

**SUPPLEMENTARY FILE 3: Consensus Definitions, Clinical Recommendations, and Research Recommendations**

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## 1. Definitions

**Table 1. Definitions**

Word	Definition
<b>Core Definitions (voted on)</b>	
<b>D1. Rehabilitation</b>	A health strategy aimed at enabling people with a health condition reach and maintain their optimal physical, sensory, intellectual, psychological and social functional levels. It does so by providing them with the tools needed to attain independence and self-determination.
<b>D2. Prevention</b>	Activities that mitigate modifiable risk factors for disease/illness. These activities can focus on reducing the risk of disease <sup>b</sup> /illness <sup>c</sup> in healthy individuals (primary prevention), early identification and reducing progression to disease or illness in individuals at high risk or with pre-clinical disease/illness (secondary prevention), or improving function and reducing disability in persons diagnosed with a disease/illness (tertiary prevention). In the context of OPTIKNEE, prevention refers to identifying and reducing progression from 'at-risk' to PTOA diagnosis in persons who have had a traumatic knee joint injury (secondary prevention).
<b>D3. Structural knee OA</b>	Knee OA defined by the presence of structural features on imaging, or arthroscopy, which reach an established expert or consensus threshold of magnitude and character to be termed OA (e.g., Kellgren & Lawrence grade, MRI-defined OA based on the MRI Osteoarthritis Knee Score, ICRS cartilage score).
<b>D4. Symptomatic knee OA</b>	Knee OA defined by consensus-based clinical signs and symptoms (e.g., American College of Rheumatology (ACR), National Institutes for Health and Care Excellence (NICE), European League Against Rheumatology (EULAR) definitions), excluding age restrictions, with or without the presence of structural features identified on imaging or arthroscopy.
<b>D5. Knee Injury</b>	Knee joint tissue damage or derangement resulting from a rapid or repeated transfer of kinetic energy.
<b>D6. Knee PTOA</b>	Structural or symptomatic OA that develops following a traumatic knee joint injury.
<b>D8. Early-onset knee PTOA</b>	Symptomatic or structural knee PTOA that develops in youth and young adults (i.e., young people with old knees). NOTE: Similar in concept to 'early-onset' as in 'early-onset' dementia.
<b>Other Definitions (not voted on)</b>	
<b>D9. Gender</b>	Socially constructed roles, behaviours, expressions and identities of girls, women, boys, men, and gender diverse people. It influences how people perceive themselves and each other, how they act and interact, and the distribution of power and resources in society. <sup>a</sup>
<b>D10. Sex</b>	A set of biological attributes in humans and animals. It is primarily associated with physical and physiological features including chromosomes, gene expression, hormone levels and function, and reproductive/sexual anatomy. Sex is usually categorized as female or male but there is variation in the biological attributes that comprise sex and how those attributes are expressed <sup>a</sup>
<b>D11. Disease</b>	The underlying biology and pathophysiology of a health condition.
<b>D12. Illness</b>	A person's experience of a health condition.
<b>D13. Function (physical)</b>	Body functions, activities and involvement in life situations that require moving around and performing activities <sup>b</sup>
<b>D14. Functional (physical) Performance</b>	The action of carrying out or accomplishing a movement, movement task or movement activity
<b>D15. Functional (physical) Impairment</b>	A decrement in physical functioning at the body level. <sup>b</sup>
<b>D16. Activity Limitation</b>	A decrement in physical functioning at a person level. <sup>b</sup>
<b>D17. Participation Restriction (physical)</b>	A decrement in physical functioning at a societal level. <sup>b</sup>
<b>D18. Credibility</b>	The quality of being trusted, convincing or believable.
<b>D19. Health Burden</b>	The impact of a health problem as measured by financial (years of life lived with disability, disability adjusted life years), mortality, morbidity (e.g., pain, functional or HRQOL decrements), or other indicators.
<b>D20. Health-related Quality of Life (HRQOL)</b>	A person's perception of their 'health' well-being. HRQOL is a multifactorial construct that consists of the physical, psychological, and social aspects of health and is influenced by an individual's perceptions, experiences, expectations, and beliefs. Solan et al 2008

<b>D21. Muscle Function</b>	An overarching term that refers to the capacity of a muscle to do work. Muscle function can be measured by neuromuscular outcomes such as strength (force), torque, power, endurance and rate of force development.
<b>D22. Muscle Strength</b>	The ability of a muscle to produce tension and a resulting force <sup>c</sup> <ul style="list-style-type: none"> <li>• Isometric: a change in muscle tension with no change in muscle length</li> <li>• Isotonic: a change in muscle length with a given muscle tension</li> <li>• Isokinetic: a change in muscle length and tension with a set contraction speed</li> <li>• Slow speed: 60, 90 and 120 deg/s</li> <li>• High speed: 180 and 300 deg/s</li> </ul>
<b>D23. Muscle Power</b>	The ability of a muscle to produce a force quickly (force x velocity (distance/time)) = rate of work)
<b>D24. Muscle Endurance</b>	The ability of a muscle to contract repeatedly against a load, generate and sustain tension and resist fatigue over a period of time.
<b>D25. Neuromuscular Control Exercises</b>	Activities that aim to enhance the optimal unconscious neurological and motor responses required for joint, limb and whole-body control of efficient postures and movement (e.g., balance, proprioceptive, readiness of response).
<b>D26. Plyometrics</b>	Activities that involve a rapid resisted eccentric muscle contraction immediately followed by a rapid resisted concentric contraction (reversal of movement) of the same muscle aimed at improving muscle power.

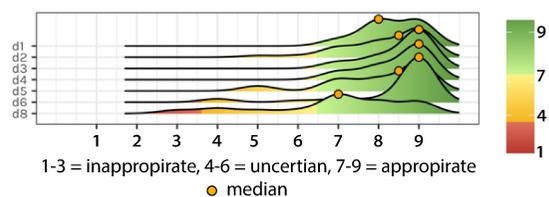
<sup>a</sup> <https://cihr-irsc.gc.ca/e/48642.html>

<sup>b</sup> <https://www.who.int/standards/classifications/international-classification-of-functioning-disability-and-health>

<sup>c</sup> Biodex Medical System. System 4 Clinical Resources Manual. Isokinetic Testing and Data Interpretation

PTOA (post-traumatic osteoarthritis), OA (osteoarthritis)

## 2. Core Definitions: Voting Distribution



### 3. Core Definitions: Dissenting Viewpoints

**Table 2. Core Definitions: Dissenting Viewpoints**

Word	Definition	Dissenting Viewpoint(s)
<b>D1. Rehabilitation</b>	A health strategy aimed at enabling people with a health condition reach and maintain their optimal physical, sensory, intellectual, psychological and social functional levels. It does so by providing them with the tools needed to attain independence and self-determination.	<ul style="list-style-type: none"> <li>A person may not be 'provided' the tools to be independent though this may be the 'aim'</li> <li>I interpret this to mean that folks universally do not have independence or self-determination prior to rehab, and they universally attain this through the tools provided. I would drop the last sentence.</li> </ul>
<b>D2. Prevention</b>	Activities that mitigate modifiable risk factors for disease/illness. These activities can focus on reducing the risk of disease/illness in healthy individuals (primary prevention), early identification and reducing progression to disease or illness in individuals at high risk or with pre-clinical disease/illness (secondary prevention), or improving function and reducing disability in persons diagnosed with a disease/illness (tertiary prevention). In the context of OPTIKNEE, prevention refers to identifying and reducing progression from pre-clinical to post-traumatic osteoarthritis diagnosis in persons who have had a traumatic knee joint injury (secondary prevention).	<ul style="list-style-type: none"> <li>Mostly appropriate but can't help feeling "injury" (primary) or "re-injury" (secondary) should be included with disease/illness.</li> <li>For the secondary prevention definition, I am not sure what "pre-clinical disease/illness" entails. Is this needed? Or can we go with targeting those at high risk?</li> <li>Not sure if the definition needs to include 'identifying'.</li> <li>The definition is too long</li> </ul>
<b>D3. Structural Knee OA</b>	Knee OA defined by the presence of structural features on imaging, or arthroscopy, which reach an established expert or consensus threshold of magnitude and character to be termed OA (e.g., Kellgren & Lawrence grade, MRI-defined OA based on the MRI Osteoarthritis Knee Score, ICRS cartilage score).	<ul style="list-style-type: none"> <li>Add an example for arthroscopy.</li> </ul>
<b>D4. Symptomatic Knee OA</b>	Knee OA defined by consensus-based clinical signs and symptoms (e.g., American College of Rheumatology (ACR), National Institutes for Health and Care Excellence (NICE), European League Against Rheumatology (EULAR), Osteoarthritis Research Society International (OARSI) definitions), excluding age restrictions, with or without the presence of structural features identified on imaging or arthroscopy.	<ul style="list-style-type: none"> <li>Many consensus-definitions are limited in applicability to PTOA by their age limit criteria</li> <li>What about ruling out other sources of symptoms in the absence of structural disease.</li> </ul>
<b>D5. Knee Injury</b>	Knee joint tissue damage or derangement resulting from a rapid or repeated transfer of kinetic energy.	<ul style="list-style-type: none"> <li>'Normal knee function' only applies to an initial injury with no history prior knee injury.</li> <li>'Repeated transfer of energy' implies overuse injuries and not relevant here. Remove the word 'kinetic' as it is not common to non-native English-speaking persons, or persons with no prior biomechanics' knowledge</li> </ul>
<b>D6. Knee PTOA</b>	Structural or symptomatic OA that develops following a traumatic knee joint injury.	<ul style="list-style-type: none"> <li>PTOA develops 'because' a knee injury occurred. Adding 'because' would signal a cause effect relationship and better delineate PTOA from insidious onset OA.</li> <li>It would be helpful to have a time frame to differentiate PTOA from early onset PTOA</li> </ul>
<b>D7. Early-onset Knee PTOA</b>	Symptomatic or structural knee PTOA that develops in youth and young adults (i.e., young people with old knees). NOTE: Similar in concept to 'early-onset' as in 'early-onset' dementia.	<ul style="list-style-type: none"> <li>Early-onset PTOA could occur in a middle-aged adult so 'young people with old knees' is not ideal as part of this definition.</li> <li>Recommend focusing on time after traumatic injury rather on specific age range.</li> <li>Early-onset may be better defined as "X amount of time since injury" rather than the age of the individual who has sustained an injury?</li> <li>Limiting to youth and young adults does not seem appropriate. It implies that PTOA is age related, whereas it is likely related to time post trauma than age.</li> <li>What we really mean, is an early-in-life incidence of OA, not an earlier onset of PTOA compared to the usual 10-15 years after knee trauma.</li> <li>I would not limit to "youth and young adults", as early PTOA can happen in adults (i.e., 30-35 years). The key is that the onset is younger than what is typically expected with OA (e.g., 60s) and leads to a greater number of years lived with disability.</li> </ul>

