Supplementary Table 1: Description of all clinical tests

Test	Protocol description
Tibiofemoral frontal plane alignment	• Palpate & mark tibial tuberosity & midpoint over the talus neck • Ask participant to stand on footprint map with foot at 10° external rotation, feet shoulder width, looking forward, 50% weightbearing • Place callipers of inclinometer in alignment with the the two landmarks • Record varus/valgus direction in degrees
Herrington test	• Participant supine on plinth, knee positioned and supported in 20° of knee flexion (to place the patella within the trochlea groove) • With knee in position, place a piece of 1" Leukotape (or similar) across the knee joint, and mark the medial and lateral epicondyles of the femur and mid-point of the patella. Be sure to make note of medial and lateral end of tape • Repeat 3 times, attaching tape to this document for measuring later
30 second chair stand test	• **Shoes on**, middle of chair, feet ~ shoulder width apart and slightly behind knees with feet flat on floor, arms crossed on chest • Instructions *"stand up keeping arms across chest, and ensure you* stand completely up so hips and knees are fully extended; then sit completely back down, so that the bottom fully touches the seat, *as many times as possible in 30 seconds,"* • 1-2 practice repetitions for technique • One 30-second test trial • Record number of correctly performed full stands (if more than ½ of way up at end of the test, counted as a full stand)
Repetitive single leg rise test	• **Shoes on**, seated on edge of plinth, foot placed with heel 10 cm forward from a plumb line at edge of plinth, other leg held at side of body, arms across chest. • Height of plinth adjusted so knee angle is 90° • Instructions: *"keep back of heel on marker, stand as many times as possible on one leg keeping arms across chest, in time with the* ***metronome (45bpm)****. If you get to 50 we will stop. Control yourself on the descent"* • 2-3 practice tests

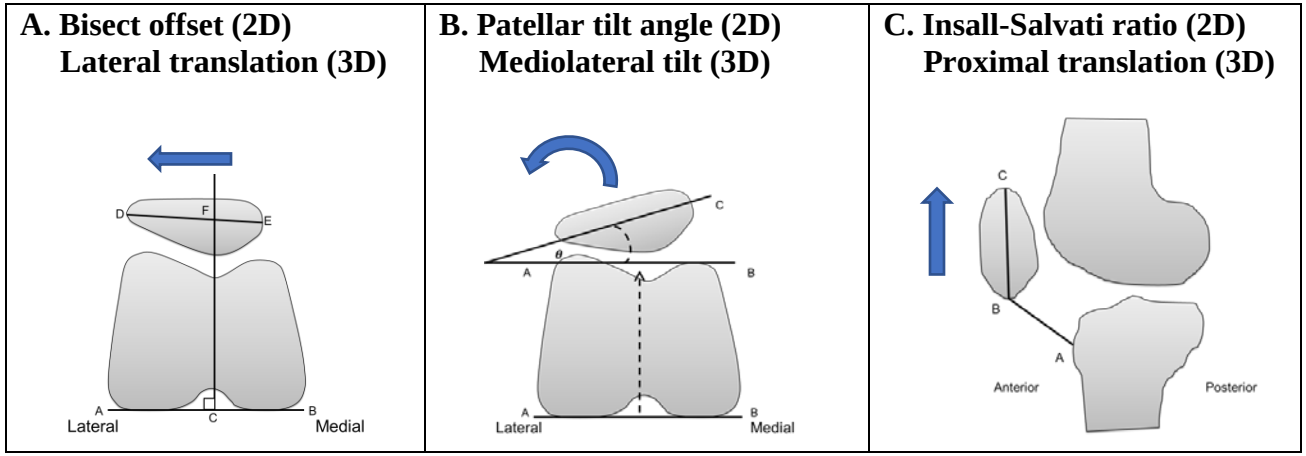
	• If nonweightbearing leg touches ground, do not count that rise; if touches ground 3 times during test, record number of rises to that point only and stop test
Timed 12 stair climb	• Participant wears usual footwear • Instructions *"climb up then down the 2 small flights of stairs as quickly as possible but safely"* • 1-2 practice trials for technique and to confirm safety • Trial: record time to ascend and descend 12 steps - up 2 flights of 6 steps then descend • (both feet touch down at bottom of landing to end timer) • No use of hand-rails or gait aids • Height of step: 18 cm • Depth of step: 32 cm
Ankle dorsiflexion range of motion (ROM)	• Participant stands in front of a wall with horizontal line bisecting calcaneus and second toe • Participant instructed to lunge forward to touch knee to wall • Move foot back gradually until can just touch wall while maintaining heel on floor • Measure distance between tip of great toe and wall • Measure shank length from lateral knee joint line to lateral malleolus
Knee hyperextension ROM	• Participant supine on plinth, towel under Achilles tendon • Measure ROM using 12" goniometer – axis over lateral epicondyle of femur; stationary arm towards greater trochanter; movable arm toward lateral malleolus
Knee flexion ROM	• Participant supine on plinth, slides heel towards buttocks without lifting heel off plinth • Measure ROM using 12" goniometer – axis over lateral epicondyle of femur; stationary arm towards greater trochanter; movable arm toward lateral malleolus
Hip extension ROM	• Participant prone, feet off end of plinth, chin resting on hands • Belt across pelvis • Measure ROM using 12" goniometer – axis over greater trochanter; stationary arm parallel to mid-axillary line of trunk; movable arm toward lateral epicondyle of femur • Knee maintained in extension
Hip flexion ROM	• Participant supine on plinth, bends knee and draws knee towards chest without using hands • Measure ROM using 12" goniometer – axis over greater trochanter; stationary arm parallel to mid-axillary line of trunk; movable arm toward lateral epicondyle of femur
Hip internal rotation ROM	• Participant prone on plinth, test leg in 90° knee flexion • Belt across pelvis

