

SUPPLEMENTARY FILE 4: Example

- 1. Examples to accompany the clinical and research recommendations**
- 2. Guidance for interpreting changes in patient reported outcomes, muscle function and functional performance outcomes**

1. Examples to accompany clinical and research recommendations

Table 1. Examples* to accompany clinical and research recommendations

*The table contains examples (not voted on) and is not meant to be an exclusive list

<p>C1. WHO to target to prevent PTOA:</p> <p>People with single and multi-structure injuries (particularly ACL tears, meniscal tears, intraarticular tibiofemoral fractures, and patellar dislocations with concomitant chondral lesions).</p> <p><u>Prioritise</u> people with symptoms and/or functional impairments that persist beyond usual recovery times, or with a subsequent injury.</p> <p>People to prioritise for PTOA prevention:</p> <ul style="list-style-type: none"> • Unable to reach a patient acceptable symptom state • Hop test limb symmetry index <90%¹ • Quadriceps strength symmetry index <80%² • Hamstring strength symmetry index <90%¹ • Overweight or obese³ • ACL graft rupture or ACLR revision
<p>C2. WHAT and WHEN to target to prevent PTOA after traumatic knee injury:</p> <p>Promote knee health through <u>education</u>, <u>self-management</u>, mitigating known modifiable <u>risk factors for re-injury and non-traumatic OA</u>, and <u>person-centred goals</u>. Start these efforts at the time of injury (as possible) and continue across the lifespan.</p> <p>Education topics⁴⁻⁷:</p> <ul style="list-style-type: none"> • Medium- and long-term impact of knee injuries on physical, mental and social health • Benefits of exercise (including strength training) and physical activity • Importance of preventing re-injury for OA prevention • Benefits and risks associated with surgery (including ACLR), and when and how to decide to progress to surgery <p>Self-management topics^{6,8}:</p> <ul style="list-style-type: none"> • Self-monitoring function • Adjusting exercise prescription • Pacing exercise and physical activity • Overcoming pain/effusion flares • Seeking healthcare support <p>Risk factors for re-injury and non-traumatic OA:</p> <ul style="list-style-type: none"> • Unhealthy bodyweight³ • Lower-limb muscle weakness, especially quadriceps strength^{1,2} • Physical inactivity⁹ • Female sex¹⁰ • Premature return to sport¹¹ <p>Features of patient centred goals¹²:</p> <ul style="list-style-type: none"> • Respect patients' values, preferences, expressed needs and available resources • Set in collaboration with the patient • Re-evaluated at regular intervals

C3. WHAT TO DO after ACL tear:

First-line ACL tear treatment includes education and exercise-therapy-based rehabilitation. Delay the decision to undergo ACLR until there is a 'quiet knee'. The decision to have an ACLR should be made by the patient (informed by relevant stakeholders) if they cannot achieve their acceptable functional level despite sufficient muscle function.

ACL tear and ACLR rehabilitation incorporates patient preferences, is goal and/or criterion-based, and begins with supervised rehabilitation then semi-supervised home (gym)-based rehabilitation to unsupervised home (gym) self-management.

Core components of ACL tear and ACLR exercise-based rehabilitation include: Weight-bearing, mobility, open and closed kinetic chain resistance-based, neuromuscular control and plyometric lower-limb exercises (including neuromuscular electrical stimulation to improve quadriceps strength); return to work, sport or other physical activity preparation; techniques to promote exercise adherence and self-management of knee health⁴; and cognitive behavioural techniques as appropriate.

ACL tear and ACLR Rehabilitation DOES NOT include blood-flow restriction training, whole-body vibration, continuous passive motion, or knee bracing.

Return to pivoting sports criteria after ACL tear or ACLR include being at least 9-months post-ACL tear or ACLR **AND** passing a return to sport test battery.