#### 4. Clinical Recommendations: Summary of Evidence and Appropriateness Rating

**Table 3. Clinical Recommendations: Summary of Evidence and Appropriateness Rating**

Clinical Recommendation		Evidence	Median	Min-Max	Mode	Appropriateness	Votes
<b>Who to target to delay or halt the onset of OA after traumatic knee injury</b>							
C1ai.	Persons with single structure knee injuries (cruciate ligament; collateral ligament; meniscus; chondral; fracture; dislocation) are at elevated risk of <i>symptomatic knee OA</i> compared to people without a knee injury.	Moderate (GRADE) <sup>1</sup>	9	7-9	9	Appropriate	32
C1aii	Persons with multi-structure knee injuries (ACL tear with concomitant injury; patellar dislocation with concomitant chondral injury) are at elevated risk of <i>symptomatic knee OA</i> compared to people without a knee injury or a single structure knee injury.	Moderate (GRADE) <sup>1</sup>	9	7-9	9	Appropriate	32
C1b.	Knee injuries associated with the most elevated risk of <i>symptomatic knee OA</i> include ACL tears, meniscus tears, intra-articular tibiofemoral fractures, and patellar dislocations with concomitant chondral lesions.	Moderate (GRADE) <sup>1</sup>	8.5	5-9	9	Appropriate	32
C1c.	Priority should be given to persons with knee-related symptoms and/or functional impairments that persist beyond the usual knee injury recovery times, or persons with a recurrent injury. <sup>a</sup>	Expert Opinion	7	2-9	7	Appropriate	32
<b>What and when to target to delay or halt the onset of symptomatic knee OA after a traumatic knee injury</b>							
Promote knee health through:							
C2a.	i. education <sup>a</sup>	Expert opinion <sup>2</sup>	9	5-9	9	Appropriate	32
	ii. self-management <sup>a</sup>	Expert opinion <sup>2</sup>	9	6-9	9	Appropriate	32
	iii. mitigating known modifiable risk factors for re-injury ad non-traumatic OA <sup>a</sup>	Expert opinion <sup>2</sup>	9	6-9	9	Appropriate	32
	iv. person-centered goals <sup>a</sup>	Expert opinion <sup>2</sup>	9	5-9	9	Appropriate	32
Efforts to delay or halt the onset of <i>symptomatic knee OA</i> after a traumatic knee injury:							
C2b.	i. commence at the time of injury (as possible)	Expert opinion <sup>2</sup>	8	3-9	9	Appropriate	32
	ii. continue across the lifespan	Expert opinion <sup>2</sup>	9	5-9	9	Appropriate	32
<b>What to do after and ACL tear</b>							
<i>The following are applicable to patients who have had an ACL tear and/or undergone an ACLR; but may not apply to every individual and situation.</i>							
<i>It is important that the patient and healthcare provider consider the unique features of a patient's injury, the resources available to them and their unique situation when developing a treatment plan.</i>							
First-line treatment of an ACL tear includes:							
C3a.	i. education <sup>a</sup>	Expert Opinion <sup>3</sup>	9	4-9	9	Appropriate	34
	ii. exercise therapy-based rehabilitation (see c3c, d and e)	Low <sup>4,5</sup> (GRADE)	9	6-9	9	Appropriate	34
The decision to undergo ACLR is:							
C3b.	i. delayed at least until there is a 'quiet knee' <sup>b</sup>	Expert opinion <sup>3</sup>	9	4-9	9	Appropriate	34
	ii. considered when a patient cannot achieve their acceptable functional level despite sufficient muscle function <sup>a</sup>	Expert opinion <sup>3</sup>	8	2-9	8	Appropriate	34
	iii. made by the patient and informed by relevant stakeholders <sup>a</sup>	Expert opinion <sup>3</sup>	9	2-9	9	Appropriate	34

ACL tear and ACLR rehabilitation:								
C3c.	i.	incorporate patient preferences	Expert opinion <sup>6,7</sup>	9	6-9	9	Appropriate	34
	ii.	are goal and/or criterion-based	Expert opinion <sup>8</sup>	9	6-9	9	Appropriate	34
	iii.	begin with supervised rehabilitation and progresses through semi-supervised home(gym)-based rehabilitation to unsupervised home (gym) self-management	Moderate (GRADE) <sup>4</sup> Expert opinion <sup>7</sup>	8.5	5-9	9	Appropriate	34
Core components of ACL tear and ACLR rehabilitation include:								
C3d.	i.	weight-bearing and ROM exercises <sup>a</sup>	Expert opinion <sup>8,7</sup>	9	7-9	9	Appropriate	34
	ii.	open and closed kinetic chain lower-limb resistance-based exercises <sup>a</sup>	Moderate (GRADE) <sup>4</sup> Expert opinion <sup>7</sup>	9	6-9	9	Appropriate	34
	iii.	lower-limb neuromuscular control exercises <sup>a</sup>	Very low (GRADE) <sup>4</sup> Expert opinion <sup>7</sup>	9	6-9	9	Appropriate	34
	iv.	lower-limb plyometrics <sup>a</sup>	Very low (GRADE) <sup>5</sup> Expert opinion <sup>7</sup>	8.5	6-9	9	Appropriate	34
	v.	return to work, sport or other physical activity preparation <sup>a</sup>	Expert opinion <sup>3,9</sup>	9	7-9	9	Appropriate	34
	vi.	techniques to promote exercise adherence and self-management of knee health <sup>a</sup>	Expert opinion <sup>10</sup>	9	6-9	9	Appropriate	34
	vii.	cognitive behavioural techniques <sup>c</sup>	Low (GRADE) <sup>4</sup> Expert opinion <sup>6,7</sup>	8	2-9	9	Appropriate	34
ACL tear and ACLR rehabilitation includes the following adjunct treatments to improve quadriceps strength:								
C3e.	i.	neuromuscular electrical stimulation <sup>a</sup>	Moderate (GRADE) <sup>4</sup> Expert opinion <sup>7</sup>	7	2-9	7	Appropriate	34
	ii.	blood-flow restriction training <sup>a</sup>	Very low (GRADE) <sup>4</sup> Expert opinion <sup>7</sup>	5.5	1-9	6	Uncertain	34
	iii.	whole-body vibration <sup>a</sup>	Low (GRADE) <sup>4</sup> Expert opinion <sup>7</sup>	4.5	1-9	5	Uncertain	34
ACL tear and ACLR rehabilitation <b>DOES NOT INCLUDE</b> the following adjunct treatments:								
C3f.	i.	continuous passive motion	Very low (GRADE) <sup>4</sup>	9	6-9	9	Appropriate	34
	ii.	knee bracing	Moderate (GRADE) <sup>4</sup>	7	1-9	9	Appropriate	34
The following criteria are achieved prior to returning to pivoting sports after ACL tear or ACLR:								
C3g.	i.	at least 9-months post ACLR surgery	Expert opinion <sup>3,9</sup>	9	2-9	9	Appropriate	34
	ii.	pass a return to sport test battery <sup>a</sup>	Expert opinion <sup>3,9</sup>	9	7-9	9	Appropriate	34

**What to monitor after a traumatic knee injury**  
 Recommendations apply to any traumatic knee injury and/or associated surgery unless otherwise indicated. Choice of domain(s) will vary based on individual presentation, goals and practicality. Domains are listed in alphabetical order.

Core domains to monitor after knee injury include:							
C4a.	i. knee-related adverse events <sup>a</sup> (including subsequent knee injury and giving way episodes)	Expert consensus <sup>11 12</sup>	9	7-9	9	Appropriate	31
	ii. knee-related cognitive behavioural factors <sup>a,c</sup>		8	5-9	9	Appropriate	31
	iii. knee-related quality of life		9	7-9	9	Appropriate	31
	iv. knee-related pain		9	6-9	9	Appropriate	31
	v. knee-related symptoms other than pain <sup>a</sup>		9	6-9	9	Appropriate	31
	vi. physical activity and sport participation <sup>a</sup>		9	6-9	9	Appropriate	31
	vii. physical function (including self-reported function, functional performance and/or muscle function)		9	6-9	9	Appropriate	31
Additional domains that <i>may</i> be important for clinicians to monitor after knee injury include:							
C4b.	i. body weight	Expert consensus <sup>11</sup> Expert opinion <sup>6 13</sup>	7	1-9	8	Appropriate	31
	ii. health-related quality of life (including physical and mental aspects)		8	5-9	9	Appropriate	31
	iii. mental health <sup>a</sup>		7	2-9	9	Appropriate	31
	iv. participation in social roles, responsibilities and relationships including occupation, care-giving and community participation <sup>a</sup>		8	3-9	9	Appropriate	31
C4c.	After knee injury, diagnostic imaging is only used if it will inform treatment planning	Expert consensus <sup>14</sup>	9	6-9	9	Appropriate	31

