

PATELLA DISLOCATION - PHYSIOTHERAPY MANAGEMENT - CHW PRACTICE GUIDELINE[®]

DOCUMENT SUMMARY/KEY POINTS

- This guideline is an assessment and treatment tool for use by physiotherapists treating patients with patella dislocations.
- It includes information on assessment, imaging, conservative or surgical management and phases of rehabilitation. The appendix includes printable questionnaires and handouts for home exercise programs.

CHANGE SUMMARY

- N/A – New document.

READ ACKNOWLEDGEMENT

This document is for Physiotherapists working within the Physiotherapy Outpatient Department at the Children's Hospital at Westmead.

- Junior Physiotherapists will be supervised by Outpatient Senior Physiotherapists, and assessed on competencies as part of their routine training requirements.
- All physiotherapists working primarily within the Outpatient Team are required to read and acknowledge this document.

This document reflects what is currently regarded as safe practice. However, as in any clinical situation, there may be factors which cannot be covered by a single set of guidelines. This document does not replace the need for the application of clinical judgement to each individual presentation.

Approved by:	SCHN policy, Procedure and Guideline Committee	
Date Effective:	1 st January 2023	Review Period: 3 years
Team Leader:	Physiotherapist	Area/Dept: Physiotherapy CHW

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Background Information on Patella Dislocation

Epidemiology, Risk Factors & Outcomes

Patella dislocations are currently reported to affect 29 per 100 000 adolescents each year (Duerr 2016). The peak age of incidence is 15 years (Palmu 2008) with a potential higher representation of adolescent females. Acute patella dislocations account for 2-3% of knee injuries and is the second most common cause of traumatic haemarthrosis of the knee (Bitar 2011, Nwachukwu 2016).

Longer term implications of recurrent instability and recurrent dislocations are common with variable rates reported in the literature at 15-44% post non-operative treatment. Post dislocation, ongoing issues associated with pain, inability to return to sport and early patellofemoral arthropathy is also reported (Bitar 2011), with a knee seven times more likely to experience subsequent dislocations after the primary.

The diagnosis of an acute patella dislocation can be made by clinical evaluation together with radiology. Clinically patients have a positive patella apprehension test, where a lateral patella glide of >75% width of the patella is likely to indicate medial soft tissue insufficiency.

Influential factors contributing to dislocation can also be assessed using the patella tilt test and limb alignment review; with greater Q angles increasing the likelihood of dislocation. Dynamic patella tracking may be assessed to gauge Vastus medialis obliquus (VMO) muscle activation, as well as lateral retinacular tightness. Radiologically, patella alta and a hypoplastic lateral femoral condyle may also increase the risk for dislocation.

Risk factors for recurrent instability can be separated into significant and minor factors (Duerr 2016 Nwachukwu, 2016). Significant factors tend to be more structural factors such as; trochlear dysplasia, patella alta, lateralised tibial tuberosity and medial patellofemoral ligament insufficiency. Minor factors that are potentially amenable to physiotherapy include; VMO hypoplasia or dysplasia, vastus lateralis dominance and lateral retinaculum contracture. Other minor risk factors include; female gender, general ligamentous laxity, an immature physis, excessive internal femoral torsion, excessive external tibial torsion and excessive genu valgum.

Soft tissue structures supporting the patella are of importance, with the medial patellofemoral ligament thought to provide half of the restraint force preventing lateral displacement of the patella in 0-30 degrees of knee flexion (Zhang 2014).

Despite compliance with rehabilitation, the literature currently suggests that patients with major anatomic malalignment will do poorly, and athletes with no or mild risk factors will do predictably well. Young patients experiencing bilateral dislocations are assessed as being at highest risk of failure with conservative management. (Garth, 1996).

Muscle weakness post rehabilitation commonly sits at 80% of the contralateral limb at six months post injury. Therefore rehabilitation outcome measures should consistently measure this and aim for equal strength.

The literature also suggests that ongoing complications at 10-13 years post dislocations affect approximately 50% of patients. Education around longevity and consistent exercise therapy may be indicated and is at least a point of discussion with patients.

Background Education on Imaging in Patella Dislocations

Typically patients will have been referred for an X-Ray by the managing orthopaedic team after a dislocation to assess for bony injury. X-rays can also be useful in assessment of knee alignment and congruity. Typical views involve:

- AP
- Lateral view (knee in 30 degrees flexion) – patellofemoral anatomy, trochlear dysplasia and patella alta
- Tunnel view (PA and 40 degrees knee flexion) - loose bodies
- Merchant view (knee in 45 degrees flexion; superior to inferior view) – patellar tilt, trochlear dysplasia and lateral subluxation
- Laurin view (knee in 30 degrees flexion; inferior to superior view)

N.B. These views may not all be requested if MRI or CT scanning is ordered (Duerr, 2016 & Buchanan, 2016)

The managing orthopaedic team may also refer the patient for Magnetic Resonance Imaging (MRI) to assess; cartilage, bone, medial soft tissue integrity and identify any potential osteochondral lesions.

Computed Tomography (CT) is the gold standard to assess lateral offset of tibial tuberosity relative to trochlear groove (>20mm considered abnormal) and osseous anatomy, however its use clinically may be less widespread due to increased cost, radiation levels, availability, and the ability of MRI to assess bony and soft tissue structures.

Following a re-dislocation, the patient should be reviewed by their managing orthopaedic team, and a need for re-imaging is assessed based on the mechanism of injury and subsequent symptoms. In cases of traumatic dislocation, follow up imaging may be used by the orthopaedic team to assess for new soft tissue injury, bony or osteochondral lesions.

Background Education of Clinical Treatment Pathways:

Conservative & Surgical

Conservative management is regarded both at The Children's Hospital at Westmead, and in the literature, as initial management pathway for patients following their first episode of dislocation with absence of an osteochondral injury (Smith, 2015; Buchanan, 2016). The following information is provided to educate physiotherapists on the pathways that exist for this patient population. This Guideline however, is for use in the rehabilitation of patients following the conservative management pathway.

In the highly active adolescent patient, following initial patella dislocation with anatomy predisposing to recurrent dislocations; surgical management may be considered in the wider surgical community as first line of management to reduce the risk of recurrence (Nwachuku, 2016).

At The Children's Hospital at Westmead, orthopaedic surgical management will follow an initial episode of instability where the patella is unable to be reduced and there is a

compound injury or a large osteochondral injury. Otherwise, a minimum period of six months of physiotherapy is recommended by the orthopaedic team. If during this time or following rehabilitation, the patient has ongoing dislocations of three or more, their managing orthopaedic team may consider surgical management.

Surgical interventions target primary musculoskeletal morphology for instability. Diagnostic arthroscopy may be utilised to identify any osteochondral lesions or loose bodies (Buchanan, 2016), and commonly a medial patellofemoral ligament (MPFL) repair is performed. MPFL reconstructions are indicated in patients with a torn or lax MPFL with recurrent instability without evidence of bony pathology (Buchanan, 2016). The literature suggests outcomes of MPFL reconstructions are positive, with most evidence reporting improvements in pain and functional outcomes, with a low incidence of recurrent dislocations (Buchanan, 2016). Some complications of this particular surgical approach include patella fracture, patella stiffness, poor graft positioning which may lead to cartilage damage, pain and graft failure (Buchanan, 2016).

