

Title: PT Management of Pediatric Patients Post-Concussion: Background, Assessment, and Evidence-Based Intervention

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Databases Searched: PubMed, CINAHL, Web of Science,

The following table includes research relevant to pediatric post-concussion assessment and intervention by physical therapists. Given the sparsity of research in the current literature specific to pediatric populations, the original search was broadened to include age-nonspecific concussion literature.

Clinical Practice Guidelines (CPG) / Consensus Statements			
Author, Year	Study Design	Findings	Comments
Ontario Neurotrauma Foundation, 2013 ¹	Purpose CPG <u>Purpose</u> Provide medical guidelines for management of mild traumatic brain injuries (m-TBI) with persistent concussion symptoms (PCS) .	Outlines risk factors (both medical and contextual) associated with PCS. Patient education recommendations (2.11-2.12) Differential diagnosis (Table 9) Recommends use of Rivermead Post Concussion Symptoms Questionnaire for PCS monitoring. Outlines treatment approach for a variety of post-concussion symptoms (including post-traumatic headache, sleep disturbance, etc.)	A good foundational resource specific to management of concussion with persistent symptoms.

Marshall et al, 2015 ²	<p>CPG <u>Purpose</u> Update CPG guidelines for concussion/m-TBI and persistent symptoms for a wide range of healthcare providers including physical therapists.</p>	<p>96 recommendations for clinical management of persistent concussion symptoms.</p> <p>Includes “Return-to-Learn” progression.</p>	<p>Outlines general points of assessment and intervention for both initial concussion and persistent symptoms.</p>
McCrory et al, 2017 ³	<p>Consensus statement based on systematic literature review and expert panel consensus.</p> <p><u>Purpose</u> Update previous statement regarding sports related concussion (SRC) for use by physicians and healthcare providers, including physical therapists.</p>	<p>Outlines graduated return-to-school and return-to-activity guidelines.</p>	<p>Includes a bit more data on considerations for pediatric population than the Marshall et al CPG.</p>
Reviews			
Author, Year	Study Design, Purpose	Findings	Comments
Winkler et al, 2015 ⁴	<p>Systematic Review</p> <p><u>Purpose</u> Identify treatment effects in pediatric patients with persistent concussion symptoms (PCS).</p> <p>Reviewed interventions:</p> <ul style="list-style-type: none"> • medication for headache • written patient education materials 	<p>Nonmedical interventions had positive effects on PCS symptom severity and/or duration.</p> <p>No negative outcomes were associated with the interventions included in review.</p>	<p>Small number of included studies, all with relatively low methodological quality due to lack of control group comparisons.</p>

	<ul style="list-style-type: none"> • in-person patient education • prescribed physical/cognitive rest • exercise/active rehabilitation 		
Leddy et al, 2016 ⁵	<p>Review</p> <p><u>Purpose</u> Outlines the scientific basis for use of exercise as a PCS intervention technique.</p>	<p>Supports the inclusion of supervised, submaximal/symptom-limited aerobic exercise in management of post-concussion symptoms.</p> <p>The Buffalo Concussion Treadmill Test is described as a tool for evaluating exercise tolerance in patients with PCS.</p>	<p>The Buffalo Concussion Treadmill Test is the only functional test specifically tailored for assessing exercise tolerance in patients with PCS (as of 2016.)</p>
Shrey et al, 2011 ⁶	<p>Review</p> <p><u>Purpose</u> Using data from both human and animal studies, this review explores the acute, subacute, and chronic pathophysiologic processes at play for pediatric individuals after concussion.</p>	<p>Acute neurometabolic changes may persist in children for up to 4 weeks post-concussion, during which time neural structures may be more vulnerable to repeated injury.</p> <p>Neuroplasticity and axonal function may be impaired in the acute and sub-acute period.</p>	<p>Mostly focuses on SRC in the pediatric population, so there is a lot of “return-to-sport” framing of the discussion.</p> <p>Authors include data from some studies of “moderate” TBI, which might muddy their conclusions regarding concussion.</p>

Alsalaheen et al, 2013 ⁷	Retrospective Case Review <u>Purpose</u> Describes common vestibular rehabilitation exercise prescriptions provided to individuals after concussion.	Most commonly utilized exercise types: <ul style="list-style-type: none"> • eye-head coordination • standing static balance • ambulation 	Relatively small sample (114 patients).
Cheever et al, 2016 ⁸	Review <u>Purpose</u> Reviews clinical assessment tools available for discerning between central, vestibular, and cervical conditions.	Mechanism of injury alone is insufficient to determine the source of concussion or concussion-like symptoms, such as neck pain, dizziness, and headache.	Outlines a number of useful clinical assessments.