<b>How to Monitor: Patient Reported Outcomes</b>								
<i>Recommendations apply to any traumatic knee injury and/or associated surgery unless otherwise indicated. Recommended domains can be measured with instruments that measure multiple domains or individual domains. The instrument choice within each category will vary based on individual presentation, goals, practicality, and instrument availability. Domains and instruments are listed in alphabetical order.</i>								
C5a.	Recommended methods to monitor <b>multiple domains</b> after knee injury include:		ACL Tear:					
	<ul style="list-style-type: none"> <li>IKDC-SKF<sup>d</sup></li> <li>KOOS<sup>e</sup></li> <li>Western Ontario Meniscal Evaluation Tool (WOMET)<sup>f</sup></li> </ul>	<ul style="list-style-type: none"> <li>IKDC-SKF (COSMIN 3/8)<sup>12</sup></li> <li>KOOS (COSMIN 2/8)<sup>12</sup></li> </ul>	Meniscus Tear:	9	7-9	9	Appropriate	31
C5b.	Recommended methods to monitor <b>single domains</b> after knee injury include:							
	i.	cognitive behavioural factors: <ul style="list-style-type: none"> <li>ACL Return to Sport after Injury scale (ACL-RSI, ACL Tear only)</li> <li>Knee Self Efficacy Scale (K-SES)</li> <li>Tampa Scale of Kinesiophobia (TSK-17 or TSK-11)</li> </ul>	ACL-RSI (COSMIN 6/8) <sup>12</sup> K-SES (Expert Opinion) TSK-17, TSK-11 (Expert Opinion)	8	5-9	9	Appropriate	31
	ii.	knee-related pain: <ul style="list-style-type: none"> <li>Numerical Rating Scale (NRS)</li> <li>Visual Analogue Scale (VAS)</li> </ul>	NRS (Expert Opinion) VAS (Expert Opinion)	9	1-9	9	Appropriate	31
	iii.	knee-related quality of life: <ul style="list-style-type: none"> <li>ACL QOL score (ACL Tear only)</li> </ul>	ACL QOL (COSMIN 3/8) <sup>12</sup>	8	5-9	9	Appropriate	31
	iv.	health-related quality of life: <ul style="list-style-type: none"> <li>VAS: At this moment, how good or bad is your general/overall health? (0-the worst health you can imagine, 10-the best health you can imagine)</li> <li>SF-12<sup>g</sup></li> </ul>	Expert Opinion <sup>13</sup>	7	3-9	7	Appropriate	31
	v.	mental health <sup>e</sup> <ul style="list-style-type: none"> <li>See supplementary file for examples<sup>a</sup></li> </ul>	Expert Opinion <sup>16</sup>	7	1-9	7	Appropriate	31
	vi.	participation in social roles, responsibilities and relationships (including occupation, care-giving and community participation) <ul style="list-style-type: none"> <li>See supplementary file for examples<sup>a</sup></li> </ul>	Expert Opinion	7	1-9	7	Appropriate	31
	vii.	physical activity and sport participation <ul style="list-style-type: none"> <li>Physical Activity resumption and frequency<sup>a</sup></li> <li>Sport Participation type<sup>a</sup></li> </ul>	Expert Opinion <sup>17</sup>	8	5-9	9	Appropriate	31

<b>How to Monitor: Muscle Function<sup>h</sup></b>							
<i>Recommendations apply to any traumatic knee injury and/or associated surgery unless otherwise indicated. Tests should only be performed when it is safe to do so. Method choice may be influenced by individual presentation, goals, practicality, and availability of instruments. Methods are listed in alphabetical order.</i>							
C6a.	Recommended clinical measures of knee muscle function <sup>h</sup> after knee injury are peak knee extensor and flexor strength.	Expert Opinion <sup>18,19</sup>	9	5-9	9	Appropriate	33
	Recommended methods to estimate peak knee extensor and flexor strength in clinical settings include:						
	i. Computerised Dynamometry: concentric isokinetic contraction at $\geq 60^\circ/s$	Extensor GRADE <sup>18</sup> : • + Very low (Intra-RR) • + Moderate (Construct validity) Flexor GRADE <sup>18</sup> : • + Very low (Intra-RR) • - Moderate (Construct validity)	8.5	3-9	9	Appropriate	33
C6b.	ii. Hand-held Dynamometry <sup>h</sup> : isometric 1RM	Extensor GRADE <sup>18</sup> : • + Moderate (Intra-RR) • - Very low (Inter-RR) • - High (Criterion validity) • - High (Construct validity)	7	1-9	7	Appropriate	33
	iii. weight machine (e.g., knee extension or prone leg curl): concentric isotonic 1RM <sup>j</sup>	Extensor/Flexor GRADE <sup>18</sup> : • + High (Criterion validity)	8	4-9	9	Appropriate	33
C6c.	Recommended additional clinical measures of knee muscle function <sup>h</sup> that are important to monitor after knee injury include:						
	i. knee extensor and flexor endurance	Expert Opinion	7	1-9	7	Appropriate	33
	ii. knee extensor and flexor power	Expert Opinion	8	2-9	7	Appropriate	33
C6d.	Recommended other muscle groups to monitor after knee injury include those in the lower leg, hip and trunk (see supplementary file for examples <sup>a</sup> )	Expert Opinion	8	4-9	9	Appropriate	33

<b>How to Monitor: Functional Performance<sup>k</sup></b>							
<i>Recommendations apply to any traumatic knee injury and/or associated surgery unless otherwise indicated. Tests should only be performed when it is safe to do so. Method choice may be influenced by individual presentation, goals, practicality, and availability of instruments. Methods are listed in alphabetical order.</i>							
C7a.	Recommended clinical measures of functional performance <sup>k</sup> after a knee injury are hop performance.	Expert Opinion <sup>20</sup>	9	5-9	9	Appropriate	33
Recommended methods to estimate hop performance in clinical settings include:							
C7b.	i. a battery of hop tests (e.g., more than one test)	Expert Opinion <sup>20</sup>	9	5-9	9	Appropriate	33
	ii. the hop battery should include tests that assess forward (single and repeated), diagonal and/or vertical hopping		9	5-9	9	Appropriate	33
Recommended hop tests for use after knee injury include <sup>l</sup> :							
C7c.	i. Diagonal hop = Crossover Hop Test (CH) <sup>m</sup>	CH GRADE <sup>21</sup> : • + Moderate (Intra-RR) • + Moderate (Construct validity) + Low (Responsiveness)	8	4-9	9	Appropriate	33
	ii. Single forward hop = Single Hop Test (SLH) <sup>m</sup>	SLH GRADE <sup>21</sup> : • + High (Intra-RR) • + Low (Construct validity) + Low (Responsiveness)	8	5-9	9	Appropriate	33
	iii. Repeated forward hop = Triple Hop Test (TH) <sup>m</sup>	TH GRADE <sup>21</sup> : • + Very low (Intra-RR) • + Moderate (Construct validity) - Low (Responsiveness)	8	4-9	9	Appropriate	33
	iv. Vertical hop = Vertical Hop Test (VH) <sup>m</sup>	VH GRADE <sup>21</sup> : • + Moderate (Intra-RR) + Moderate (Construct validity)	8	5-9	9	Appropriate	33
	v. Repeated forward hop = 6-meter Timed Hop Test (6mTH) <sup>m</sup>	6mTH GRADE <sup>21</sup> : • + Moderate (Intra-RR) • + Moderate (Construct validity) - Low (Responsiveness)	8	4-9	9	Appropriate	33
C7d.	Recommended additional clinical measures of functional performance that are important to monitor after knee injury include balance, agility or other task meaningful to the patient. <sup>a</sup>	Expert Opinion	9	5-9	9	Appropriate	33

<b>Interpreting Patient Reported, Muscle Function and Functional Performance Outcome Status and Change</b>							
C8a.	To interpret a change in an outcome domain after knee injury, ask the patient if they have noticed a meaningful change in the domain. <i>Example: 'Have you noticed a meaningful change in your <u>knee pain</u>, over the last <u>6 weeks</u>?'</i>		9	7-9	9	Appropriate	31
C8b.	To assess the current state of an outcome domain after knee injury, ask the patient if they feel their current state is acceptable/satisfactory. <i>For example: 'Taking into consideration all you do in a typical day, is the current state of your <u>hop performance</u> satisfactory?'</i>	GROC concept <sup>22</sup> PASS concept <sup>23</sup> Expert Opinion	8.5	6-9	9	Appropriate	31
C8c.	To better understand a patient's experience of an outcome domain after a knee injury, ask them about individual PROM item responses. <i>Example (KOOS Q3): '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?'</i>		9	6-9	9	Appropriate	31
To document an outcome domain for a health record or report, include the following information:							
	i. The baseline and follow-up score, and any change (either improvement or deterioration) in the outcome. <i>Example: <u>insert name</u> had a 15% improvement in knee extensor strength over <u>4 weeks</u>, (baseline scores = <u>25 lbs</u>, follow-up score = <u>29 lbs</u>)</i>		9	6-9	9	Appropriate	31
C8d.	ii. If the patient felt the change in the outcome was meaningful. <i>Example: <u>insert name</u> felt that the increase was meaningful</i>		9	7-9	9	Appropriate	31
	iii. If the person feel that their current state of an outcome is acceptable/satisfactory. <i>Example: <u>insert name</u> 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.</i>		9	6-9	9	Appropriate	31

<sup>a</sup>See attached supplementary file for examples (examples were not be voted on)

<sup>b</sup>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.<sup>24</sup>

<sup>c</sup>Techniques that target characteristics of a person that affect performance and learning

<sup>d</sup>Assesses knee-related symptoms, sports activities, function and activities of daily living

<sup>e</sup>Assesses knee-related pain, other symptoms, function in daily living, function in sport and recreation, quality of life

<sup>f</sup>Assesses knee-related physical symptoms, sports, recreation, work, lifestyle, emotions

<sup>g</sup>Licensing requirements apply but may be available through your employer

<sup>h</sup>Muscle function refers to the capacity of a muscle to do work. Muscle function can be measured as strength, power, or endurance.