In conjunction with MPFL repairs, bony interventions may be undertaken to address identified bony morphology. These may include:

- Tibial tuberosity osteotomy or transfer: utilised in patients with an increased tibial tuberosity – trochlear groove (TT-TG) distance, patella alta or high grade osteochondral lesions in the patellofemoral joint. (Buchanan, 2016). Outcomes in a recent systematic review reported a recurrence rate of 7% in an analysis of 38 articles (Buchanan, 2016).
- Correction of valgus/varus deformities: 8 plates or epiphysiodesis
- Correction of femoral anteversion: osteotomy
- Lateral retinacular release

Trochleoplasty is considered a “salvage” procedure, and is utilised in patients with flat or convex lateral trochlear facets, with hypoplasia of the medial trochlear facet, in the presence of normal or near normal articular cartilage (essential for reshaping). This approach is contraindicated in patients with open physes or those with diffuse patellofemoral arthritis and patellofemoral joint pain without history of dislocation. Hence, this approach is rarely used in the paediatric population.

As outlined above, this information is for the educational benefit of the managing physiotherapist of the two potential pathways, conservative and surgical. Whilst it is outside of the role of the physiotherapist to dictate which pathway the patient should take, it is helpful to understand what surgical management pathway may entail. It is also important for treating physiotherapists to understand when the patients’ orthopaedic team may consider surgical management.

Initial Physiotherapy Assessment

The following table outlines the assessment of a patient presenting with a patella dislocation. This table is extensive, and as such, all aspects may not be appropriate to be completed during an initial assessment but rather may require ongoing assessment over multiple appointments. During an initial assessment, it would be considered necessary to observe,

palpate, assess range of movement, muscle strength and control, balance/gait and perform appropriate functional testing.

<i>Observation</i>	<p>Used as a baseline and reassessment measure throughout rehabilitation.</p> <ul style="list-style-type: none"> • Swelling • Asymmetry • Muscle bulk <p>Reason for Orthopaedic review; significant increase in swelling/ effusion</p> <p>Concern if asymmetry/ muscle atrophy remains despite rehabilitation</p>
<i>Palpation</i>	<p>Palpate structures to localise pain sources and structural involvement. Also useful for reassessment, as painful areas should become asymptomatic over time.</p> <ul style="list-style-type: none"> • Medial Retinaculum (mid portion, origin, insertion) • Adductor tubercle (Basset's sign) • Bony Landmarks of the patella • Lateral femoral condyle • Medial femoral condyle • Medial and lateral tibiofemoral joint lines • Patella tendon • Tibial tuberosity • Accessible retropatellar surfaces • General patella region with active range of motion to evaluate for crepitus
<i>Girth</i>	<p>Obtain girth measurements to quantify and monitor oedema and atrophy. Oedema is measured circumferentially around the knee joint across the joint line, whilst knee is straight. Quadriceps bulk can be measured circumferentially 15cm proximal to knee joint line.</p>
<i>Range of Movement (ROM) and Flexibility</i>	<p>Evaluate lower extremity passive ROM and active ROM for hips, knees and ankles using inclinometer/goniometer as appropriate. Useful to ascertain patient anatomic profile, and to monitor progress and function.</p> <ul style="list-style-type: none"> • Hip: Flexion, extension, abduction, adduction, internal rotation and external rotation • Knee: Flexion and extension, medial and lateral rotation • Ankle: plantarflexion and dorsiflexion <p>Reason for Orthopaedic review; patient not achieving 90-100% ROM within six weeks.</p>

<i>Muscle Strength and Control</i>	Useful to assess baseline strength, target rehabilitation and monitor progress. Perform muscle testing using manual muscle testing or hand held dynamometer: <ul style="list-style-type: none"> • Hip flexors/extensors/abductors/internal and external rotators. • Knee extensors and flexors • VMO activation in extension (open chain) and closed chain seated • Ankle plantarflexors and dorsiflexors (heel walks)
<i>Special Tests/ Standing Alignment</i>	To identify structural factors that may increase the risk of re-dislocation. Can assist in guiding education, targeting rehabilitation exercises, and return to sport expectations. <p>Standing:</p> <ul style="list-style-type: none"> • Patella orientation (position, glide, size, tilt, rotation, McConnell's measurement) • Extent of internal/external rotation of tibia/femur at 0 and 90 degrees flexion • Genu Varus/valgus • Genu recurvatum • Standing Q-angle • Foot/ankle posture (pronation) • Trendelenberg <p>Sitting:</p> <ul style="list-style-type: none"> • McConnell's Test. Appendix 2.1. <p>Supine:</p> <ul style="list-style-type: none"> • Modified Thomas test
<i>Balance/Gait</i>	To identify functional/dynamic factors that should guide targeted rehabilitation. Can be used at baseline and reassessment throughout rehabilitation. <p>Evaluate gait in regards to:</p> <ul style="list-style-type: none"> • Ability to weight bear on limb • Safety of ambulation on even/uneven surfaces. • Ability to stand and balance on single leg. • Extent of internal rotation of the femur during stance phase. • Extent of Trendelenberg during stance phase • Ability to weight shift onto stance leg during stance phase • Extent of terminal knee extension control/avoidance • Push off during transition from stance to swing phase.

	<ul style="list-style-type: none"> • Extent of hip and knee flexion during swing phase • Step length • Activation and timing of trunk and lower extremity musculature. <p>Reason for Orthopaedic review; patient not achieving independent walking within six weeks from injury.</p>
<p><i>Functional Testing – may not all be appropriate for initial assessment. Consider prior to 'Restoring Function Phase'.</i></p>	<p>To identify functional/dynamic factors that should guide targeted rehabilitation. Can be used at baseline and reassessment throughout rehabilitation.</p> <ul style="list-style-type: none"> • Bed mobility and transfers • Double leg and single leg squat • Double leg and single leg calf raises • Stair negotiation • Running in straight line and changing direction • Double leg jumping • Hopping: on the spot, forwards, sideways.
<p><i>Evaluation of knee ligaments</i></p>	<p>Useful to ascertain base understanding of patient anatomic profile and any difference in knee laxity between sides.</p> <ul style="list-style-type: none"> • Anterior cruciate ligament: Lachman's/Anterior Drawer • Posterior Cruciate ligament: Posterior Sag/Posterior Drawer • Medial collateral ligament: 0 & 30 degrees flexion valgus stress • Lateral collateral ligament: 0 & 30 degrees flexion varus stress
<p><i>Joint hypermobility - See appendix 6.2</i></p>	<p>Useful to assess general connective tissue profile. If patient is deemed 'hypermobility' with a score of >4/9, this may increase expected time in rehabilitation, may alter long term return to sport expectations, and may increase risk of redislocation.</p> <ul style="list-style-type: none"> • Beighton's Hypermobility Scale. Appendix 2.2. <p>Reason for further medical review: score of 9/9 may warrant a referral to the connective tissue disorder clinic.</p>
<p><i>Knee subjective Questionnaires - See appendix 6</i></p>	<p>Choose one or more of the following questionnaires to assess subjective experience of injury. Useful for monitoring functional progress.</p> <ul style="list-style-type: none"> • Pedi-IKDC • Kujala Patellofemoral Disorder Score • Tegner & Lysholm Activity Score. Appendix 2.3. • Patient Specific Function Scale • Tampa