Education topics:

- Information about the injury
- Potential for tissue healing (e.g., ACL tear healing)
- Recovery timeline
- Management approaches (e.g., rehabilitation and/or surgery)
- Importance of (lifelong) self-management
- Return to activity criteria
- Risk for PTOA

Quiet knee:

- Little to no joint effusion or pain, full passive and active tibiofemoral and patellofemoral range of motion, straight leg raise with little to no extension lag, and little to no limp with gait.¹³

Stakeholders:

- Orthopaedic surgeon
- Rehabilitation professional
- Family members
- Coach

Sufficient muscle function:

- Limb symmetry index $\geq 90\%$ but still experiencing activity-related knee giving away

Supervised rehabilitation:

- Clinic or gym based
- Group class
- Digital (telerehab)

Exercise-based Rehabilitation:

- Weight bearing (e.g., walking, step up) and mobility (e.g., cycling, stretching) exercises
- Open (e.g., knee extension, hamstring curl), and closed chain (e.g., leg press, step down, squat) resistance-based exercises
- Open and closed chain lower limb neuromuscular control exercises (e.g., one leg balance, lunge)
- Open and closed chain lower limb plyometric exercises (e.g., jumping, hopping, pivoting, skipping)

Techniques for promoting exercise adherence and self-management¹⁴:

- Social support (therapeutic alliance)¹⁵
- Action planning and goal setting (e.g., SMART goals)¹⁶
- Instruction of behaviour followed by demonstration of behaviour
- Feedback on behaviour
- Practice/rehearsal

Cognitive behavioural techniques¹⁷:

- Relaxation
- Reframing injury and recovery
- Coping modelling
- Guided imagery
- Guided discovery of movements associated with fear
- Exposure to movements that are associated with a lack of confidence or fear
- Mindful movement

Return to sport test battery:

- >90% on the Knee Outcome Survey (Activities of Daily Living Scale), global rating scale of function, quadriceps symmetry AND hop test battery (crossover hop, single hop, triple hop and 6m timed hop) symmetry¹¹

C4. WHAT TO MONITOR after a traumatic knee injury:

Core clinical outcomes include: knee-related pain, other symptoms, adverse events, cognitive behavioural factors that influence learning and performance, physical function (e.g., self-reported function, functional performance and/or muscle function), QOL, and physical activity and sport participation.

Other important clinical outcomes can include: body weight, health-related QOL, participation in social roles, responsibilities and relationships (e.g., occupation, care-giving community participation), and injury-related mental health (e.g., depression, anxiety).

Diagnostic imaging is only indicated when results will inform treatment planning.

Other symptoms:

- Stiffness
- Functional instability
- Functional limitations
- Locking
- Clicking or crepitus

Adverse events:

- Contra-lateral knee injury
- Subsequent injury
- ACL graft rupture
- Giving away
- Locking

Cognitive behavioural factors that influence learning and performance^{8 18}:

- Fear (re-injury, giving out, locking)
- Anxiety (re-injury, giving out, locking)
- Frustration
- Knee confidence
- Knee self-efficacy
- Psychological readiness to return to sport

Physical activity and sport participation:

- Step count (commercial fitness tracker e.g., Fitbit®, iWatch®)
- Minutes of moderate intensity physical activity (commercial fitness tracker e.g., Fitbit®, iWatch®)
- Return to physical activities¹⁹
- Recreational activities or sport
- Return to competition
- Level of competition
- Restricted participation in a desired activity

C5. HOW TO MONITOR PATIENT-REPORTED OUTCOMES (PROs) after a traumatic knee injury:**Core clinical PROs to choose from to monitor MULTIPLE domains include:**

- IKDC-SKF (composite score of knee-related symptoms, function and sports activities)
- KOOS (composite score AND single scores for knee pain, other symptoms, function in daily living, function in sport/recreation, QOL)
- WOMET (overall composite score of knee-related physical symptoms, sports/recreation/work/lifestyle, and emotions; meniscal injury only)

Other clinical PROs to choose from to monitor SINGLE domains include:

- Pain: Numerical Rating Scale or Visual Analogue Scale
- Knee-related QOL: ACL QOL Score (ACL injury only)
- Health-related QOL: Visual Analogue Scale, or SF-12
- Knee-related cognitive behaviour factors: ACL-RSI Scale (ACL injury only), K-SES, or TSK-11
- Physical activity and sport participation: sport resumption and frequency
- Participation in social roles, responsibilities and relationships: occupation, care-giving and community
- Injury-related mental health: anxiety and depression

Health-related quality of life Visual Analogue Scale:

- At this moment how good or bad is your health? (0=the worst health you can imagine, 10=the best health you can imagine)

Physical activity and sport participation¹⁹:

- Since your knee injury have you attempted to do any recreational physical activity? (yes/no)
- Since your knee injury have you attempted training or competition in ANY sport? (no/yes-competition/yes-training only)
- Since your knee injury have you attempted training or competition in your MAIN pre-injury sport? (no/yes-at same or higher level/yes-at lower level, training only)
- Since your knee injury have you returned to your desired performance level? (no/yes)
- How many weeks in the last month have you done (*insert recommended number of minutes for your country*) minutes of moderate intensity physical activity?
- According to your commercial grade activity monitor (e.g., Fitbit®, iWatch®) what is your average weekly step count or minutes of exercise?

Participation in social roles, responsibilities and relationships:

- What (if any) social roles (e.g., committee leadership, coach, group membership, volunteer roles etc.), responsibilities (e.g., care provider, occupation etc.) and relationships (e.g., family role, friendships, mentor etc.) have been impacted by your knee injury?
- Which (if any) social roles, responsibilities and relationships are still impacted by your knee injury?

Injury-related mental health²⁰:

- Depression
 - Patient Health Questionnaire 9 (PHQ-9)
 - Beck Depression Inventory (BDI) and BDI-II
 - Community Epidemiologic Survey Depression (CES-D) scale for DSM-III depression
 - Zung depression scale
 - Quick Inventory of Depressive Symptomatology (QIDS)
- Anxiety
 - Beck Anxiety Inventory (BAI)
 - General Anxiety Disorder Scale 7 (GAD-7)
- Depression and Anxiety
 - Hopkins's symptom checklist (SCL-90)
 - Hospital and Anxiety Scale (HADS)

C6. HOW TO MONITOR MUSCLE FUNCTION after a traumatic knee injury

Core clinical knee muscle function measures include: peak thigh muscle (knee extensor/flexor) strength.

Clinical measures of peak knee extensor/flexor strength include (as available):

- Computerized dynamometry (concentric isokinetic contraction at $\geq 60^\circ/s$)
- Hand-held dynamometry (isometric 1RM)
- Weight machine (concentric isotonic 1RM knee extension or knee flexor curl)

Other important clinical muscle function measures include: thigh muscle endurance and power, and trunk, hip and leg, muscle function.

Computerized Dynamometry (concentric isokinetic contraction $\geq 60^\circ/s$):

- see Undheim et al²¹ for an example protocol

Hand-held Dynamometry (isometric 1RM):

- see Sinacore et al²² for an example protocol

Weight machine (concentric isotonic 1RM):

- see Sinacore et al²² for an example protocol
- see National Strength and Conditioning Association²³

Knee extensor or Flexor Endurance:

- Number of knee extension against a set weight until fatigue
- Number of hamstring curls against a set weight until fatigue

Knee extensor or flexor Power:

- Standing Broad Jump²³
- Vertical Jump²³

Trunk Muscles:

- Trunk flexors
- Trunk extensors
- Trunk side flexors
- Trunk rotators

Hip Muscles:

- Hip flexors
- Hip extensors
- Hip side flexors
- Hip rotators

Leg Muscles:

- Ankle plantar flexors
- Ankle dorsiflexors
- Ankle evertors
- Ankle invertors
- Toe extensors
- Toe flexors
- Foot intrinsics

C7. HOW TO MONITOR FUNCTIONAL PERFORMANCE after a traumatic knee injury:

Core clinical measures of functional performance include: hopping

Clinical measures to estimate hop performance include: a battery of forward (single and repeated), diagonal and/or vertical hop tests.