Intervention Studies					
Author, Year	Study Design, Purpose	Variables / Interventions	Outcome Measure(s) <small>* See Table 1</small>	Findings	Comments: review this before submission
Hugentobler et al, 2015 ⁹	Case Series <u>Purpose</u>	PT intervention programs were individualized to each	<ul style="list-style-type: none"> • PCSS • Modified BESS 	The majority of patients were	All case subjects were 15-19 years old.

	Using retrospective case data from six pediatric patients who experienced PCS, outlines various physical therapy evaluation and treatment strategies for PCS symptoms.	<p>patient, but included some combination of:</p> <ul style="list-style-type: none"> • Aerobic Activity • Anaerobic/Sport-Specific Activity • Stretching • Resistance Training • Postural Re-Education • Manual Therapy • Balance Training • Dual Tasking • Gaze Stability Exercises 	<ul style="list-style-type: none"> • Gaze stability testing • RPE • heart rate • blood pressure 	<p>seen by PT for ~7 sessions.</p> <p>Post-treatment, 66% returned to pre-injury activity level, while the remainder returned to “modified activity.”</p> <p>Subjects showed improvements in symptom severity and frequency, gaze stability, balance and postural control, and self-management of symptoms.⁹</p>	<p>4 SRC, 2 MVA-related concussions.</p> <p>Small sample size.</p> <p>Provides detailed step-by-step process of in-clinic management: history taking/systems review/intervention etc.</p>
Chan et al, 2018 ¹⁰	<p>Randomized Control Trial</p> <p><u>Purpose</u> Evaluates the safety of active rehabilitation programs for pediatric patients with PCS symptoms.</p>	<p>Subjects grouped into “treatment as usual” (TAU) or “treatment as usual + active rehabilitation” (TAU + AR)</p> <p>TAU:</p> <ul style="list-style-type: none"> • Symptom management 	<p>Patient or parent-reported adverse events during 6-week intervention.</p> <p>In clinic symptom exacerbations during aerobic activity.</p>	<p>= # of adverse events reported in TAU & TAU+AR groups.</p> <p>PCSS scores showed > improvements</p>	<p>This is one of the few actual RCTs focused on PT intervention for PCS in pediatric patients.</p> <p>Small sample size.</p>

		<ul style="list-style-type: none"> • Return-to-school /play advice • Psychiatry consultation <p>TAU + AR:</p> <ul style="list-style-type: none"> • TAU interventions • submaximal aerobic training • visualization exercises • coordination exercises 	PCSS	in TAU + AR group.	
Leddy et al, 2015 ¹¹	<p>Retrospective Review</p> <p><u>Purpose</u> Explores if patient reported symptoms can distinguish physiologic from cervicogenic/vestibular related post-concussion disorder (PCD).</p>	<p>Subjects grouped by PCD classification based on exercise testing and physical exam.</p> <p><u>Physiologic PCD:</u></p> <ul style="list-style-type: none"> • Abnormal treadmill performance • Normal cervical and/or vestibular physical examinations <p><u>Cervicogenic/Vestibular PCD:</u></p> <ul style="list-style-type: none"> • Normal treadmill performance • Abnormal cervical and/or vestibular physical examinations 	PCSS	Self-reported symptoms alone do no distinguishing physiologic from cervicogenic and/or vestibular PCD.	Supports screening of the c-spine and vestibular system in post-concussion patients.