<p>General Health Instruments - See appendix 6 for Questionnaire, scoring information and cut off scores.</p>	<p>The treating therapist may have reason for concern for the patient's psychological well-being. One of the following questionnaires may be used to assess this. Results of the chosen questionnaire may indicate a need for a review /referral to psychology and back to the managing orthopaedic team.</p> <ol style="list-style-type: none"> 1. Child Mental Health Checklist via website: suitable 4-16 yrs of age https://healthyfamilies.beyondblue.org.au/age-6-12/mental-health-conditions-in-children/child-mental-health-checklist. 2. Pediatric Symptom Checklist: attached in Appendix 2.5, suitable 4-16years of age. https://www.massgeneral.org/psychiatry/treatments-and-services/pediatric-symptom-checklist/
<p>Attitudes and Belief of patient and family</p>	<ul style="list-style-type: none"> • Establish family and patient's ability to participate and adhere to management. • Attitudes and beliefs, including confidence and perceived importance of physiotherapy rehabilitation. • Establish patient/family's knowledge and understanding of the condition. • Establish goals of therapy: Long and short term SMART goals. • Identify potential barriers to attending physiotherapy sessions/adherence to HEP.
<p>Goals</p>	<p><i>Facilitating goal centred rehabilitation may assist with adherence to physiotherapy rehabilitation. Focussing on a return to sport or recreational activity as per Australian physical activity Guidelines for youth guidelines.</i></p> <ul style="list-style-type: none"> • Identify specific patient activity goals, return to sport or recreational goals.

Phase 1 - Initial Phase of Rehabilitation

This phase aims to engage patients in activities that will restore their ability to perform basic tasks associated with normalising ROM and gait.

Recommendations for Phase 1 – Initial Phase of Rehabilitation

- 1 For pain relief:
 - i. Cryotherapy
 - ii. Electrical stimulation and/or TENS as per clinician direction
 - iii. Medications: patients should be encouraged to follow physician recommendations regarding appropriate analgesia.
 - iv. Brace/taping/ patella stabilisation brace (Zimmer splint bracing is generally recommended for no longer than two weeks following dislocation – whether initial or recurrent - and may be either a Zimmer splint or ROM brace locked in extension. A lateral support brace may be used during the first few weeks of rehab if it aids in reducing pain and increasing function. There is no evidence to support bracing beyond this period.) A Patella Stabilisation Brace can be used long term as a replacement to taping, to provide a lateral block to the patella.
- 2 For effusion:
 - i. Cryotherapy
 - ii. Vasopneumatic device
 - iii. Elastic compression wrap/Tubigrip before and after therapy sessions and during the day as required.
- 3 For ROM/Flexibility:
 - i. Mobilisation of patella all directions, except lateral, conducted by patient (*Exercise for Phase 1*).
 - ii. Static stretches for quadriceps, hamstrings, hip adductors, hip extensors and calves (*Exercise for Phase 1*).
 - iii. AROM and AAROM with overpressure (*Exercise for Phase 1*).
- 4 Strength and Control: initiated with 2 x 10-15 reps as appropriate, with progression to 3 sets when achieving 2 sets with appropriate technique. Ensure contralateral leg and core muscles are also being addressed.
 - i. Isometric exercises targeting hip and knee musculature in gravity minimised positions (*Exercise for Phase 1*).
 - ii. Progress to isotonic gravity assisted exercises when achieving 3 sets of Isometric exercises (*Exercise for Phase 1*).
 - iii. Progress to isotonic anti-gravity exercises when achieving 3 sets of gravity assisted isotonic (*Exercise for Phase 1*).

5 Balance:

- i. Begin with an emphasis on symmetrical weight bearing in double limb stance with minimal to no assist (*Exercise for Phase 1*).
- ii. Progress to weight-shifting in anterior-posterior and medial-lateral directions with good control (*Exercise for Phase 1*).

6 Gait re-training:

- i. Patient-specific ambulation exercises should be implemented with the aim of restoring a typical gait pattern.

7 Functional Tasks:

- i. Patients should be provided with training and education in bed mobility, transfers and safe stair navigation with progression toward minimal use of assistive devices as appropriate
- ii. Engage in exercises for cardiovascular fitness; such as walking, upper body ergometer and/or pool walking as tolerated.

Exercises for Phase 1 – Initial Phase of Rehabilitation

Range of Movement/Flexibility:

1. Partial/full revolution on stationary bike



2. Mobilisation of patella all directions except lateral



3. Stretches:

- i. Adductor Stretch



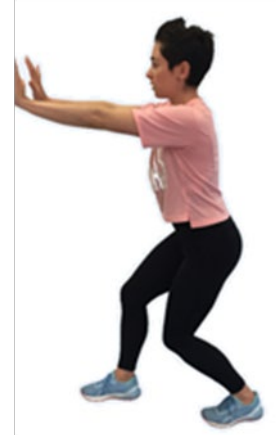
- ii. Knee flexion stretch with towel



- iii. Knee extension (hamstring) stretch



- iv. Gastrocnemius and soleus stretch



v. Gluteal stretch



Strength and Control:

1. Quadriceps isometric sets



2. Gluteal isometric sets



3. Clamshells



4. Long arc quadriceps



5. Side lying straight leg raises:

i. Abduction



ii. Adduction



iii. Extension



iv. Flexion



6. Mini squat with table assistance (hip vs. knee strategy)



7. Double leg calf raises (standing, or seated if unable to stand)



8. Wall planks



9. Double leg bridge



10. Co-contraction of quadriceps and hamstrings



11. VMO activation into extension



Balance:

1. Standing on two feet: review equal weight-bearing on scale if required

2. Weight shifting

i. Anterior-posterior



ii. Medial-lateral



Functional Tasks:

1. Cardiovascular fitness; such as walking, upper body ergometer



2. Pool walking as tolerated

i. Marching



ii. Walking forward/backwards



iii. Lateral stepping



iv. Heel to bottom



Outcome Measures for Phase 1 – Initial Phase of Rehabilitation

The patient must achieve the intended goals for the red, yellow and green stages of each objective measure before progressing to Phase 2.

Objective Measure	Assessment	Goal	Achieved
Pain	Visual Analogue Scale (VAS) With little to no indication of pain during ambulation, weight bearing as tolerated +/- crutches	≤2/10	<input type="radio"/>
	Brush Swipe Test Visual observations	Minimal to none	<input type="radio"/>
ROM / Flexibility	Goniometer reading for active ROM	Minimum 5° extension & 90° flex	<input type="radio"/>
	Straight leg raise in supine: assess extensor lag	Minimal to none	<input type="radio"/>
	Manual Muscle Testing (MMT) – for quadriceps, hamstrings, glut and calf muscle groups. Appendix 2.6.	MMT ≥3/5	<input type="radio"/>
Balance	Assess amount of weight bearing in double leg stance on affected side with minimal to no assistance	≥50% BW on scales	<input type="radio"/>
	Independent, safe and normal walking mechanics with appropriate use of assistive device as needed. Monitor for common compensation strategies such as; flexed knee/ knee hyperextension/ limp.	Minimal to no compensation	<input type="radio"/>
	Assess transfers, bed mobility and stair navigation +/- assistive device.	Safe & Independent	<input type="radio"/>

Phase 2 - Restoring Basic Function

The purpose of this phase is to ensure the patient can perform all basic functional tasks relevant to them, excluding sport or higher level exercise.