Core clinical hop tests include:

- Crossover hop (diagonal)
- Single hop (single-forward)
- Triple-hop (ciii) and 6m timed hop (repeated-forward)
- Vertical hop (vertical)

Other important clinical measures of functional performance include: balance, agility or other tasks meaningful to the patient.

Crossover Hop Test:

- see Kyritsis et al²⁴ and Xergia et al²⁵ for an example protocols

Single Hop Test:

- see Kyritsis et al²⁴ for an example protocol

Triple Hop Test:

- see Moksnes and Risberg²⁶ for an example protocol

6-meter Triple Hop Test:

- see Kise et al²⁷ for an example protocol

Vertical Hop Test:

- see Kotsifaki et al²⁸ for an example protocol

Balance tests:

- Y-balance test²⁹
- STAR excursion balance test³⁰

Agility tests:

- Shuttle run³¹
- T-ability test²⁴
- Sprint test³²
- Illinois agility test³²
- Figure of 8 run^{33 34}

Other meaningful functional tasks:

- Ascending or descending stairs or inclines
- Squatting
- Lunging
- Kneeling

C8. HOW TO INTERPRET PATIENT-REPORTED, MUSCLE FUNCTION, AND FUNCTIONAL PERFORMANCE outcome status and change:

To **interpret the change** and **current state** of an outcome, ask the patient if they have noticed a meaningful change in the domain, and if they feel their current state is acceptable/satisfactory. To better **understand a patient's experience** of an outcome domain after a knee injury ask about responses to individual PRO items.

Record the baseline and follow-up score, and direction of change (either improvement or deterioration) in the outcome, if the patient felt the change was meaningful, and if they feel that their current state of that outcome is acceptable/satisfactory.

To understand the current state, change and a patient's experience of an outcome domain:

- *'Have you noticed a meaningful change in your knee pain over the last 6 weeks?'*
- *'Taking into consideration all you do in a typical day, is the current state of your knee pain satisfactory?'*
- *'You indicate you are severely troubled by a lack of knee confidence; can you tell me a bit more about that? In what situations do you feel confident or lack confidence in your knee?'*

To document an outcome domain in a health record or report:

- *Name had a 15% improvement in their maximal knee extensor strength over 4 weeks, (baseline scores = 25 lbs, follow-up score = 29 lbs)*
- *Name reports that after taking into account all they have to do in a typical day, the current state of their knee extensor strength is satisfactory.*

ACL (Anterior Cruciate Ligament), ACL-QOL (ACL Quality-of-Life Score), ACLR (ACL reconstruction), ACL-RSI (ACL Return to Sport after Injury scale), BMI (body mass index), EQ-5D (EuroQol 5 Dimensions), GROC (Global Rate of Change), HHD (Hand-held dynamometry), IKDC-SKF (International Knee Documentation Committee Subjective Knee Form), K-SES (Knee Self Efficacy Scale), KOOS (Knee injury and Osteoarthritis Outcome Score), Lbs (pounds), m (meter), NRS (Numerical Rating Scale), PASS (patient acceptable symptom state), PTOA (post-traumatic osteoarthritis), PROs (patient-reported outcome measures), QOL (quality-of-life), RM (repetition maximum), SF-12 (Short Form 12), SF-36 (Short Form 36), SMART (specific, measurable, attainable, relevant, timebound), TSK (Tampa Scale of Kinesiophobia), WOMET (Western Ontario Meniscal Evaluation Tool).

2. Guidance for interpreting changes in patient reported outcomes, muscle function and functional performance outcomes

The following table contains information that will assist interpreting changes in patient reported, muscle function and functional performance outcomes.