<sup>i</sup>Hand-held dynamometry assessment of isometric knee extensor and flexor strength can underestimate strength. To obtain the most precise estimate it is important to secure the femur, have the patient push into resistance generated by a fixed belt (not the assessor hand), and for re-assessment to be conducted by the same assessor. Isometric scores are not interchangeable with isokinetic or isotonic scores.

<sup>j</sup>Estimates of 1RM should be based on the average of at least two repeated measures of maximum effort.

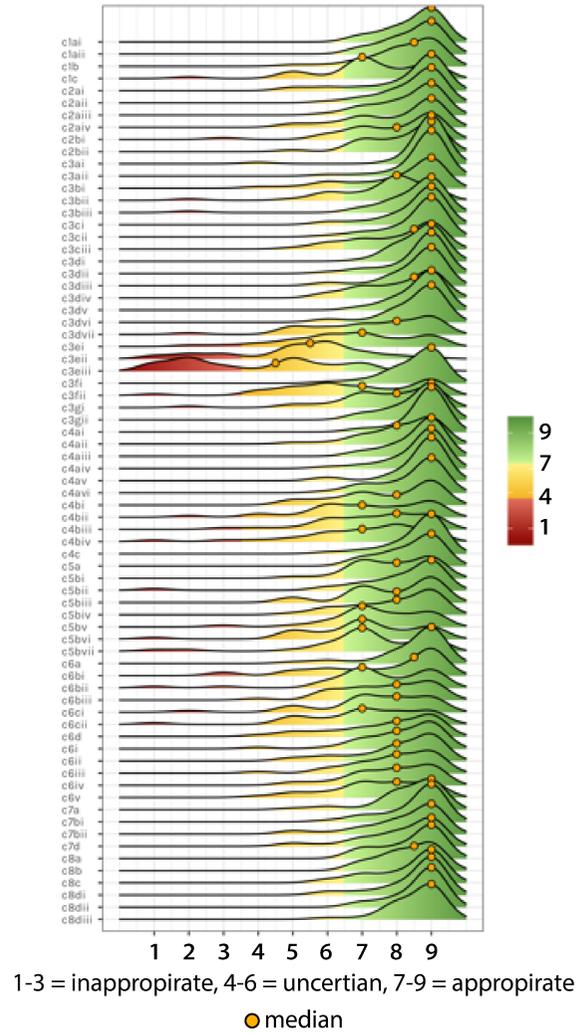
<sup>k</sup>Functional performance is the action of carrying out or accomplishing a movement, movement task or movement activity

<sup>l</sup>Insufficient evidence to inform the 'best' test or 'best' order

<sup>m</sup>See supplementary file for test description

+ (sufficient measurement property), - (insufficient measurement property) as per the COSMIN, 1-RM (1 repetition maximum), ACL (Anterior Cruciate Ligament), ACLR (ACL reconstruction), GRADE (Grading of Recommendations, Assessment, Development and Evaluations), OA (osteoarthritis), PROM (patient reported outcome measure), ROM (range of motion), RR (Rater Reliability)

### 5. Clinical Recommendations: Voting Distribution



## 6. Clinical Recommendations: Dissenting Viewpoints

**Supplementary Table 4. Clinical Recommendations: Dissenting Viewpoints**

Clinical Recommendation		Comments and Dissenting Viewpoints
<b>Who to target to delay or halt the onset of OA after traumatic knee injury</b>		
C1a.	Persons with single structure knee injuries (cruciate ligament; collateral ligament; meniscus; chondral; fracture; dislocation) are at elevated risk of <i>symptomatic knee OA</i> compared to people without a knee injury.	<ul style="list-style-type: none"> <li>Is this list exhaustive meant to be exhaustive?</li> </ul>
C1b.	Persons with multi-structure knee injuries (ACL tear with concomitant injury; patellar dislocation with concomitant chondral injury) are at elevated risk of <i>symptomatic knee OA</i> compared to people without a knee injury or a single structure knee injury.	
C1c.	Knee injuries associated with the most elevated risk of <i>symptomatic knee OA</i> include ACL tears, meniscus tears, intra-articular tibiofemoral fractures, and patellar dislocations with concomitant chondral lesions.	<ul style="list-style-type: none"> <li>Is there specific guidance being provided on usual knee injury recovery times?</li> </ul>
C1d.	Priority should be given to persons with knee-related symptoms and/or functional impairments that persist beyond the usual knee injury recovery times, or persons with a recurrent injury. <sup>a</sup>	<ul style="list-style-type: none"> <li>It is unclear what priority should be given to these people? Priority to healthcare access, prevention, extensive evaluation, larger dose of treatment?</li> </ul>
<b>What and when to target to delay or halt the onset of OA after a traumatic knee injury</b>		
Efforts to delay or halt the onset of <i>symptomatic knee OA</i> after a traumatic knee injury should promote knee health through:		
C2a.	i. Education <sup>a</sup>	
	ii. Self-management <sup>a</sup>	<ul style="list-style-type: none"> <li>I can see all of these points as part of a broad strategy to facilitate self-management.</li> </ul>
	iii. Mitigating known modifiable risk factors for re-injury and non-traumatic OA <sup>a</sup>	
	iv. Person-centered goals <sup>a</sup>	<ul style="list-style-type: none"> <li>Is a patient-centered goal a goal that a patient has established themselves? Or a goal that is set with consideration for patient preference? I am not sure if a goal that a patient sets entirely themselves will prevent OA, but I do think it is the correct approach to treatment</li> </ul>
Efforts to delay or halt the onset of <i>symptomatic knee OA</i> after a traumatic knee injury should:		
C2b.	i. Commence at the time of injury (as possible)	<ul style="list-style-type: none"> <li>The initial injury management period already has enough immediate priorities to add PTOA as an additional core focus.</li> </ul>
	ii. Continue across the lifespan	<ul style="list-style-type: none"> <li>'Lifespan may be too vague'.</li> </ul>
<b>What to do after and ACL tear</b>		
<i>The following are applicable to patients who have had an ACL tear and/or undergone an ACLR; but may not apply to every individual and situation. It is important that the patient and healthcare provider consider the unique features of a patient's injury, the resources available to them and their situation when developing a treatment plan.</i>		
First-line treatment of an ACL tear includes:		
C3a.	i. Education <sup>a</sup>	<ul style="list-style-type: none"> <li>Is education the best word? It implies that someone chooses the knowledge to push to the patient vs. the patient requesting information that is relevant = Informational Support</li> </ul>
	ii. Exercise therapy-based rehabilitation (see C3c, d and e)	
The decision to undergo ACLR should be:		
C3b.	i. Delayed at least until there is a 'quiet knee' <sup>b</sup>	
	ii. Considered when a patient cannot achieve their acceptable functional level despite sufficient muscle function <sup>a</sup>	<ul style="list-style-type: none"> <li>What if a patient cannot achieve muscle function? What is sufficient muscle function? Is this a critical metric for surgical decision making? Are some patients unable to achieve sufficient muscle function due to pain or other symptoms relating to instability?</li> </ul>
	iii. Made by the patient and informed by relevant stakeholders <sup>a</sup>	

	ACL tear and ACLR rehabilitation should:	
C3c.	i. Incorporate patient preferences	
	ii. Be goal and/or criterion-based	
	iii. Begin with supervised rehabilitation and progress through semi-supervised home (gym)-based rehabilitation to unsupervised home (gym) self-management	<ul style="list-style-type: none"> <li>• What about periodic check-ups when transitioning to fully away from the clinic. Supervision at later stages is also important – is it a question about resources?</li> </ul>
	Core components of ACL tear and ACLR rehabilitation include:	
C3d.	i. Weight-bearing and ROM exercises <sup>a</sup>	
	ii. Open and closed kinetic chain lower-limb resistance-based exercises <sup>a</sup>	
	iii. Lower-limb neuromuscular control exercises <sup>a</sup>	
	iv. Lower-limb plyometrics <sup>a</sup>	
	v. Return to work, sport or other physical activity preparation <sup>a</sup>	
	vi. Techniques to promote exercise adherence and self-management of knee health <sup>a</sup>	
	vii. Cognitive behavioural techniques <sup>c</sup>	
	Adjunct treatments for ACL tear and ACLR rehabilitation to improve quadriceps strength can include:	
C3e.	i. Neuromuscular electrical stimulation <sup>a</sup>	
	ii. Blood-flow restriction training <sup>a</sup>	<ul style="list-style-type: none"> <li>• Not convinced there is enough benefit to outweigh cost, therapist need, and discomfort</li> </ul>
	iii. Whole-body vibration <sup>a</sup>	
	ACL tear and ACLR rehabilitation does not include the following adjunct treatments:	
C3f.	i. Continuous passive motion	
	ii. Knee bracing	<ul style="list-style-type: none"> <li>• There may be a time for bracing (e.g., unloader orthoses in the early post-ACL injury to improve weight bearing, placebo effect when doing demanding activities, lack of knee confidence, to progress rehabilitation, patient preference, to limit knee motion for patients with range of motion restrictions - meniscus repair).</li> <li>• Acknowledge that this recommendation could change over time with new evidence.</li> </ul>
	After an ACL tear or ACLR, the following criteria should be achieved prior to returning to pivoting sports:	
C3g.	i. At least 9-months post ACLR surgery	<ul style="list-style-type: none"> <li>• 9-month cut off is arbitrary and based on one study. I agree with the rationale for using a time cut. Not sure what the appropriate 'time' is.</li> </ul>
	ii. Pass a return to sport test battery <sup>a</sup>	
<b>What to monitor after a traumatic knee injury</b>		
<i>Recommendations apply to any traumatic knee injury and/or associated surgery unless otherwise indicated. Choice of domain(s) will vary based on individual presentation, goals and practicality. Domains are listed in alphabetical order.</i>		
	Core domains to monitor after knee injury include	
C4a.	i. knee-related adverse events <sup>a</sup> (including subsequent knee injury and giving way episodes)	
	ii. knee-related cognitive behavioural factors <sup>b,c</sup>	<ul style="list-style-type: none"> <li>• Does it have to be "knee-related" or can it be broad cognitive behavioural factors?</li> </ul>
	iii. knee-related quality of life	
	iv. knee-related pain	
	v. knee-related symptoms other than pain <sup>a</sup>	
	vi. physical activity and sport participation <sup>a</sup>	
	vii. physical function (including self-reported function, functional performance and/or muscle function)	