Recommendations for Phase 2 – Restoring Basic Function

- 1 For ROM/Flexibility:
 - i. Introduce dynamic stretches for lower extremity musculature for quadriceps, hamstrings and calves (*Exercise for Phase 2*).
- 2 Strengthen and Control: Ensure contralateral leg and core muscles are also being addressed.
 - i. Resisted isometric and isotonic strengthening exercise, utilising therabands, weights and other equipment, targeting the hip, knee and ankle musculature (*Exercise for Phase 2*).
 - ii. Concurrently, exercise focusing on Vastus Medialis Obliquus activation at 0-30° of knee flexion (*Exercise for Phase 2*).
 - iii. Closed chain exercises should be emphasised to regain control of terminal knee extension (*Exercise for Phase 2*).
- 3 Balance:
 - i. Double limb stance challenges on dynamic surfaces or with other external perturbations (*Exercise for Phase 2*).
 - ii. Single leg exercises must be introduced when patient is performing double limb balance exercises without episodes of instability or requirement of assistance (*Exercise for Phase 2*).
- 4 Gait:
 - i. The remaining deficits in the gait cycle (e.g. knee hyperextension) should continue to be addressed
 - ii. Progress the patient off any assistive devices and normalise gait patterns on even and uneven surfaces (*Exercise for Phase 2*).
- 5 Functional Tasks:
 - i. Stair navigation training should be incorporated
- 6 Minimal intensity cardiovascular exercise should be performed at a rate of perceived exertion (RPE) of 9-11 on the Original Borg Scale (Appendix 2.8) or 1-2 on the Children's Hospital RPE Scale (Appendix 2.7).
- 7 Discuss with family and provide school with appropriate sport integration for school PDHPE classes; this may include physiotherapy exercises within the dedicated PDHPE class time.

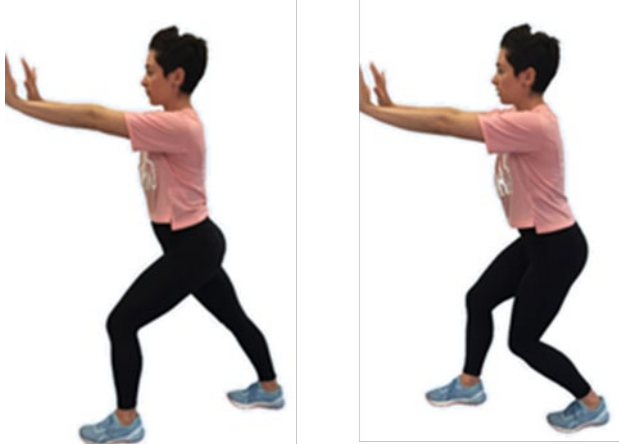
Exercises for Phase 2 – Restoring Basic Function

Range of Movement/Flexibility:

1. Full revolutions on stationary bike



3. Gastrocnemius and soleus stretches



Strength and Control:

1. Step ups:

- i. Forwards



- ii. Lateral



iii. Reverse



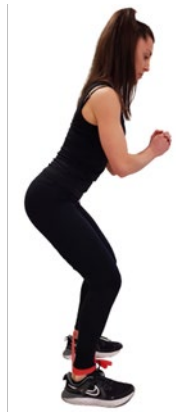
2. Squats (hip vs. knee strategy)



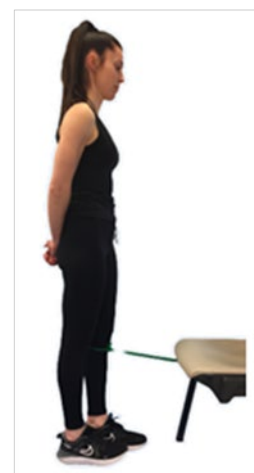
3. Wall squats



4. Side stepping with theraband



5. Knee extension with theraband (closed chain)



6. Double leg squat with theraband around knees



7. Glute squeeze against wall



8. Forward lunges



10. Bridging with theraband around knees



11. Single leg glute bride/hamstring bridge



12. Hamstring curls on ball



13. Swiss ball roll outs



14. Calf raises



15. Four point kneeling with alternation upper/lower extremity extension



16. Side planks (on knees)



17. Push ups



Balance:

1. Double leg dynamic balance



2. Arabesque with knee control



3. Single leg balance on firm surface. Add in rotation of cervical spine and thorax with balance tasks



Gait:

1. Obstacle avoidance and quick changes of direction whilst walking



Functional Tasks:

1. Repeated chair squats



2. Reciprocal stair climbing



3. Cardiovascular fitness; such as walking, upper body ergometer



Outcome Measures for Phase 2 – Initial Phase of Rehabilitation

The patient must achieve the intended goal for the red, yellow and green stages of objective measures before progressing to Phase 3.

Objective Measure	Assessment	Goal	Achieved
Pain	Visual Analogue Scale (VAS) With little to no indication of pain during ambulation, weight bearing as tolerated +/- crutches	≤2/10	<input type="radio"/>
	Brush Swipe Test Visual observations	Intermittent to none	<input type="radio"/>
ROM / Flexibility	Goniometer reading for active ROM	0° to ≥100° flexion	<input type="radio"/>
	Straight leg raise in supine: assess extensor lag	No lag with a 10 second hold	<input type="radio"/>
	Manual Muscle Testing (MMT) – all bilateral lower limb and core muscle groups. Appendix 2.6.	MMT >4/5	
	Dynamometry testing of lower limb – effected compared to non-effected side	60-65% strength	
Double leg squat, no assistive device, on even and uneven surfaces Foot and ankle control in stance phase ± orthotics device	Nil compensation strategies		
Balance	Assess a timed single leg balance Star excursion balance test – See Appendix 3.7.	≥90% on involved side compared to uninvolved side	<input type="radio"/>
Gait	Walking mechanics with no assistive device on even and uneven surfaces	No compensation	<input type="radio"/>
	Quick change of direction while ambulating Appropriate hip and knee control with stairs	Safe & Independent	<input type="radio"/>
Functional Tasks	10 minutes of minimal intensity activity e.g. waking or low resistance stationary bike	Tolerates with no complaints	<input type="radio"/>

Phase 3 - Restoring Advanced Function Phase

The purpose of this phase is to restore the patient to an advanced level of function, inclusive of returning to modified or basic sporting activities.

Recommendations for Phase 3 – Restoring Advanced Function

- 1 For ROM/Flexibility:
 - i. Passive and dynamic stretches for lower extremity musculature should continue for maintenance of good ROM and flexibility.
- 2 Strength and Control: Ensure contralateral leg and core muscles are also being addressed.
 - i. Resisted isometric and isotonic strengthening exercise, utilising therabands, weights and other equipment, targeting the hip, knee and ankle musculature (*Exercise for Phase 3*).
 - ii. Exercises to optimise control, alignment and appropriate muscle recruitment for double and single leg activities.
- 3 Balance:
 - i. Single leg balance exercises inclusive of; perturbations, stable and unstable surfaces and sport specific balance tasks (*Exercise for Phase 3*).
- 4 Gait:
 - i. Exercise interventions that emphasise optimal, symmetrical and safe gait patterns for jogging and running should be integrated into this phase (*Exercise for Phase 3*).
- 5 Functional Tasks: Attention should be made to foot and ankle strategy; knee, hip and trunk strategy; with each segment contributing an equal part in the skill (*Exercise for Phase 3*).
 - i. Quick changes in direction and de-acceleration activities
 - ii. Optimal landing technique for age-appropriate activities such as skipping, jumping and hopping.
 - iii. Increase intensity and dynamic motions associated with sports specific tasks.
- 6 High intensity cardiovascular exercises should be integrated with an RPE of 14-17 (Appendix 2.7) on the Original Borg scale or 3-4 on the Children's Hospital Exertion Scale (Appendix 2.8).