Considerations for Interpreting the Change Scores in Table 2:

- Patient reported outcome meaningful change scores:
 - Reflect what the average participant considers to be a threshold for a meaningful improvement and can guide the interpretation of outcome domains after knee injury.
 - Are based on the most conservative thresholds reported for persons who have had an ACL tear with or without a concomitant meniscal tear, or meniscal surgery, spanning gender and various timepoints post injury/surgery (6-24 months). As they are based on the most conservative threshold for what might be considered a severe intra-articular knee injury, they are less likely to lead to the interpretation that a change was meaningful when it was not, but may lead to missing a meaningful change when one has occurred.
 - Are likely to change as new knowledge becomes available.
- Muscle Strength outcome change scores:
 - Reflect variation or change in muscle strength scores that can guide interpretation of a true change (greater than measurement error) after knee injury.
 - Variation is based on reported coefficients of variation (standard deviation/mean).
 - Change is based on reported standard deviations of change ($SDC=1.96*\sqrt{2}*Standard\ Error\ of\ Measurement$).
- Hop Test outcome change scores:
 - Reflect limb symmetry index values that can guide interpretation of a true change (greater than measurement error) after knee injury.
 - Limited by the observation that limb symmetry index is influenced by changes in performance of both the injured and contralateral leg.

Table 2. Guidance for interpreting changes in PROs, muscle function and hop performance

	Domain, Instrument and Meaningful Change Score	Evidence Level
Patient Reported Outcome	Multiple domain instruments change scores: <ul style="list-style-type: none"> • KOOS: see individual subscale change scores below • IKDC-SKF: change of 16/100 (ACL tear), 11/100 (meniscus tear) • WOMET: change of 15/100 (meniscus tear) 	ACL Tear IKDC-SKF (Low credibility) ^{35 36} Meniscus Tear IKDC-SKF (Very low credibility) ^{35 37} WOMET (Expert opinion) ^{38 39}
	Knee-related pain instruments change scores: <ul style="list-style-type: none"> • KOOS_{Pain}: change of 12/100 • NRS and VAS: change of 1.5/10 	KOOS _{Pain} (Low credibility) ³⁵ NRS (Expert opinion) ⁴⁰ VAS (Expert opinion) ⁴⁰
	Knee-related other symptoms instruments change scores: <ul style="list-style-type: none"> • KOOS_{Symptoms}: change of 6/100 (ACL tear), 12/100 (meniscus surgery) 	KOOS _{Symptoms} (Low credibility) ³⁵
	Knee-related physical function instrument change scores: <ul style="list-style-type: none"> • KOOS_{Sport/Rec}: change of 22/100 (ACL tear), 17/100 (meniscus tear) 	ACL Tear IKDC-SKF (Low credibility) ^{35 36} KOOS _{Sport/Rec} (Low credibility) ^{35 41} Meniscus Tear IKDC-SKF (Very low credibility) ^{35 37}
	Knee-related quality of life instruments change scores: <ul style="list-style-type: none"> • ACL QOL: change of 9/100 • KOOS_{QOL}: change of 18/100 (ACL tear), 17/100 (meniscus tear) 	ACL Tear ACL QOL (Very low credibility) ⁴² KOOS _{QOL} (High credibility) ^{35 41} Meniscus Tear KOOS _{QOL} (Low credibility) ^{2, 17}
	Knee-related cognitive behavioural factor instruments change scores: <ul style="list-style-type: none"> • ACL RSI: change of 3/100 • K-SES: change of 15/100 • TSK-17: change of 1/68 (ACL tear), 8/68 (meniscus tear) • TSK-11: change of 5/44 	ACL Tear ACL RSI (Low credibility) ^{35 43} K-SES (Expert opinion) TSK-17 (Low credibility) ^{35 44} TSK-11 (Expert opinion) Meniscus Tear TSK-17/TSK-11 (Expert opinion)
	Health-related quality of life instruments change scores: <ul style="list-style-type: none"> • EQ-5D-5L Index: change of 0.12 • SF-36 bodily pain: change of 8/100 • SF-12: change of 5.1/100 (PCS), 4.3/100 (MCS) 	EQ-5D-5L (Expert opinion) ⁴⁵ SF-36 (Expert opinion) ⁴⁶ SF-12 (Very low credibility) ²
	Patient Global Assessment (PASS) instrument change scores: <ul style="list-style-type: none"> • IKDC-SKF: 85/100 (ACLR), 69/100 (meniscal surgery) • KOOS_{Pain}: 93/100 (ACLR), 81/100 (meniscal surgery) • KOOS_{Symptoms}: 83/100 (ACLR), 78/100 (meniscal surgery) • KOOS_{Sport/Rec}: 88/100 (ACLR), 80/100 (meniscal surgery) • KOOS_{QOL}: 79/100 (ACLR), 57/100 (meniscal surgery) 	Expert opinion ^{2 11 16 17}
Muscle Strength	Muscle strength^a <ul style="list-style-type: none"> • Peak concentric knee extensor strength (60°/s): variation^a of 8.3% • Peak concentric knee extensor strength (180°/s): variation^a of 2.9% • Peak isometric knee extensor normalised (BW) strength: change^b of 1.7% • Peak concentric knee extensor strength LSI: change^b of 10.5% • Peak concentric knee flexor strength (60°/s and 180°/s): variation^a of 3.4% (60°/s) and 3.3% (180°/s) 	GRADE ⁴⁷ Very low
Hop Performance	Hop performance^{b,c} <ul style="list-style-type: none"> • Crossover Hop Test (CHT): LSI change of 14.6% • Single Hop Test (SHT): LSI change of 6.7%-9.7% • Triple Hop Test (THT): LSI change of 12.0% • Vertical Hop: LSI change of 10.0% • 6-meter Timed Hop Test: LSI change of 15.5% 	SHT, CHT, 6mTH, THT GRADE Very low ⁴⁸ VH Expert opinion