Additional domains that <i>may</i> be important for clinicians to monitor after knee injury include:	
i. body weight	<ul style="list-style-type: none"> <li>• Monitor weight on a case-by-case basis depending on and in consultation with the patient.</li> <li>• Weight management may be appropriate, but clinically calculating BMI is time consuming.</li> <li>• BMI is not as meaningful as body weight to a patient.</li> <li>• Focusing on PA and nutrition is probably more effective than focusing on weight.</li> </ul>
-----	
C4b. ii. health-related quality of life (including physical and mental aspects)	
iii. mental health <sup>a</sup>	<ul style="list-style-type: none"> <li>• It might be appropriate to screen for mental health issues but not to monitor ongoing.</li> <li>• Mental health monitoring requires a specific skill set and requires consultation with qualified healthcare professional vs. a physiotherapist.</li> <li>• I don't agree with monitoring or measuring continuously.</li> <li>• How is mental health different from mental aspects of QOL?</li> </ul>
-----	
iv. participation in social roles, responsibilities and relationships including occupation, care-giving and community participation <sup>a</sup>	<ul style="list-style-type: none"> <li>• It might be appropriate to screen but not to monitor in an ongoing fashion.</li> </ul>
-----	
C4c. After knee injury, diagnostic imaging is only used if it will inform treatment planning	
<b>How to Monitor: Patient Reported Outcomes</b>	
<i>Recommendations apply to any traumatic knee injury and/or associated surgery unless otherwise indicated. Recommended domains can be measured with instruments that measure <b>multiple domains</b> or <b>individual domains</b>. The instrument choice within each category will vary based on individual presentation, goals, practicality, and instrument availability. Domains and instruments are listed in alphabetical order.</i>	
Recommended methods to monitor <b>multiple domains</b> after knee injury include:	
C5a. <ul style="list-style-type: none"> <li>• IKDC-SKF<sup>d</sup></li> <li>• KOOS<sup>e</sup></li> <li>• Western Ontario Meniscal Evaluation Tool (WOMET)<sup>f</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Freely available multi-domain instruments are the best value for the clinic (time and resource restraints)</li> </ul>
-----	
Recommended methods to monitor <b>single domains</b> after knee injury include:	
i. cognitive behavioural factors: <ul style="list-style-type: none"> <li>• ACL Return to Sport after Injury scale (ACL-RSI, ACL Tear only)</li> <li>• Knee Self Efficacy Scale (K-SES)</li> <li>• Tampa Scale of Kinesiophobia (TSK-17 or TSK-11)</li> </ul>	<ul style="list-style-type: none"> <li>• TSK17/11 may not assess fear of reinjury/reinjury anxiety but I guess the best out there?</li> <li>• The recommendations offer guidance on which domain(s) to evaluate, but not which specific PROM is best to use within each domain</li> </ul>
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ii. knee-related pain: <ul style="list-style-type: none"> <li>• Numerical Rating Scale (NRS)</li> <li>• Visual Analogue Scale (VAS)</li> </ul>	
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iii. knee-related quality of life: <ul style="list-style-type: none"> <li>• ACL QOL score (ACL Tear only)</li> </ul>	
-----	
C5b. iv. health-related quality of life: <ul style="list-style-type: none"> <li>• VAS: At this moment, how good or bad is your general/overall health? (0-the worst health you can imagine, 10-the best health you can imagine)</li> <li>• SF-12<sup>g</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Why is EQ-5D-5L not included</li> </ul>
-----	
v. mental health <sup>a</sup> <ul style="list-style-type: none"> <li>• See supplementary file for examples<sup>a</sup></li> </ul>	
-----	
vi. participation in social roles, responsibilities and relationships (including occupation, care-giving and community participation) <ul style="list-style-type: none"> <li>• See supplementary file for examples<sup>a</sup></li> </ul>	
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vii. Physical activity and sport participation <ul style="list-style-type: none"> <li>• Physical Activity resumption and frequency<sup>a</sup></li> <li>• Sport Participation type<sup>a</sup></li> </ul>	

<b>How to Monitor: Muscle Function<sup>b</sup></b>	
<i>Recommendations apply to any traumatic knee injury and/or associated surgery unless otherwise indicated. Tests should only be performed when it is safe to do so. Method choice may be influenced by individual presentation, goals, practicality, and availability of instruments. Methods are listed in alphabetical order.</i>	
C6a. Recommended clinical measures of knee muscle function <sup>b</sup> after knee injury are peak knee extensor and flexor strength.	<ul style="list-style-type: none"> <li>It is important to state whether this is something all should do, or only those that have the time and equipment for it. Obviously, muscle strength is important, but not all would have a dynamometer, so if it is something we consider a core outcome, then we need to accept that people do it with a weight machine although the other measures might be better.</li> </ul>
Recommended methods to estimate peak knee extensor and flexor strength in clinical settings include:	<ul style="list-style-type: none"> <li>Consider indicating that this list is a gradient from best/most accurate to least accurate - dynamometer &gt; HHD &gt; weight machine. Clinicians should understand and acknowledge the uncertainty and imprecision when making clinical decisions.</li> </ul>
C6b. i. computerised Dynamometry: concentric isokinetic contraction at $\geq 60^\circ/s$	<ul style="list-style-type: none"> <li>Based on availability – appropriate if available/access</li> </ul>
ii. Hand-held dynamometry <sup>d</sup> : isometric 1RM	<ul style="list-style-type: none"> <li>Isokinetic testing at <math>\geq 180^\circ/s</math> is less reliable and can be quite uncomfortable for patients</li> <li>Include caveat on measurement position/set up are needed for quad</li> <li>1 RM can be estimated sub maximally, and may be most appropriate in acute situations</li> </ul>
iii. weight machine (e.g., knee extension or prone leg curl): concentric isotonic 1RM <sup>e</sup>	<ul style="list-style-type: none"> <li>I like 3 or 5 RM for weight machine for knee extension or hamstring curl. I find this to be better for the patient. Might suggest adding a one line here of 1, 3, or 5 RM.</li> </ul>
Recommended additional clinical measures of knee muscle function <sup>b</sup> that are important to monitor after knee injury include:	<ul style="list-style-type: none"> <li>Is there a hierarchy implied here, e.g., endurance is more important than power or vice versa? Is one more important than the other?</li> </ul>
C6c. i. knee extensor and flexor endurance	<ul style="list-style-type: none"> <li>Provide examples on how to do assess power and endurance otherwise leave out. Typically, power and endurance highly correlate with strength anyway.</li> </ul>
ii. knee extensor and flexor power	<ul style="list-style-type: none"> <li>I question the clinical feasibility of muscle power tests (e.g., rate of force development)</li> </ul>
C6d. Recommended other muscle groups to monitor after knee injury include those in the lower leg, hip and trunk.	<ul style="list-style-type: none"> <li>It is important to keep monitoring the most important muscles (i.e., knee extensors/flexors).</li> </ul>
<b>How to Monitor: Functional Performance<sup>k</sup></b>	
<i>Recommendations apply to any traumatic knee injury and/or associated surgery unless otherwise indicated. Tests should only be performed when it is safe to do so. Method choice may be influenced by individual presentation, goals, practicality, and availability of instruments. Methods are listed in alphabetical order.</i>	
C7a. Recommended clinical measures of functional performance <sup>k</sup> after a knee injury are hop performance.	<ul style="list-style-type: none"> <li>What if a hop is not a meaningful function for the patient?</li> <li>Clinically, hopping is less important than peak strength, and power and endurance in functional tasks</li> </ul>
Recommended methods to estimate hop performance in clinical settings include:	
C7b. i. a battery of hop tests (e.g., more than one test)	<ul style="list-style-type: none"> <li>All directions of hop may be appropriate but not feasible in a general clinical setting.</li> <li>Clarify that this recommendation is based on a combination of tests, rather than recommending all are completed with each patient</li> </ul>
ii. the hop battery should include tests that assess forward (single and repeated), diagonal and/or vertical hopping	<ul style="list-style-type: none"> <li>Do we know enough to recommend all hop directions - as it increases testing burden?</li> <li>Should be specific to the patient's needs and intended activity/sport demands.</li> <li>Is there a hierarchy implied in the order?</li> </ul>
Recommended hop tests for use after knee injury include <sup>l</sup> :	
C7c. i. Diagonal hop = Crossover Hop Test (CH) <sup>m</sup>	
ii. Single forward hop = Single Hop Test (SLH) <sup>m</sup>	
iii. Repeated forward hop = Triple Hop Test (TH) <sup>m</sup>	
iv. Vertical hop = Vertical Hop Test (VH) <sup>m</sup>	
v. Repeated forward hop = 6-meter Timed Hop Test (6mTH) <sup>m</sup>	<ul style="list-style-type: none"> <li>Caution for responsiveness (insufficient but low evidence)</li> </ul>
C7d. Recommended additional clinical measures of functional performance that are important to monitor after knee injury include balance, agility or other task meaningful to the patient. <sup>a</sup>	<ul style="list-style-type: none"> <li>This is really broad</li> <li>For balance, consider dynamic balance, which has more use in sport setting.</li> <li>Should we also recommend monitor performance of tasks under fatigue?</li> </ul>