Exercises for Phase 3 – Restoring Advanced Function

Range of Movement/Flexibility:

1. Full revolutions on stationary bike



Muscle Strength and Control:

1. Single leg squat: 45-60 degrees



2. Single leg balance with hip abduction



3. Single leg deadlifts



4. Side planks on toes



5. Glutes against the wall with squat – single leg



6. Single leg bridge (hamstring and glute)



7. Transverse lunges



8. Plank with hip extension



9. Swiss ball pike



10. Swiss ball roll out with hip extension



11. Step ups:

i. Forwards (high)



ii. Lateral (high)



iii. Reverse (high)



12. Wall squat with increased depth +/- hold



13. Double leg squat to 90°



14. Resisted diagonal stepping



15. Four point kneeling with alternating upper extremity/lower extremity extension



16. Forward lunge + trunk rotation



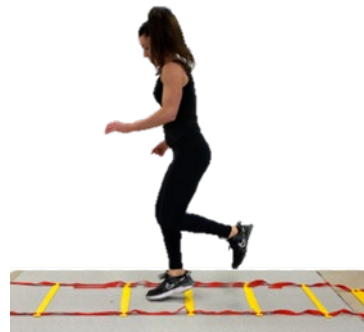
17. Reverse lunge



18. Stability ball roll out



19. Agility ladder drills



20. Double leg jumps (vertical, posterior/anterior, medial/lateral, diagonal)



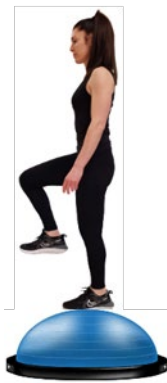
21. Low to high level single leg hop



Balance:

1. Single leg balance on uneven surfaces

2. Arabesque with head turns



3. Single leg balance with external and internal perturbations



Gait:

1. Walking program with progression to running.

Functional Tasks:

1. Cardiovascular fitness
 - i. Stationary bike or elliptical trainer – progressively increase intensity and duration



Outcome Measures for Phase 3 – Advanced Phase of Rehabilitation

The patient must achieve the intended goal for the red, yellow and green stages of objective measures before progressing to Phase 4.

Objective Measure	Assessment	Goal	Achieved
Pain	Visual Analogue Scale (VAS) score with all ADLs, recreational activities and age appropriate skills	No pain (0)	<input type="radio"/>
	Brush Swipe Test Visual observations	Nil with all activities	<input type="radio"/>
Strength & Control	Manual Muscle Testing (MMT) – all bilateral lower limb and core muscle groups. Appendix 2.6. Dynamometry testing of lower limb – effected compared to non-effected side	MMT 5/5 80% strength	<input type="radio"/>
	Single leg Sit-To-Stand with good functional alignment/control. Appendix 3.1.	>25 reps	<input type="radio"/>
	Single leg calf raises with good functional alignment/control. Appendix 3.2.	>30 reps	
	Plank Test – See Appendix 3.3	>90 sec	
	Side Bridge Test – See Appendix 3.4	>60 sec + >80% unaffected side	
	Biering-Sorensen back extension test – See Appendix 3.5	>90 sec	
	Vertical drop jump test – See Appendix 3.6	Good functional alignment/control	
Balance	Star excursion balance test – See Appendix 3.7	≥95% on involved side compared to uninvolved side	
Gait	Optimal gait mechanics while running/sprinting at sport specific distances and at pre-injury intensity	No compensation	<input type="radio"/>
Functional Tasks	Sport specific ball or apparatus skills: - Running and stopping while passing/catching - Running and kicking at various speeds/directions - Striking with integrated full body movement in ball and stick sports	Safe with optimal mechanics and balance	<input type="radio"/>
	Hop Tests Battery – See Appendix 3.8: - Single leg hop for distance - Triple hop for distance - Triple crossover hop - 6m timed hop - Medial rotation hop for distance	>80% on involved side compared to uninvolved side Optimal mechanics	<input type="radio"/>
	Cardiovascular activities at an intensity required for desired sport	No increased pain or instability episodes	<input type="radio"/>

Phase 4 - Return to Sport Phase

The purpose of this phase is to return to sport specific training, prior to a full return to sport.

Recommendations for Phase 4 – Return to Sport Phase

- 1 Balance:
 - i. Balance tasks should include advanced activities in single leg standing inclusive of: external perturbations, stable and unstable surfaces and sport specific tasks (including the use of ball/ bat/ stick as appropriate) (*Exercise for Phase 4*).
- 2 Gait:
 - i. Exercises that emphasise optimal, symmetrical and safe gait patterns for running and sprinting, with the inclusion of sport specific defensive players or opponents (*Exercise for Phase 4*).
- 3 Strength and Control:
 - i. Advanced resistance exercises targeting the knee, hip and ankle musculature with a focus on optimal control, and alignment (*Exercise for Phase 4*).
- 4 Functional Tasks: These exercises should now be implemented following cardiovascular fatigue, with a focus on maintaining good alignment in a fatigued state (*Exercise for Phase 4*).
 - i. Quick change in direction exercises
 - ii. Optimal landing technique in jumping and hopping
 - iii. De-acceleration tasks
 - iv. Progressive return to team training with modifications including:
 - The number of drills the player participates in
 - The number of external factors (number of opponents/ size of the field etc).
 - The length of rest breaks
 - v. Progressive return to game play:
 - Continue to progress to full team training without limitations

Exercises for Phase 4 – Return to Sport Phase

Functional Training: Targeting balance, strength, neuromuscular control, gait and return to sport.

1. Single leg squat 0 – 45 degrees



2. Side plank with hip abduction



3. Front plank with hip abduction



4. Front plank with hip extension



5. Single leg deadlift



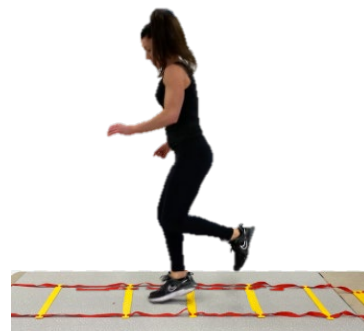
6. Transverse lunge



7. Stability ball pike up



8. Agility ladder drills



8. Multi planar lunges



9. Box jumps with rebound



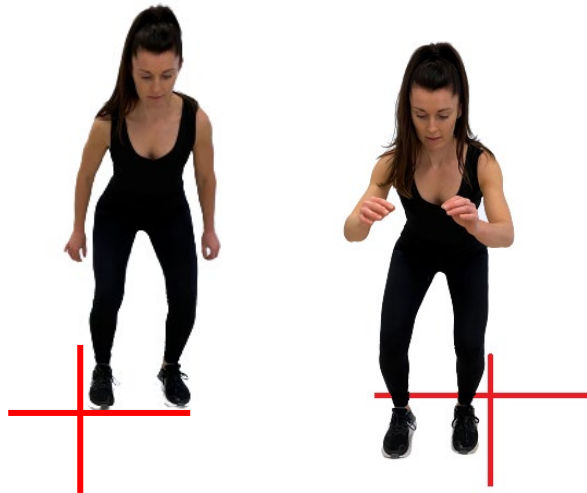
10. Double leg plyometric jumps



11. Lung/Alternating lung jumps



12. Double leg jumping/Squat jumps



12. Low to high level single leg hops



14. Cutting and pivoting technique/exercises (change of direction)

Cardiovascular Fitness:

1. Elliptical trainer
2. Jogging/running
3. Sprinting
4. Swimming

Outcome Measures for Phase 4 – Return to Sport Phase

The patient must achieve the intended goal for the red, yellow and green stages of the objective measures. Once all of the following requirements are achieved, return to play should be progressed in minutes played to allow for improvement in cardiovascular and neuromuscular levels of fatigue.

