1.06 (0.53-2.11)   | 127 (72.6%)        | 47 (78.3%)        | 1.21 (0.57-2.55)   |
| Immediate effusion                             | 36 (24.5%)        | 31 (30.1%)        | 1.09 (0.56-2.12)   | 42 (24%)           | 18 (30%)          | 1.22 (0.61-2.44)   |
| Continuation activity impossible               | 94 (63.9%)        | 77 (74.8%)        | 1.00 (0.50-1.99)   | 120 (68.6%)        | 45 (75%)          | 0.83 (0.39-1.74)   |
| Popping sensation                              | 38 (25.9%)        | 48 (46.6%)        | 2.42 (1.27-4.59)*  | 52 (29.7%)         | 31 (51.7%)        | 2.32 (1.22-4.41)*  |
| <b>Severity of knee complaints<sup>3</sup></b> |                   |                   |                    |                    |                   |                    |
| Invited afterward consultation                 | 69 (46.9%)        | 29 (28.2%)        | 0.96 (0.45-2.05)   | 68 (38.9%)         | 18 (30%)          | 1.41 (0.63-3.15)   |
| Effusion previous week                         | 56 (38.1%)        | 73 (70.9%)        | 2.18 (1.13-4.20)*  | 74 (42.3%)         | 46 (76.7%)        | 3.20 (1.53-6.71)*  |
| NPRS previous 48h, median (IQR)                | 5 (2, 6)          | 6 (4, 7)          | 1.29 (1.11-1.50)*  | 4 (2, 6)           | 6 (5, 7)          | 1.36 (1.15-1.60)*  |
| Tegner score, median (IQR)                     | 4 (3, 5)          | 2 (1, 4)          | 0.87 (0.75-1.03)** | 3 (2, 5)           | 2 (1, 4)          | 0.96 (0.82-1.13)   |



**Appendix 1** Results of the bivariate logistic regression analysis for return to sports (continued)

|                                    | 6-weeks follow-up    |                         | 3-months follow-up   |                         |
|------------------------------------|----------------------|-------------------------|----------------------|-------------------------|
|                                    | Return (n=147)       | No return (n=103)       | Return (n=175)       | No return (n=60)        |
| TSK-11, median (IQR)               | 25 (21, 29)          | 27 (24, 32)             | 25 (21, 28)          | 28 (24, 32)             |
| KOOS QoL, median (IQR)             | 50 (37.5, 56.2)      | 37.5 (31.3, 50)         | 50 (37.5, 56.3)      | 37.5 (31.3, 43.8)       |
|                                    |                      |                         | OR (95% CI)          | OR (95% CI)             |
|                                    |                      |                         | 1.04 (0.98-1.10)     | 1.05 (0.99-1.12)**      |
|                                    |                      |                         | 0.98 (0.95-1.01)**   | 0.96 (0.92-0.99)*       |
| <b>Magnetic Resonance findings</b> | <b>Return (n=73)</b> | <b>No return (n=55)</b> | <b>Return (n=85)</b> | <b>No return (n=36)</b> |
|                                    |                      |                         | OR (95% CI)          | OR (95% CI)             |
| Effusion                           | 21 (28.8%)           | 33 (60%)                | 28 (32.6%)           | 22 (61.1%)              |
| Bone bruise FTJ                    | 17 (23.3%)           | 31 (56.4%)              | 28 (32.6%)           | 17 (47.2%)              |
| Fracture                           | 2 (2.7%)             | 9 (16.4%)               | 5 (5.8%)             | 5 (13.9%)               |
| Traumatic meniscal tear            | 8 (11%)              | 14 (25.5%)              | 8 (9.3%)             | 12 (33.3%)*             |
| MCL/PCL distortion                 | 11 (15.1%)           | 12 (21.8%)              | 18 (20.9%)           | 4 (11.1%)               |
| ACL/PCL tear                       | 12 (16.4%)           | 20 (36.4%)              | 16 (18.6%)           | 13 (36.1%)              |
| Cartilage damage                   | 15 (20.5%)           | 15 (27.3%)              | 17 (19.8%)           | 10 (27.8%)              |
|                                    |                      |                         | 1.07 (0.42-2.72)     | 1.26 (0.48-3.31)        |

Adjusted for duration of complaints at study inclusion and return to sports at baseline. Data are presented as numbers (percentages) unless otherwise stated. Missing values ranged up to 1.6%. p/w: per week. MR: magnetic resonance. IQR: inter quartile range. 95% CI: 95% confidence interval. OR: odds ratio. BMI: body mass index. MSK: musculoskeletal. NPRS: Numeric Pain Rating Scale on a scale from 0 to 10, with a higher score indicating more pain. TSK-11: Shortened version of the Tampa scale for kinesiophobia, from 11 to 44, with a higher score indicating more kinesiophobia. KOOS: Knee injury and Osteoarthritis Outcome Score on a scale from 0 to 100, with a higher score indicating less problems. QoL: quality of life. Tegner score from 0 to 10, with a higher score indicating less problems. FTJ: femorotibial joint. MCL: medial collateral ligament. LCL: lateral collateral ligament. ACL: anterior cruciate ligament. PCL: posterior cruciate ligament. \*p<0.05. \*\*p<0.20. † Unable to compute because of complete separation. ‡The variables 'sports in competition' and the 'Tegner score before trauma' were removed from the analysis because of multicollinearity with ball sport before trauma. §The variable 'trauma during ball sport' was removed from the analyses because of multicollinearity with trauma during sport. ¶The variables 'pain during previous week', the 'Lysholm score', 'KOOS pain', 'KOOS symptoms' and 'KOOS function in daily living' and KOOS sport and recreation were removed from the analyses because of multicollinearity.