**Interpreting Patient Reported, Muscle Function and Functional Performance Outcome Domain Status and Change**

- C8a. To interpret a change in an outcome domain after knee injury, ask the patient if they have noticed a meaningful change in the domain.  
*Example: 'Have you noticed a meaningful change in your knee pain, over the last 6 weeks?'*
- C8b. To assess the current state of an outcome domain after knee injury, ask the patient if they feel their current state is acceptable/satisfactory.  
*For example: 'Taking into consideration all you do in a typical day, is the current state of your hop performance satisfactory?'*
- C8c. To better understand a patient's experience of an outcome domain after a knee injury, ask them about individual PROM item responses.  
*Example (KOOS Q3): '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?'*
- C8d. To document an outcome domain for a health record or report, include the following information:
- i. The baseline and follow-up score, and any change (either improvement or deterioration) in the outcome  
*Example: insert name had a 15% improvement in knee extensor strength over 4 weeks, (baseline scores = 25 lbs, follow-up score = 29 lbs)*
  - ii. If the patient felt the change in the outcome was meaningful  
*Example: insert name felt that the increase was meaningful*
  - iii. If the person feels that their current state of an outcome is acceptable/satisfactory.  
*Example: insert 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.*

## 7. Research Recommendations: Summary of Evidence and Appropriateness Rating

**Table 5. Research Recommendations: Summary of Evidence and Appropriateness Rating**

	Research Recommendation	Evidence	Median	Min-Max	Mode	Appropriateness	Votes
<b>Overarching priorities for post-traumatic knee OA research</b>							
R1a.	Prioritize <b>symptomatic</b> definitions of post-traumatic knee OA (consensus-based clinical signs and symptoms with or without the presence of structural features) over <b>structural</b> definitions.	Expert Opinion	9	5-9	9	Appropriate	32
R1b.	Reach consensus on how to define, measure and report <b>symptomatic and structural</b> post-traumatic knee OA to facilitate data synthesis and meta-analysis (including individual participant data meta-analyses).	Expert Opinion	9	7-9	9	Appropriate	32
R1c.	Investigate the influence of sex, gender, race, and other social determinants of health on the development of post-traumatic knee OA to understand disparities across populations.	Expert Opinion	8	4-9	9	Appropriate	32
<b>Study Design: Risk factors for OA after traumatic knee injury</b>							
R2a.	Consider ACL tear and non-ACL tear related injuries when investigating risk factors for <b>symptomatic</b> post-traumatic knee OA.	Expert Opinion	9	5-9	9	Appropriate	32
R2b.	Report <b>structural</b> knee OA by overall knee joint and individual joint compartment (i.e., medial tibiofemoral, lateral tibiofemoral and patellofemoral).	Expert Opinion	9	5-9	9	Appropriate	32
<b>Study Design: Interventions after traumatic knee injury</b>							
R2c.	Clinical trials of rehabilitation interventions with follow-up beyond 5 years would provide a better understanding if interventions can reduce the risk of <b>symptomatic</b> and <b>structural OA</b> after knee injury.	Expert Opinion	9	8-9	9	Appropriate	34
R2d.	Evaluate the effectiveness (clinical trial) of different management strategies (including rehabilitation interventions) in participants with ACL deficiency, isolated meniscal tears, an/or non-ACL tear knee injuries.	Expert Opinion	9	5-9	9	Appropriate	34
<b>Study Design: Outcome domains after a traumatic knee injury</b>							
<i>Recommendations apply to any traumatic knee injury and/or associated surgery unless otherwise indicated. Choice of domain(s) will vary based on the research question. Domains are listed in alphabetical order.</i>							
Core domains to monitor in intervention and observational studies of persons following a knee injury include							
R3a.	i. knee-related adverse events <sup>a</sup> (including subsequent knee injury and giving way episodes)	Expert Opinion <sup>11 12</sup>	9	7-9	9	Appropriate	31
	ii. knee-related cognitive behavioural factors <sup>a,b</sup>		9	5-9	9	Appropriate	31
	iii. knee-related quality of life		9	7-9	9	Appropriate	31
	iv. knee-related pain		9	5-9	9	Appropriate	31
	v. knee-related symptoms other than pain <sup>a</sup>		9	5-9	9	Appropriate	31
	vi. patient global assessment <sup>a</sup>		9	5-9	9	Appropriate	31
	vii. physical activity and sport participation <sup>a</sup>		9	7-9	9	Appropriate	31
	viii. physical function (including self-reported function, functional performance and/or muscle function)		9	6-9	9	Appropriate	31

Depending on the research question, it may also be important to assess:								
R3b.	i.	body mass index and adiposity		9	3-9	9	Appropriate	31
	ii.	comorbidities		8	6-9	9	Appropriate	31
	iii.	health-related quality of life (including physical and mental aspects)		9	5-9	9	Appropriate	31
	iv.	injury-related costs (direct and indirect)	Expert consensus <sup>11</sup>	9	5-9	9	Appropriate	31
	v.	mental health <sup>a</sup>	Expert opinion <sup>6 13 14</sup>	8	4-9	9	Appropriate	31
	vi.	molecular and imaging biomarkers		8	2-9	9	Appropriate	31
	vii.	participation in social roles, responsibilities and relationships including occupation, care-giving and community participation <sup>a</sup>		8	6-9	9	Appropriate	31
R3c.	Consider monitoring individuals at elevated risk of <b>symptomatic</b> post-traumatic knee OA across the entire timespan from injury to any OA diagnosis.		Expert opinion <sup>2 12</sup>	9	6-9	9	Appropriate	31
<b>How to Monitor: Patient Reported Outcomes</b>								
Recommendations apply to any traumatic knee injury and/or associated surgery unless otherwise indicated. PROM choice may be influenced by individual research questions. Domains and instruments are listed in alphabetical order.								
Recommended options to monitor <b>core domains</b> after knee injury to facilitate data synthesis include:								
R4a.	i.	knee-related cognitive behavioural factors: • ACL Return to Sport after Injury scale (ACL-RSI, ACL Tear only) • Knee Self Efficacy Scale (K-SES) • Tampa Scale of Kinesiophobia (TSK-17 or TSK-11)	ACL-RSI (COSMIN 6/8) <sup>12</sup> K-SES (Expert Opinion) TSK-17, TSK-11 (Expert Opinion)	8	6-9	9	Appropriate	31
	ii.	knee-related pain: • KOOS Pain subscale (KOOS <sub>Pain</sub> ) • Numerical Rating Scale (NRS) • Visual Analogue Scale (VAS)	KOOS <sub>Pain</sub> (COSMIN 2/8) <sup>12</sup> NRS (Expert Opinion) VAS (Expert Opinion)	9	7-9	9	Appropriate	31
	iii.	knee-related physical function: • KOOS Function in Sport and Recreation subscale (KOOS <sub>Sport/Rec</sub> )	KOOS <sub>Sport/Rec</sub> (COSMIN 2/8) <sup>12</sup>	9	6-9	9	Appropriate	31
	iv.	knee-related quality of life: • ACL QOL score (ACL Tear only) • KOOS QOL subscale	ACL QOL (COSMIN 3/8) <sup>12</sup> KOOS <sub>QOL</sub> (COSMIN 2/8) <sup>12</sup>	9	7-9	9	Appropriate	31
	v.	knee-related SYMPTOMS other than pain: • KOOS Symptoms subscale (KOOS <sub>Symptoms</sub> )	KOOS <sub>Symptoms</sub> (COSMIN 2/8) <sup>12</sup>	9	5-9	9	Appropriate	31
	vi.	patient global assessment: • Global Rate of Change Score (GROC) • Patient Acceptable Symptom State (PASS) • Treatment Failure (TF)	GROC <sup>22</sup> (Expert Opinion) <sup>25</sup> PASS <sup>23</sup> TF <sup>26</sup>	9	5-9	9	Appropriate	31
	vii.	physical activity and sport participation: • Physical Activity resumption and frequency <sup>a</sup> • Sport Participation type <sup>a</sup>	Expert Opinion <sup>17</sup>	9	6-9	9	Appropriate	31

Recommended methods to monitoring <b>additional domains</b> after knee injury to facilitate data synthesis include:								
R4b.	i.	health-related quality of life: • EQ-5D Index <sup>c</sup> • SF-12 or SF-36 <sup>c</sup>	Expert opinion <sup>13</sup>	9	6-9	9	Appropriate	31
	ii.	mental health: • Methods used to assess these constructs will depend upon the research question and study population <sup>3</sup>	Expert Opinion <sup>16</sup>	8	5-9	9	Appropriate	31
	iii.	participation in social roles, responsibilities and relationships (including occupation, care-giving and community participation): • Methods used to assess these constructs will depend upon the research question and study population <sup>3</sup>	Expert Opinion	8	5-9	9	Appropriate	31
	iv.	multiple domains after knee injury: • IKDC-SKF <sup>d</sup> • Western Ontario Meniscal Evaluation Tool <sup>e</sup>	ACL Tear: • IKDC-SKF (COSMIN 3/8) <sup>12</sup> Meniscus Tear: • IKDC-SKF (COSMIN 2/8) <sup>15</sup> • WOMET (COSMIN 4/8) <sup>15</sup>	9	1-9	9	Appropriate	31
<b>How to Monitor: Muscle Function<sup>f</sup></b>								
<i>Recommendations apply to any traumatic knee injury and/or associated surgery unless otherwise indicated. Method choice may be influenced by individual research questions.</i>								
R5a.	The best available measures of muscle function after knee injury are peak knee extensor and flexor strength.		Expert Opinion <sup>18,19</sup>	9	5-9	9	Appropriate	33
Recommended methods to estimate peak knee extensor and flexor strength in research settings (in order of most to least scientific rigor) include;								
R5b.	i.	computerised dynamometry: concentric isokinetic contraction at $\geq 60^\circ/s$	Extensor GRADE <sup>18</sup> : • + Very low (Intra-RR) • + Moderate (Construct validity) Flexor GRADE <sup>18</sup> : • + Very low (Intra-RR) • - Moderate (Construct validity)	9	4-9	9	Appropriate	33
	ii.	hand-held dynamometry <sup>g</sup> : isometric 1RM <sup>h</sup>	Extensor GRADE <sup>18</sup> : • + Moderate (Intra-RR) • - Very low (Inter-RR) • - High (Criterion validity) • -High (Construct validity)	7	1-9	7	Appropriate	33
	iii.	weight machine (e.g., knee extension or prone leg curl): concentric isotonic 1RM <sup>h</sup>	Extensor/Flexor GRADE <sup>18</sup> : • + High (Criterion validity)	7	4-9	7	Appropriate	33
Recommended additional measures of knee muscle function <sup>h</sup> that are important to monitor after knee injury include:								
R5c.	i.	knee extensor and flexor power <sup>a</sup>	Expert Opinion <sup>19</sup>	8	4-9	9	Appropriate	33
	ii.	knee extensor and flexor endurance <sup>a</sup>		8	3-9	9	Appropriate	33
	iii.	knee extensor and flexor morphology <sup>a</sup>		7	4-9	7	Appropriate	33
	iv.	knee extensor and flexor neurophysiology <sup>a</sup>		7	4-9	9	Appropriate	33