Objective Measure	Assessment	Goal	Achieved
Pain	Visual Analogue Scale (VAS) score with all ADLs, recreational activities and age appropriate skills	No pain (0)	<input type="radio"/>
Psychometric Testing	Complete all of the following patient recorded outcome measures: <ul style="list-style-type: none"> - Pedi-IKDC - Kujala Patellofemoral Disorder Score - Lysholm/Tegner Activity Score - Patient Specific Functional Scale or Tampa 	Pass all with >95% of goal target	<input type="radio"/>
Balance	Able to perform sport specific single leg balance drills with sport relevant external perturbations	Safe with optimal mechanics	<input type="radio"/>
Gait	Optimal gait mechanics while performing sport specific ball or apparatus skills in game-like situations	No compensation	<input type="radio"/>
Functional Tasks	Hop Tests Battery – See Appendix 3.8: <ul style="list-style-type: none"> - Single leg hop for distance - Triple hop for distance - Triple crossover hop - 6m timed hop - Medial rotation hop for distance 	>95% on involved side compared to uninvolved side Optimal mechanics	<input type="radio"/>
	Cardiovascular activities at an intensity required for desired sport- See Appendix 3.11: <ul style="list-style-type: none"> - The Yo-Yo Intermittent Recover Test 	As per age related norms – Appendix 3.11	<input type="radio"/>
	Optimal mechanics for all agility movements: <ul style="list-style-type: none"> - T-Test: see Appendix 3.9, or - Illinois Agility Test: see Appendix 3.10 	As per age related norms – Appendix 3.9/3.10	<input type="radio"/>

Appendix 1: General Information

Epidemiology, Risk Factors & Outcomes

Patella dislocations are currently reported to effect 29 per 100 000 adolescents each year (Duerr 2016). The peak age of incidence is 15 years (Palmu 2008) with a potential higher representation of adolescent females. Acute patella dislocations account for 2-3% of knee injuries and is the second most common cause of traumatic haemarthrosis of the knee (Bitar 2011, Nwachukwu 2016).

Longer term implications of recurrent instability and recurrent dislocations are common with variable rates reported in the literature at 15-44% post non-operative treatment. Post dislocation issues including pain, inability to return to sport and early patellofemoral arthropathy are also reported (Bitar 2011), with an patient seven times more likely to experience subsequent dislocations after the primary.

The diagnosis of an acute patella dislocation can be made by clinical evaluation together with radiology. Patients who have a positive patella apprehension test; with a lateral patella glide of >75% width of the patella; are likely to have medial soft tissue insufficiency.

Influential factors for dislocation can also be assessed using the patella tilt test, measuring Q angle at the knee, assessing for dynamic J tracking of the patella, vastus medialis obliquus (VMO) muscle bulk and activation, and lateral retinacular tightness. Radiologically patella alta and a hypoplastic lateral femoral condyle may also suggest a likelihood of dislocation.

Risk factors for recurrent instability can be separated into significant and minor factors (Duerr 2016 Nwachukwu, 2016). Significant factors tending to be more structural factors such as trochlear dysplasia, patella alta, lateralised tibial tuberosity and medial patellofemoral ligament insufficiency. Minor factors that are potentially amenable to physiotherapy are general ligamentous laxity, VMO hypoplasia or dysplasia, vastus lateralis dominance and lateral retinaculum contracture. Other minor risk factors include female gender, an immature physes, excessive internal femoral torsion, excessive lateral tibial torsion and excessive genu valgum.

Soft tissue structures supporting the patella are of importance, with the medial patellofemoral ligament thought to provide half of the restraint force preventing lateral displacement of the patella in 0-30 degrees of knee flexion (Zhang 2014).

Despite compliance with rehabilitation, the literature currently suggests that patients with major anatomic malalignment will do poorly, and athletes with no or mild risk factors will do predictably well. Young patients experiencing bilateral dislocations are assessed as being at highest risk of failure with conservative management. (Garth, 1996).

Muscle weakness post rehabilitation commonly sits at 80% of the contralateral limb at six months; and the literature also suggests that ongoing complications at 10-13 years post dislocations affects approximately 50% of patients. Physiotherapy intervention should be targeted at this persistent asymmetrical weakness, as well as providing patients with thorough education on the importance of exercise.

Appendix 2: Special Tests & Questionnaires

2.1 Special Test: McConnell's Test

Procedure

Part I:

- Patient is seated with legs hanging over the end of the table
- Therapist sits in front of the client
- Therapist instructs patient to externally rotate the femur of the affected leg while performing active resisted isometric contractions of the quadriceps muscles at 0, 30, 60, 90 and 120 degrees of flexion.
- Therapist notes the painful degrees/ ranges

Part II:

- Therapist passively brings the patient's knee to full extension, resting the heel on something so the patient relaxes the quadriceps muscles
- Therapist glides the affected patella **medially** and holds the patella in that position
- Therapist instructs patient to perform isometric contractions at the knee ranges that were painful before

Part III:

- Therapist passively brings the patient's knee to full extension, resting the heel on the bed so the patient relaxes the quadriceps muscles
- Therapist glides the affected patella **laterally** and holds the patella in that position
- Therapist instructs patient to perform isometric contractions at the knee ranges that were painful before

Positive Test

- Pain decreases significantly after holding patella medially = patellofemoral lateral tracking problems
- Pain decreases significantly after holding patella laterally = patellofemoral medial tracking problems

McConnell, J. (1986).

2.2 Beighton Hypermobility Score

Table 1 Beighton criteria for joint hypermobility

Joint/finding	Negative	Unilateral	Bilateral
Passive dorsiflexion of the fifth finger >90°	0	1	2
Passive flexion of thumbs to the forearm	0	1	2
Hyperextension of the elbows beyond 10°	0	1	2
Hyperextension of the knees beyond 10°	0	1	2
Forward flexion of the trunk with knees fully extended and palms resting on the floor	0	1	1

Scores are assigned for features listed above and a total score of at least 5 defines hypermobility.

