Office for Health Improvement & Disparities

Physical activity for general health benefits in disabled children and disabled young people: evidence review: Appendix 7 – summary of results from individual studies

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Contents

Abbreviations

ADHD = Attention Deficit Hyperactivity Disorder
ASD = Autism Spectrum Disorders
BMI = body mass index
CP = Cerebral Palsy
DCD = Developmental Coordination Disorder
DS = Downs Syndrome
EMG = electromyography
FMS = functional motor skills
HI = hearing impairment
HR = heart rate
ID = intellectual disability
PA = physical activity
PRE = progressive resistance exercise
QoL = quality of life
RCT = randomised controlled trial
SI = sensory impairment
VI = visual impairment
VR = virtual reality

Physical disabilities

Ref #, author (date), country	**Study type (sample size), population**	**Level and quality of evidence**	**Outcomes measured [O = Objective; S = subjective]**	**Aims**	**Key findings.**
[3] Angeli et al. (2019), country not reported.	Pre-post design (11), children with physical disabilities.	Level 2 – Good.	Self-perception [S].	To determine if community-based running intended to increase PA concurrently impacted self-concept.	Increased scholastic competence. No change in athletic competence.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
[5] Ashkenazi et al. (2013), country not reported.	RCT (30), children with DCD.	Level 1 – Moderate.	Motor performance, motor skills, functional skills and enjoyment [O & S].	To investigate whether an intervention program based on a low-cost, off-the-shelf VR system will be as effective as conventional therapist-based intervention for young children with DCD.	Increased motor performance, balance, enjoyment and parent-reported motor skills.
[6] Auld and Johnston (2014), Australia.	Pre-post uncontrolled design (10), children with CP.	Level 3 – Moderate.	Functional strength, static balance, and dynamic balance [O].	To investigate the effect of a low-cost, low-dose community-based group therapy model on strength and balance outcomes of children with CP.	Increased muscular strength and lateral balance.
[7] Ayter et al. (2018), USA.	Qualitative (15), youth athletes with PD.	High.	Not applicable for this study	To explore the meaning of competitive sport participation among youth with disabilities who are members of the Northeast Passage sled hockey team.	Increased perceived social inclusion and freedom in leisure.
[8] Ballaz et al. (2011), Canada.	Pre-post uncontrolled design (3), children with CP.	Level 3 – Moderate.	Gait analysis, HR, energy expenditure, isometric strength, and functional level [O].	To examine the feasibility of a group aquatic training programme and its effectiveness to	Increased walking gait efficiency and decreased walking heart rate.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
				improve gait efficiency in adolescents with CP presenting motor deficits of various severities.	
[10] Baym et al. (2018), country not reported.	Case study (1), female with myelomeningocele.	Level 3 – Moderate.	Aerobic capacity and perceived exertion [O].	To describe the implementation and effectiveness of an 8-week intensive lower extremity PRE intervention for improving functional ambulation for an adolescent with L3 myelomeningocele.	Increased leg strength, walking endurance, hip flexor strength, joint range of motion, and self-care goals.
[14] Biricocchi et al. (2014), country not reported.	Case study (1), child with myotonic muscular dystrophy.	Level 3: Moderate	Motor proficiency and balance [O & S].	To describe the effects of tap dance program on static and dynamic balance.	Increased motor control skills, social interaction. No change in balance data.
[15] Bjornson et al. (2019), country not reported.	Uncontrolled pilot study (12), children with CP.	Level 3: Moderate.	Perceived exertion, aerobic capacity, walking performance, functional mobility, coordination and pain [O & S].	To determine the effect of short-burst interval locomotor treadmill training on the primary outcomes of walking performance and capacity and the secondary outcomes of day-to-day physical	Increased walking speed and distance. Pain approaching significance.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
				activity, mobility, mobility-based participation, fatigue, and pain in ambulatory children with CP.	
[19] Brien and Sveistrup (2011), Canada.	Repeated measures (3), adolescents with CP.	Level 2: Moderate.	Balance, mobility, aerobic capacity, functional mobility, and motor skills [O].	To examine the effects of an intense virtual reality training program on functional balance and mobility in adolescents with CP.	Increased mobility. No change in motor function.