R5d.	Recommended other muscle groups to monitor after knee injury include those in the lower leg, hip and trunk. • See supplementary file for examples <sup>a</sup>	Expert Opinion	8	4-9	9	Appropriate	33
<b>How to Monitor: Functional Performance<sup>l</sup></b> <i>Recommendations apply to any traumatic knee injury and/or associated surgery unless otherwise indicated. Method choice may be influenced by individual research questions. Methods are listed in alphabetical order.</i>							
R6a.	The best available measures of functional performance <sup>l</sup> after a knee injury are hop performance tests.	Expert Opinion <sup>20</sup>	9	4-9	9	Appropriate	33
Recommended methods to estimate hop performance in a research setting include:							
R6b.	i. a battery of hop tests (e.g., more than one test)	Expert Opinion <sup>20</sup>	9	5-9	9	Appropriate	33
	ii. the hop battery should include tests that assess forward (single and repeated), diagonal and/or vertical hopping	Expert Opinion <sup>20</sup>	9	5-9	9	Appropriate	33
Recommended hop tests for use after knee injury include <sup>l</sup> :							
	i. Diagonal hop = Crossover Hop Test (CH) <sup>k</sup>	CH GRADE <sup>21</sup> : • + Moderate (Intra-RR) • + Moderate (Construct validity) • + Low (Responsiveness)	9	4-9	9	Appropriate	33
	ii. Single forward hop = Single Hop Test (SLH) <sup>k</sup>	SLH GRADE <sup>21</sup> : • + High (Intra-RR) • + Low (Construct validity) • + Low (Responsiveness)	9	5-9	9	Appropriate	33
R6c.	iii. Repeated forward hop = Triple Hop Test (TH) <sup>k</sup>	TH GRADE <sup>21</sup> : • + Very low (Intra-RR) • + Moderate (Construct validity) • - Low (Responsiveness)	9	4-9	9	Appropriate	33
	iv. Vertical hop = Vertical Hop Test (VH) <sup>k</sup>	VH GRADE <sup>21</sup> : • + Moderate (Intra-RR) • + Moderate (Construct validity)	9	5-9	9	Appropriate	33
	v. Repeated forward hop = 6-meter Timed Hop Test (6mTH) <sup>k</sup>	6mTH GRADE <sup>21</sup> : • + Moderate (Intra-RR) • + Low (Construct validity) • - Insufficient (Responsiveness)	8	4-9	9	Appropriate	33
R6d.	Recommended additional measures of functional performance that are important to monitor after knee injury include balance, agility or other task meaningful to the participant. <sup>a</sup>	Expert Opinion	8	4-9	9	Appropriate	33
<b>Interpreting Patient Reported, Muscle Function and Functional Performance Outcome Domain Status and Change</b>							
• Information to assist in the interpretation of PROMs <sup>l</sup> , muscle strength and hop performance can be found in the supplementary file 4. The information was <b>not voted on</b> .							

<sup>a</sup>See attached supplementary file for examples (examples were not be voted on)

<sup>b</sup>Characteristics of a person that affect performance and learning

<sup>c</sup>Licensing requirements apply but may be available through your employer

<sup>d</sup>Assesses knee-related symptoms, sports activities, function and activities of daily living

<sup>e</sup>Assesses knee-related physical symptoms, sports, recreation, work, lifestyle, emotions

<sup>f</sup>Muscle function refers to the capacity of a muscle to do work. Muscle function can be measured as strength, power, or endurance.

<sup>g</sup>HHD assessment of isometric knee extensor and flexor strength can underestimate strength. To obtain the most precise estimate it is important to secure the femur, have the patient push into resistance generated by a fixed belt (not the assessor hand), and for re-assessment to be conducted by the same assessor. Isometric scores are not interchangeable with isokinetic or isotonic scores.

<sup>h</sup>Estimates of 1RM should be based on the average of at least two *repeated* measures of maximum effort.

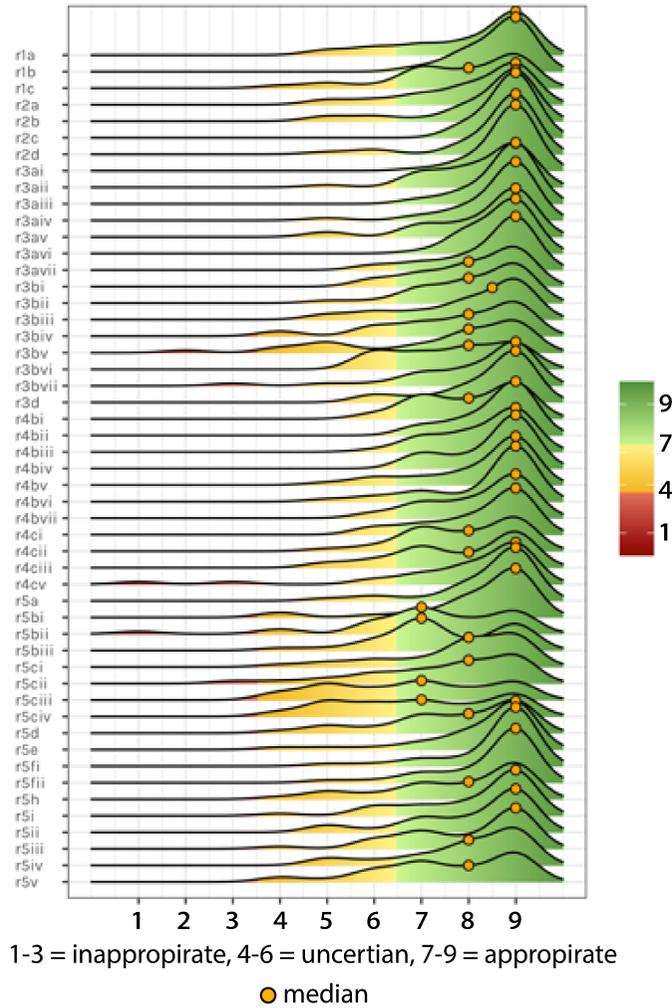
<sup>i</sup>Functional performance is the action of carrying out or accomplishing a movement, movement task or movement activity

<sup>j</sup>Insufficient evidence to inform the 'best' test or 'best' order

<sup>k</sup>See supplementary file for test description

+ (sufficient measurement property), - (insufficient measurement property) as per the COSMIN, 1 RM (1 repetition maximum), ACL (Anterior Cruciate Ligament), ACLR (ACL reconstruction), GRADE (Grading of Recommendations, Assessment, Development and Evaluations), Dynamometry), OA (osteoarthritis), PROM (patient reported outcome measure), ROM (range of motion), RR (Rater Reliability)

### 8. Research Recommendations: Voting Distribution



## 9. Research Recommendations: Dissenting Viewpoints

**Table 6. Research Recommendations: Dissenting Viewpoints**

	Research Recommendation	Comments and Dissenting Viewpoint
R1a.	Prioritize <b>symptomatic</b> definitions of post-traumatic knee OA (consensus-based clinical signs and symptoms with or without the presence of structural features) over <b>structural</b> definitions.	<ul style="list-style-type: none"> <li>Structural definitions of OA are probably very relevant for research on mechanisms, biology etc.</li> <li>Defining symptomatic OA as present or absent is useful for defining inclusion criteria, or for incidence of symptomatic OA as a dichotomous outcome. But measuring changes in this will be very hard (e.g., for epidemiology studies) due to the highly varied nature of pain.</li> </ul>
R1b.	Reach consensus on how to define, measure and report <b>symptomatic and structural</b> post-traumatic knee OA to facilitate data synthesis and meta-analysis (including individual patient data meta-analyses).	
R1c.	Investigate the influence of sex, gender, race, and other social determinants of health on the development of post-traumatic knee OA to understand disparities across populations.	
<b>Study Design: Risk factors for OA after traumatic knee injury</b>		
R2a.	Consider ACL tear and non-ACL tear related injuries when investigating risk factors for <b>symptomatic</b> post-traumatic knee OA.	<ul style="list-style-type: none"> <li>Other knee injuries should be taken into account, as single-structure or multi-structure injuries are also considered risk factors for OA development.</li> </ul>
R2b.	Report <b>structural</b> knee OA by overall knee joint and individual joint compartment (i.e., medial tibiofemoral, lateral tibiofemoral and patellofemoral).	
<b>Study Design: Interventions after traumatic knee injury</b>		
R2c.	Clinical trials of rehabilitation interventions with follow-up beyond 5 years would provide a better understanding if interventions can reduce the risk of <b>symptomatic and structural OA</b> after knee injury	
R2d.	Evaluate the effectiveness (clinical trial) of different management strategies (including rehabilitation interventions) in patients with ACL deficiency, isolated meniscal tears, an/or non-ACL tear knee injuries.	
<b>Study Design: Outcome domains after a traumatic knee injury</b>		
<i>Recommendations apply to any traumatic knee injury and/or associated surgery unless otherwise indicated. Choice of domain(s) will vary based on the research question. Domains are listed in alphabetical order.</i>		
Core domains to monitor in intervention and observational studies of persons following a knee injury include		
R3a.	i. knee-related adverse events <sup>a</sup> (including subsequent knee injury and giving way episodes	<ul style="list-style-type: none"> <li>The outcome depends on the specific research question more than the population being evaluated.</li> </ul>
	ii. knee-related cognitive behavioural factors <sup>a,b</sup>	
	iii. knee-related quality of life	
	iv. knee-related pain	
	v. knee-related symptoms other than pain <sup>a</sup>	<ul style="list-style-type: none"> <li>I am not convinced we have good enough tools to evaluate "other symptoms". KOOS Symptoms is an option, but I am not convinced of psychometric properties. It is not clear to me what symptoms would be important to include as core item domains, other than pain and instability - giving way (already captured in adverse events).</li> </ul>
	vi. patient global assessment <sup>a</sup>	<ul style="list-style-type: none"> <li>I am not sure the global assessment questions are very important to include as core domains in research studies.</li> </ul>
	vii. physical activity and sport participation <sup>a</sup>	
	viii. physical function (including self-reported function, functional performance and/or muscle function)	