	• Inclinometer held to outside of shin 5 cm proximal to lateral malleolus, starting angle is 0°. • Instructions: *"let leg drop out to side as far as possible"* • Record angle without overpressure
Hip external rotation ROM	• Participant prone on plinth, test leg in 90° knee flexion, non-test leg in slight abduction for clearance • Belt across pelvis • Inclinometer held to inside of shin 5 cm proximal to medial malleolus, starting angle is 0°. • Instructions: "*let leg drop in to centre as far as possible*" • Record angle without overpressure
Isokinetic knee extension / flexion strength (Biodex)	• Participant seated in Biodex, back rest at 70-85° • Two speeds: 60° and 180° per second • 1-2 sub-maximal practice trials (~50% effort) • One max test trial at each speed, 5 repetitions • ≥ 30 second rest between each test series • Verbal encouragement "*Go! Harder!*" • If > 15% coefficient of variance, repeat test
Hip abduction strength	• Isometric 'make' test, 3-5 second hold • Participant supine, belt across contra-lateral thigh • Index leg resting in hip neutral (0°) • Force plate of handheld dynamometer positioned 5 cm above lateral malleolus • Instructions *"keep arms folded, heel on the bed and push leg out to side against force plate as hard as possible"* • 1-2 sub-maximal practice trials • Verbal encouragement "Go! Go! Go!" • ≥ 5 second rest between each repetition • If > 10% variability, additional trial is performed • Measure lever arm length: greater trochanter to dynamometer marker (5 cm proximal to lateral malleolus)
Hip extension strength	• Isometric 'make' test, 3-5 second hold • Positioned in prone, belt across contra-lateral thigh, chin resting on hands, feet off the end of the bed • Index leg at 90º knee flexion • Force plate over centre of participant's heel • Instructions "*push foot straight up to ceiling*"

	• Therapist matches force once knee leaves surface of plinth. • 1-2 sub-maximal practice trials • Verbal encouragement "Go! Go! Go!" • ≥ 5 second rest between each repetition • If > 10% variability, additional trial is performed • Measure lever arm length: inferior greater trochanter to lateral knee joint line
Hip internal rotation strength	• Isometric 'make' test, 3-5 second hold • Positioned in prone, belt across contra-lateral thigh, index leg resting in hip neutral (0°), knee at 90° • Force plate positioned 5 cm above lateral malleolus • Instructions *"turn shin outwards as hard as possible, keeping both knees together"* • 1-2 sub-maximal practice trials • Verbal encouragement "Go! Go! Go!" • ≥ 5 second rest between each repetition • If > 10% variability, additional trial is performed • Measure lever arm length: knee joint line to dynamometer marker (5 cm proximal to lateral malleolus)
Hip external rotation strength	• Isometric 'make' test, 3-5 second hold • Positioned in prone, belt across contra-lateral thigh, index leg resting in hip neutral (0°), knee at 90° • Force plate 5 cm proximal to medial malleolus • Instructions *"turn shin inwards towards the centre as hard as possible"* • 1-2 sub-maximal practice trials • Verbal encouragement "Go! Go! Go!" • ≥ 5 second rest between each repetition • If > 10% variability, additional trial is performed • Measure lever arm length: knee joint line to dynamometer marker (5 cm proximal to medial malleolus)
Single leg squats	• Video camera 3 metres from participant, at height of lowest tripod setting (~65 cm) • Adjust height of plinth behind participant to provide squat depth target to 45° knee flexion, using 12" goniometer • Place reflective markers: midpoint of femoral condyles, bilateral ASIS, proximal thigh along line from ASIS to knee marker, midpoint of ankle malleoli, manubrium • Participant stands, **shoes off**, on foot map with arms across chest • free leg held in front of squat leg

	• metronome 60 bpm, 2 ‘ticks’ each direction • single leg squat to 45° knee flexion (plinth behind participant – buttock touch plinth as target to reproduce angle) • 2-3 practice trials • Repeat 5 times • On test completion, participants were asked “*How easy was it to perform the task?”*. Response options were on a 5-point Likert scale ranging from ‘markedly easy’ to ‘markedly hard’

Supplementary Figure 1: Participants were positioned in supine for 2D (left) and upright for 3D (right) alignment measures. Note image on right shows standing two-legged, but in the present study participants stood on one leg only. *Right-hand image from Journal of Magnetic Resonance Imaging, Macri EM et al., "Patellofemoral and tibiofemoral alignment in a fully weight-bearing upright MR: Implementation and repeatability" Published Online First: Doi:10.1002/jmri.25823, 2017, with permission from John Wiley and Sons.*



Supplementary Figure 2: Description of alignment measures

A. 2D bisect offset is the percentage (%) of the widest line across the patella that lies lateral to a line bisecting the deepest part of the trochlea (arrow indicates direction of 3D lateral translation of patella relative to femur, in mm). **B.** 2D patellar tilt angle: Angle (θ) between posterior condylar line and line across widest part of patella (arrow indicates direction of 3D lateral tilt of patella relative to femur, in degrees). **C.** 2D Insall-Salvati Ratio is the ratio of patella tendon length to the patellar height (arrow indicates direction of 3D proximal translation of patella relative to femur, in mm)