Beighton, et.al. (1969)

2.3 Lysholm Pain Score & Tegner Activity Score

Name: _____ Date: _____

SECTION 1 - LIMP

- I have no limp when I walk. (5)
 I have a slight or periodical limp when I walk. (3)
 I have a severe and constant limp when I walk. (0)

SECTION 2 - Using cane or crutches

- I do not use a cane or crutches. (5)
 I use a cane or crutches with some weight-bearing. (2)
 Putting weight on my hurt leg is impossible. (0)

SECTION 3 - Locking sensation in the knee

- I have no locking and no catching sensation in my knee. (15)
 I have catching sensation but no locking sensation in my knee. (10)
 My knee locks occasionally. (6)
 My knee locks frequently. (2)
 My knee feels locked at this moment. (0)

SECTION 4 - Giving way sensation from the knee

- My knee gives way. (25)
 My knee rarely gives way, only during athletics or vigorous activity. (20)
 My knee frequently gives way during athletics or other vigorous activities. In turn I am unable to participate in these activities. (15)
 My knee frequently gives way during daily activities. (10)
 My knee often gives way during daily activities. (5)
 My knee gives way every step I take. (0)

SECTION 5 - PAIN

- I have no pain in my knee. (25)
 I have intermittent or slight pain in my knee during vigorous activities. (20)
 I have marked pain in my knee during vigorous activities. (15)
 I have marked pain in my knee during or after walking more than 1 mile. (10)
 I have marked pain in my knee during or after walking less than 1 mile. (5)
 I have constant pain in my knee. (0)

SECTION 6 - SWELLING

- I have swelling in my knee. (10)
 I have swelling in my knee only after vigorous activities. (6)
 I have swelling in my knee after ordinary activities. (2)
 I have swelling constantly in my knee. (0)

SECTION 7 - CLIMBING STAIRS

- I have no problems climbing stairs. (10)
 I have slight problems climbing stairs. (6)
 I can climb stairs only one at a time. (2)
 Climbing stairs is impossible for me. (0)

SECTION 8 - SQUATTING

- I have no problems squatting. (5)
 I have slight problems squatting. (4)
 I cannot squat beyond a 90deg. Bend in my knee. (1)
 Squatting is impossible because of my knee. (0)

Total: _____/100

Grading the Lysholm Knee Scoring Scale

<65 Poor

65-83 Fair

84-90 Good

>90 Excellent

Tegner, Y., Lysholm, J. (1985).

Tegner Activity Scale

The Tegner activity scale is a one-item score that grades activity based on work and sports function. Zero represents disability because of knee problems and 10 represents national or international level sport participation.

Rate your level of function from 0-10:

Level 10 - Competitive sports- soccer, football, rugby (national elite)

Level 9 - Competitive sports- soccer, football, rugby (lower divisions), ice hockey, wrestling, gymnastics, basketball

Level 8 - Competitive sports- racquetball or bandy, squash or badminton, track and field athletics (jumping, etc.), down-hill skiing

Level 7 - Competitive sports- tennis, running, motorcars speedway, handball

Recreational sports- soccer, football, rugby, bandy, ice hockey, basketball, squash, racquetball, running

Level 6 - Recreational sports- tennis and badminton, handball, racquetball, down-hill skiing, jogging at least 5 times per week

Level 5 - Work- heavy labor (construction, etc.)

Competitive sports- cycling, cross-country skiing,

Recreational sports- jogging on uneven ground at least twice weekly

Level 4 - Work - moderately heavy labor (e.g. truck driving, etc.)

Level 3 - Work - light labor (nursing, etc.)

Level 2 - Work - light labor

Walking on uneven ground possible, but impossible to back pack or hike

Level 1 - Work - sedentary (secretarial, etc.)

Level 0 - Sick leave or disability pension because of knee problems

Tegner, et.al. (1985).

2.4 The Patient-Specific Functional Scale

This useful questionnaire can be used to quantify activity limitation and measure functional outcome for patients with any orthopaedic condition.

Clinician to read and fill in below: Complete at the end of the history and prior to physical examination.

Assessment:

I am going to ask you to identify up to five important activities that you are unable to do or are having difficulty with as a result of your _____ problem. Today, are there any activities that you are unable to do or are having difficulty with because of your _____ problem?

Please rate each of these problems on the 0-10 scale below.

0 = Able to perform activity at the same level as before injury or problem (No issues) .

10 = Unable to perform activity (Cannot perform).

Activity 1:										
0	1	2	3	4	5	6	7	8	9	
10										

Activity 2:										
0	1	2	3	4	5	6	7	8	9	
10										

Activity 3:										
0	1	2	3	4	5	6	7	8	9	
10										

Activity 4:										
0	1	2	3	4	5	6	7	8	9	
10										

Activity 5:										
0	1	2	3	4	5	6	7	8	9	
10										

Name: _____

DOB: _____

Date of Assessment: _____

Total Score: _____

Total score = sum of the activity scores/number of activities

Minimum detectable change (90%CI) for average score = 2 points

Minimum detectable change (90%CI) for single activity score = 3 points

Stratford, et.al. (1995).

2.5 The Pediatric Symptom Checklist

Pediatric Symptom Checklist

Emotional and physical health go together in children. Because parents are often the first to notice a problem with their child's behaviour, emotions or learning, you may help your child get the best care possible by answering these questions. Please mark under the heading that best fits your child.

		Never (0)	Sometimes (1)	Often (2)
1. Complains of aches/pains	1	_____	_____	_____
2. Spends more time alone	2	_____	_____	_____
3. Tires easily, has little energy	3	_____	_____	_____
4. Fidgety, unable to sit still	4	_____	_____	_____
5. Has trouble with a teacher	5	_____	_____	_____
6. Less interested in school	6	_____	_____	_____
7. Acts as if driven by a motor	7	_____	_____	_____
8. Daydreams too much	8	_____	_____	_____
9. Distracted easily	9	_____	_____	_____
10. Is afraid of new situations	10	_____	_____	_____
11. Feels sad, unhappy	11	_____	_____	_____
12. Is irritable, angry	12	_____	_____	_____
13. Feels hopeless	13	_____	_____	_____
14. Has trouble concentrating	14	_____	_____	_____
15. Less interest in friends	15	_____	_____	_____
16. Fights with others	16	_____	_____	_____
17. Absent from school	17	_____	_____	_____
18. School grades dropping	18	_____	_____	_____
19. Is down on him or herself	19	_____	_____	_____
20. Visits doctor with doctor finding nothing wrong	20	_____	_____	_____
21. Has trouble sleeping	21	_____	_____	_____
22. Worries a lot	22	_____	_____	_____
23. Wants to be with you more than before	23	_____	_____	_____
24. Feels he or she is bad	24	_____	_____	_____
25. Takes unnecessary risks	25	_____	_____	_____
26. Gets hurt frequently	26	_____	_____	_____
27. Seems to be having less fun	27	_____	_____	_____
28. Acts younger than children his or her age	28	_____	_____	_____
29. Does not listen to rules	29	_____	_____	_____
30. Does not show feelings	30	_____	_____	_____
31. Does not understand other people's feelings	31	_____	_____	_____
32. Teases others	32	_____	_____	_____
33. Blames others for his or her troubles	33	_____	_____	_____
34. Takes things that do not belong to him or her	34	_____	_____	_____
35. Refuses to share	35	_____	_____	_____

Total Score _____

Does your child have any emotional or behavioural problems for which she/he needs help? N Y

Are there any services that you would like your child to receive for these problems? N Y

If yes, what services? _____

Jellinek, et.al. (1988).

2.6 Manual Muscle Test:

Refer to Daniels and Worthingham's handbook, for detailed explanation of manual muscle testing techniques.

Brown, M., & Avers, D. Daniels & Worthingham's Muscle Testing: Techniques of Manual Examination. 10th Edition. Saunders, 2018.

The Oxford/ Medical Research Council Manual Muscle Testing Scale

Grade	Muscle Activity
0	No contraction
1	Flicker / trace contraction
2	Active movement with gravity eliminated through full range
3	Active movement against gravity through full range
4	Active movement against gravity and resistance through full range
5	Normal power through full range

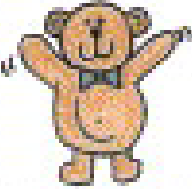





Medical Research Council (1976)

2.7 The Children's Hospital RPE Scale

Perceived Exertion Scale For Children

the children's
hospital at Westmead
Physiotherapy Department

Please explain scale before commencing exercise

	Not tired at all	0
	A little bit tired	1
	Tired	2
	Very tired	3
	Exhausted	4
	Absolutely exhausted Can't go on with exercise	5

Simon, et.al., (2003)

2.8 Borg's RPE Scale

Rating	Perceived Exertion
6	No exertion
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

Borg (1998).