*Change scores represent the most conservative average thresholds reported for persons who have had an ACL tear with or without a concomitant meniscal tear, or meniscal surgery, spanning gender and various timepoints post injury/surgery. As they are based on the most conservative threshold for what might be considered a severe intra-articular knee injury, they are unlikely to lead to the interpretation that a change was meaningful when it was not, but may lead to missing a meaningful change when one has occurred. Values are likely to change as new knowledge becomes available.

^a Variation represents the coefficient of variation (standard deviation/mean)

^b Change represents the standard deviation of change ($SDC=1.96*\sqrt{2}$ *Standard Error of Measurement)

^c Limb symmetry index (LSI) is influenced by changes in performance of both the injured and contralateral leg.

ACL (Anterior Cruciate Ligament), ACL-QOL (ACL Quality-of-Life Score), ACLR (ACL reconstruction), ACL-RSI (ACL Return to Sport after Injury scale), BW (body weight), EQ-5D-5L (EuroQol 5 Dimensions), GRADE (Grading of Recommendations, Assessment, Development and

Evaluation), IKDC-SKF (International Knee Documentation Committee Subjective Knee Form), K-SES (Knee Self Efficacy Scale), KOOS (Knee injury and Osteoarthritis Outcome Score including pain, other symptoms, function in sport and recreation and quality of life subscales), LSI (limb symmetry index), MCS (Mental Component Score), NRS (Numerical Rating Scale), OA (osteoarthritis), PTOA (post-traumatic osteoarthritis), PCS (Physical Component Score), PROs (patient-reported outcome measures), PTOA (post-traumatic osteoarthritis), QOL (quality-of-life), RM (repetition maximum), s (second), SF-12 (Short Form 12), SF-36 (Short Form 36), TSK (Tampa Scale of Kinesiophobia), VAS (Visual Analogue Scale), WOMET (Western Ontario Meniscal Evaluation Tool).

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