Moore et al, 2016 ¹²	<p>Repeated Measures/Within Subjects</p> <p><u>Purpose</u> Explores impact of a vestibular rehab (VR) and aerobic activity on patients with PCS.</p>	Supervised home exercise vestibular rehabilitation (VR) program	<p>Outcomes assessed at evaluation, 3 months, and 6 months.</p> <p><u>Outcomes:</u></p> <ul style="list-style-type: none"> • RPQ: symptom and function subscales • DHI • ABC • FGA • Return-to-work/study • Return-to-activity 	Statistically significant correlation between program participation and symptom improvement.	Offers a comprehensive overview of a number of useful outcome measures, along with an example of a vestibular/aerobic rehab program for the PCS population.
Alsalaheen et al, 2010 ¹³	<p>Retrospective Review</p> <p><u>Purpose</u> Explores impact of VR on dizziness, and gait/balance performance in participants post-concussion.</p>	Individualized VR intervention programs.	<ul style="list-style-type: none"> • ABC • DHI • DGI • SOT • Gait speed 	Patient-reported dizziness and gait/balance performance improved with participation in VR program.	<p>Discusses applicability of results across a range of ages-argues for use of VR for children with post-concussive dizziness and gait/balance dysfunction.</p> <p>Relatively small sample (114 patients).</p>
Gagon et al, 2009 ¹⁴	Case series	<p><u>MCH-RAC</u></p> <ul style="list-style-type: none"> • Aerobic activity 	<ul style="list-style-type: none"> • PCSS • BOT-2 	Participants in the MCH-RAC	Small sample (16 cases)

	<p><u>Purpose</u> Outlines the Montreal Children’s Hospital Rehabilitation After Concussion (MCH-RAC) Programme and reviews participant outcomes during the initial 17 months of the program.</p>	<ul style="list-style-type: none"> • Coordination/Skill practice • Visualization exercises • Education/Motivation <p>Mean program duration of 7 weeks.</p>	<ul style="list-style-type: none"> • BESS 	<p>program reported decreased PCS symptoms and exhibited improved balance and coordination skills.</p>	<p>Despite being a bit of an older study, this provides relatively specific intervention strategies and rationale behind them.</p> <p>Provides an example of an age-normed balance measure for children (BOT-2).</p>
<p>Kurowski et al, 2017¹⁵</p>	<p>Exploratory Randomized Clinical Trial</p> <p><u>Purpose</u> Describes methods and initial outcomes of aerobic exercise intervention program for adolescents with PCS.</p>	<p>6-week intervention period.</p> <p><u>Intervention Group:</u> Submaximal, symptom-limited aerobic exercise program</p> <p><u>Comparison Group:</u> Stretching program</p>	<ul style="list-style-type: none"> • PCSI 	<p>Intervention group showed greater improvements in PCS-related symptoms at 6-week assessment.</p> <p>There were still improvements in the comparison group, which the authors attribute to the active nature of the stretching intervention.</p>	

				No adverse events related to intervention reported.	
Imhoff et al, 2016 ¹⁶	<p>Pilot study</p> <p><u>Purpose</u> Examines the outcomes of an active rehabilitation (AR) program in addition to usual care for pediatric participants with PCS symptoms.</p>	<p><u>AR program</u></p> <ul style="list-style-type: none"> • Aerobic training • Coordination exercises • Balance exercises 	<ul style="list-style-type: none"> • PCSI • SCAT3: balance and coordination subtests • Modified BESS • m-CTSIB • LOS • BOT-2: subtests of bilateral coordination, balance, and upper-limb coordination. 	All participants reported complete symptom recovery after intervention, but further research is needed to distinguish if these improvements are a result of AR.	<p>Small sample size. No control group.</p> <p>Utilizes some neurocognitive assessments- could be helpful for discussing return-to-learn.</p> <p>Similar to the MCH-RAC program but differs in duration and intensity.</p>

Table 1. Outcome Measures Key

<p>ABC: Activities-specific Balance Confidence (ABC) Scale</p> <p>BOT-2: Bruininks-Oseretsky Test of Motor Proficiency, Second Edition</p> <p>FGA: Functional Gait Assessment</p> <p>DGI: Dynamic Gait Index</p> <p>DHI: Dizziness Handicap Inventory</p> <p>LOS: Limit of Stability test</p> <p>m-CTSIB: Modified Clinical Test of Sensory Interaction in Balance</p>	<p>Modified BESS: Modified Balance Error Scoring System</p> <p>PCSS: Post-Concussion Symptom Severity Scale</p> <p>RPE: Rating of Perceived Exertion</p> <p>RPQ: Rivermead Post-Concussion Questionnaire</p> <p>SOT: Sensory Organization Test</p> <p>SCAT3: Sport Concussion Assessment Tool 3</p>
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