Appendix 3: Standardised Goal Attainment Tests

3.1 The Single Leg Sit-to-Stand Test

The maximum number of single leg sit-to-stands are performed at a controlled speed from a standardized height plinth (knee at 90° flexion in sitting). Record the maximum number of rises to fatigue.

3.2 Heel Rise Test

Holding onto a wall for gentle support, perform a unilateral heel rise with knee extended. Count the number of repetitions until fatigue. Fatigue can be classified as the inability to raise the heel an appropriate height from the floor, falling into knee flexion, or poor ankle posture e.g. rolling into eversion/ inversion.

3.3 Plank Test norms

The aim of this test is to hold an elevated position for as long as possible. Start with the upper body supported off the ground by the elbows and forearms, and the legs straight with the weight taken by the toes. The hips are lifted off the floor creating a straight line from head to toe. As soon as the subject is in the correct position, the stopwatch is started. The head should be facing towards the ground and not looking forwards. The test is over when the subject is unable to hold the back straight and the hips are lowered.

Test norms

Rating	Time
Excellent	>6 minutes
Very good	4-6 minutes
Above Average	2-4 minutes
Average	1-2 minutes
Below Average	30-60 seconds
Poor	15-30 seconds
Very poor	<15 seconds

****Please note these are adult test norms**

Strand, (2014).

3.4 Side Bridge Test

The aim of this test is to hold an elevated position for as long as possible. The subject lays on their right side, the upper body supported off the ground by the right elbow and forearm. The legs are straight, with the left foot (top) in front of your right foot. The hip is lifted off the floor so that the elbow and feet support the body, creating a straight line from head to toe. As soon as the subject is in the correct position, the stopwatch is started. The test is over when the subject is unable to hold the back straight and the hip is lowered. After 5 minutes rest, repeat on the other side.

Test norms

	Men	Women
Side plank right	94 seconds	72 seconds
Side plank left	97 seconds	77 seconds

McGill, (1999).

3.5 Biering-Sorensen Back Extensor Test

The aim of this test is to measure back extension endurance. The patient lies prone on the table with the top of the iliac crests in line with the edge of the table. A stool is placed in front of the patient to provide support whilst setting up. The lower body is fixed to the table using straps. With the arms fixed across the body the patient lifts their chest up to create a straight line from head to toe. As soon as the patient is in the correct position, the stopwatch is started. The test is over when the patient is unable to hold a straight line and the chest is lowered, or after 240 seconds.

Test Norms

	Men	Women
Back extension	146 seconds	189 seconds

McGill, (1999).

3.6 Drop Jump Test

This test is performed from a 30cm box height. The patient jumps down from the box and lands on the ground and immediately jumps vertically upward as high as possible. The assessor views the jump from both in front, and to the side; to analyse the hip, knee and ankle mechanics upon landing and take-off.

Hewett, et.al. (2006).

3.7 Star Excursion Balance Test / Modified Star Excursion Balance Test

Using two pieces of tape, mark a '+', with the other '+' being placed over top to form an 'x' so that a star shape is formed. It is important that all lines are separated from each other by a 45° angle. The goal of the SEBT is to maintain single leg stance on one leg while reaching as far as possible with the contralateral leg in 8 different directions (anterior, anteromedial, medial, posteromedial, posterior, posterolateral, lateral and anterolateral). The patient must not rest the foot on the floor, and only tap the line, then return the foot to the centre. Three trials may be attempted, and the average distance is measured. The test should be performed on both legs, and the results compared. The test may also be modified to assess only three directions; anterior, posteromedial and posterolateral.

3.8 Hop Test Battery

Single Hop for Distance

Stand on one leg and hop forward as far as possible landing on the same leg. Hold the position for 3 seconds. Measure the distance from the toe at take-off to heel at landing. The average mean distance (in cm) of two valid hops are recorded. Repeat test on other leg. When comparing legs, calculate the mean distance of the involved limb divided by the mean distance of the non-involved limb to find a percentage difference.

Triple Hop for distance

Stand on one leg and perform three consecutive hops forward as far as possible ensuring to land on the same leg. Hold the final position for 3 seconds. Measure the distance from the toe at take-off to heel at the final landing position. The average mean distance (in cm) of two valid hops are recorded. Repeat test on other leg. When comparing legs, calculate the mean distance of the involved limb divided by the mean distance of the non-involved limb to find a percentage difference.

Triple Crossover Hop for Distance

Lay a marking strip on the floor that is 15cm in width.

Stand on one leg and perform 3 consecutive hops, in a medial to lateral to medial direction, as far as possible ensuring to land on the same leg. Hold the final position for 3 seconds. Measure the distance from the toe at take-off to heel at landing. The average mean distance (in cm) of two valid attempts are recorded. Repeat test on other leg. When comparing legs, calculate the mean distance of the involved limb divided by the mean distance of the non-involved limb to find a percentage difference.

6m Timed Hop

Stand on one leg at the start of a 6 meter long line. Perform consecutive large hops on one leg for the total distance (6 meters). A stopwatch is started when the tested foot lifts from the starting position and is stopped once the tested foot passes the finish line. The average mean time (in seconds) of two valid hops are recorded. Repeat test on other leg. When comparing legs, calculate the mean time of the involved limb divided by the mean time of the non-involved limb to find a percentage difference.

Medial Rotation Hop for Distance

Stand on one leg where the medial aspect of the foot being tested is against the starting line. Hop as far as possible while rotating the body 90 degrees in the air and land facing forward

on the same leg. Hold the position for 3 seconds. Measure the distance from the toe at take-off to heel at landing. The average mean distance (in cm) of two valid hops are recorded. Repeat test on other leg. When comparing legs, calculate the mean distance of the involved limb divided by the mean distance of the non-involved limb to find a percentage difference.

3.9 T Test norms

	Males (Seconds)	Females (Seconds)
Excellent	<9.50	<10.50
Good	9.51-10.50	10.51-11.50
Average	10.51-11.50	11.51-12.50
Poor	>11.50	>12.50

Hoffman, (2006).

3.10 Illinois Agility Test norms

For 16 to 19-year-olds:

Gender	Excellent	Above Average	Average	Below Average	Poor
Male	<15.2 secs	15.2 - 16.1 secs	16.2 - 18.1 secs	18.2 - 19.3 secs	>19.3 secs
Female	<17.0 secs	17.0 - 17.9 secs	18.0 - 21.7 secs	21.8 - 23.0 secs	>23.0 secs

Davis, (2000).

3.11 Yo-Yo test norms

Males

Rating	Metres	Level
Elite	>2400	>20.1
Excellent	2000-2400	18.7-20.1
Good	1520-1960	17.3-18.6
Average	1040-1480	15.7-17.2
Below average	520-1000	14.2-15.6
Poor	<520	<14.2

Females

Rating	Metres	Level
Elite	>1600	>17.5
Excellent	1320-1600	16.6-17.5
Good	1000-1280	15.6-16.5
Average	680-960	14.6-15.5
Below average	320-640	13.1-14.5
Poor	<320	<13.1

Wood, R. (2018)

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