	Depending on the research question, it may also be important to assess:	
	i. body mass index and adiposity	<ul style="list-style-type: none"> <li>BMI should be moved up to core domain, while other measures of adiposity are optional.</li> </ul>
	ii. comorbidities	
R3b.	iii. health-related quality of life (including physical and mental aspects)	<ul style="list-style-type: none"> <li>it is not clear what the distinction is between mental health and mental aspects of QOL, but agree that it may be important to evaluate mental health.</li> </ul>
	iv. injury-related costs (direct and indirect)	
	v. mental health <sup>a</sup>	
	vi. molecular and imaging biomarkers	<ul style="list-style-type: none"> <li>Only relevant for specific research questions.</li> </ul>
	vii. participation in social roles, responsibilities and relationships including occupation, care-giving and community participation <sup>a</sup>	
R3d.	Consider monitoring individuals at elevated risk of <b>symptomatic</b> post-traumatic knee OA across the entire timespan from injury to any OA diagnosis.	<ul style="list-style-type: none"> <li>Monitor beyond OA diagnosis as well?</li> <li>It's not clear to me if the focus is that: individuals should be at risk of symptomatic knee PTOA, people should be monitored at all time points following injury, or studies should have a lifelong follow-up time?</li> </ul>
<b>How to Monitor: Patient Reported Outcomes</b>		
<i>Recommendations apply to any traumatic knee injury and/or associated surgery unless otherwise indicated. PROM choice may be influenced by individual research questions. Domains and instruments are listed in alphabetical order.</i>		
	Recommended options to monitor <b>core domains</b> after knee injury to facilitate data synthesis include:	
	i. knee-related cognitive behavioural factors:	
	<ul style="list-style-type: none"> <li>ACL Return to Sport after Injury scale (ACL-RSI, ACL Tear only)</li> <li>Knee Self Efficacy Scale (K-SES)</li> <li>Tampa Scale of Kinesiophobia (TSK-17 or TSK-11)</li> </ul>	<ul style="list-style-type: none"> <li>TSK17/11 not the best tool for fear of reinjury/reinjury anxiety but I guess the best out there</li> <li>Not as much known about these PROMs- less confident.</li> </ul>
	ii. knee-related pain:	
	<ul style="list-style-type: none"> <li>KOOS Pain subscale (KOOS<sub>Pain</sub>)</li> <li>Numerical Rating Scale (NRS)</li> <li>Visual Analogue Scale (VAS)</li> </ul>	
	iii. knee-related physical function:	
	<ul style="list-style-type: none"> <li>KOOS Function in Sport and Recreation subscale (KOOS<sub>Sport/Rec</sub>)</li> </ul>	
R4a.	iv. knee-related quality of life:	
	<ul style="list-style-type: none"> <li>ACL QOL score (ACL Tear only)</li> <li>KOOS QOL subscale</li> </ul>	
	v. knee-related SYMPTOMS other than pain:	
	<ul style="list-style-type: none"> <li>KOOS Symptoms subscale (KOOS<sub>Symptoms</sub>)</li> </ul>	<ul style="list-style-type: none"> <li>Agree that assessing symptoms is important, but I am worried whether the KOOS Symptoms scale has good enough measurement properties.</li> </ul>
	vi. patient global assessment:	
	<ul style="list-style-type: none"> <li>Global Rate of Change Score (GROC)</li> <li>Patient Acceptable Symptom State (PASS)</li> <li>Treatment Failure (TF)</li> </ul>	<ul style="list-style-type: none"> <li>Consider re-phrasing patient 'global assessment' to patient 'global status'</li> </ul>
	vii. physical activity and sport participation:	
	<ul style="list-style-type: none"> <li>Physical Activity resumption and frequency<sup>a</sup></li> <li>Sport Participation type<sup>a</sup></li> </ul>	

	Recommended methods to monitoring <b>additional domains</b> after knee injury to facilitate data synthesis include:	
	i. health-related quality of life: <ul style="list-style-type: none"> <li>EQ-5D Index<sup>c</sup></li> <li>SF-12 or SF-36<sup>c</sup></li> </ul>	
	ii. mental health: <ul style="list-style-type: none"> <li>Methods used to assess these constructs will depend upon the research question and study population<sup>g</sup></li> </ul>	
R4b.	iii. participation in social roles, responsibilities and relationships (including occupation, care-giving and community participation): <ul style="list-style-type: none"> <li>Methods used to assess these constructs will depend upon the research question and study population<sup>g</sup></li> </ul>	
	iv. multiple domains after knee injury: <ul style="list-style-type: none"> <li>IKDC-SKF<sup>d</sup></li> <li>Western Ontario Meniscal Evaluation Tool<sup>e</sup></li> </ul>	<ul style="list-style-type: none"> <li>Unclear why single domain subscales (e.g., KOOS QOL, Pain) are included in research recommendations, but not as single domain options for clinical recommendations</li> <li>Include the KOOS as a multiple domain instrument using KOOS4 as the outcome</li> <li>Multiple domains evaluated by an aggregate score cannot be used for data synthesis across studies/instruments since it is unclear what construct(s) the multi-domain instrument assess.</li> </ul>
<b>How to Monitor: Muscle Function<sup>f</sup></b>		
<i>Recommendations apply to any traumatic knee injury and/or associated surgery unless otherwise indicated. Method choice may be influenced by individual research questions.</i>		
R5a.	The best available measures of muscle function after knee injury are peak knee extensor and flexor strength.	
	Recommended methods to estimate peak knee extensor and flexor strength in research settings (in order of most to least scientific rigor) include;	<ul style="list-style-type: none"> <li>All are acceptable depending on the question being asked, but computerized dynamometry should be the standard if measuring muscle function in this population, regardless of the question.</li> <li>Isokinetic testing at <math>\geq 180^\circ/s</math> is less reliable and can be quite uncomfortable for patients</li> <li>Include caveat about methods</li> </ul>
R5b.	i. Computerised Dynamometry: concentric isokinetic contraction at $\geq 60^\circ/s$	
	ii. HHD <sup>g</sup> : isometric 1RM <sup>h</sup>	
	iii. Weight machine (e.g., knee extension or prone leg curl): concentric isotonic 1RM <sup>h</sup>	
	Recommended additional clinical measures of knee muscle function <sup>h</sup> that are important to monitor after knee injury include:	
	i. knee extensor and flexor power <sup>a</sup>	<ul style="list-style-type: none"> <li>Is there a hierarchy implied here, e.g., endurance is more important than power or vice versa? Is one more important than the other?</li> </ul>
R5c.	ii. knee extensor and flexor endurance <sup>a</sup>	
	iii. knee extensor and flexor morphology <sup>a</sup>	<ul style="list-style-type: none"> <li>Need more information regarding "morphology" and "neurophysiology" to be able to vote on</li> <li>Morphology and Neurophysiology are not that important to monitor</li> </ul>
	iv. knee extensor and flexor neurophysiology <sup>a</sup>	
R5d.	Recommended other muscle groups to monitor after knee injury include those in the lower leg, hip and trunk. <ul style="list-style-type: none"> <li>See supplementary file for examples<sup>a</sup></li> </ul>	

**How to Monitor: Functional Performance<sup>1</sup>**

Recommendations apply to any traumatic knee injury and/or associated surgery unless otherwise indicated. Method choice may be influenced by individual research questions. Methods are listed in alphabetical order.

R6a.	The best available measures of functional performance <sup>1</sup> after a knee injury are hop performance tests.	• What if a hop is not a meaningful for the patient?
	Recommended methods to estimate hop performance in a research setting include:	
R6b	i. a battery of hop tests (e.g., more than one test)	
	ii. the hop battery should include tests that assess forward (single and repeated), diagonal and/or vertical hopping	
	Recommended hop tests for use after knee injury include:	
R6c.	i. Diagonal hop = Crossover Hop Test (CH) <sup>k</sup>	
	ii. Single forward hop = Single Hop Test (SLH) <sup>k</sup>	
	iii. Repeated forward hop = Triple Hop Test (TH) <sup>k</sup>	
	iv. Vertical hop = Vertical Hop Test (VH) <sup>k</sup>	
	v. Repeated forward hop = 6-meter Timed Hop Test (6mTH) <sup>k</sup>	
		• Caution for responsiveness (insufficient but low evidence)
R6d.	Recommended additional clinical measures of functional performance that are important to monitor after knee injury include balance, agility or other task meaningful to the patient. <sup>a</sup>	• How do we incorporate "other task meaningful to the patient" in a research setting?

**Interpreting Patient Reported, Muscle Function and Functional Performance Outcome Domain Status and Change**

Information to assist in the interpretation of PROMs<sup>1</sup>, muscle strength and hop performance can be found in the supplementary file. The information in the table was **not voted on**.

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