[20] Bryant et al. (2013), United Kingdom.	RCT (23), children with CP.	Level 1: Moderate.	Motor function and balance [O].	To determine the effect of a six-week exercise intervention, using a static bicycle or treadmill, on gross motor function ability in non-ambulant children with CP.	Increased motor function and standing ability.
[23] Canella-Malone et al. (2011), country not reported.	Small cohort study (3), children with developmental disabilities.	Level 3 – Moderate.	Challenging behaviour [S].	To implement an antecedent exercise programme across the school day and collect data on challenging behaviour from the time the students arrived at school in the morning	Decreased challenging behaviour.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
				until they left at the end of the day.	
[24] Capio et al. (2015), country not reported.	Pre-post (14), children with CP.	Level 2 – Moderate.	Physical activity, FMS [O].	Hypothesis: improving FMS proficiency will have a greater impact on children with disability than those without disability.	Increased moderate-vigorous PA and fundamental movement, and reduced sedentary time.
[26] Carter et al. (2014), United Kingdom.	Qualitative (35), children with and without disabilities, parents.	Moderate.	Not applicable for this study	To explore, from the children's, parents'/carers', siblings' and stakeholders' perspectives, their experiences and perceptions of 'The Cheetahs' and what benefits (if any) occur as a result of bringing children with disabilities and children without disability together.	Increased social skills, socialisation, confidence and "becoming stronger."
[31] Chen et al. (2013), Taiwan.	RCT (27), children with CP.	Level 1 – Moderate.	Motor function, muscle strength and bone density [O].	To investigate the efficacy of a home-based virtual cycling training programme on bone	Increased muscular strength and bone density. No change in motor function.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
				mineral density in children with CP.	
[32] Chen at al. (2012), Taiwan.	RCT (28), children with CP.	Level 1 – Moderate.	Gross motor function and muscle strength [O].	To investigate the effectiveness of a novel home-based virtual cycling training protocol with an RCT design for improving muscle strength and gross motor function in children with spastic CP.	Increased muscular strength. No change in gross motor function.
[33] Cherriere et al. (2020), country not reported.	Pre-post (10), adolescents with CP.	Level 2 – Moderate.	Balance, walk speed, stability, rhythm production, attention, and working memory [O].	To assess the effects of dance practice on static and dynamic balance using validated clinical and laboratory measures which can be viewed as complementary tools.	Increased balance.
[34] Chiu at al. (2014), country not reported.	Single randomised (62), children with CP.	Level 1 – Good.	Coordination, strength and hand function [O & S].	To explore the use of *Wii Sports Resort* training for children with cerebral palsy in a home-based setting in improving coordination, strength, hand function, and	Increased perceived hand function. No change in objectively measured hand function or coordination.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
				carers' perception of hand function.	
[37] Chunxiao and Shihui (2012), Hong Kong.	Qualitative (n/a), children with CP.	Moderate.	Lived experience [S].	To investigate the PA experiences from special school students with CP.	Increased joy and happiness. Experienced fatigue, pain and injury.
[39] Clutterbuck et al. (2020), Australia	Survey (39), children with CP	Level 3 - Moderate	Parent – reported experience [S].	Investigating the parental perspectives of a PA programme for children with CP.	Perceived increase in enjoyment, locomotor skills, social activity competence, cognitive anxiety performance and psychological performance.
[40], Clutterbuck et al. (2020), Australia.	RCT (54), children with CP.	Level 1 – Moderate.	Motor function, functional mobility, QoL and PA competence [O & S].	To investigate the effectiveness of a practitioner-led, peer-group sports intervention for children with CP at GMFCS Level I–II.	Increased motor function and PA competence. No change in motor skills or QoL.
[42] Colquitt et al. (2020), USA.	Randomised crossover (12), children with CP.	Level 1 – Good.	Pain [O].	To examine the effects of an upper-extremity, community- based, and power-training intervention.	Mixed change in pain score.
[43] Cook et al. (2015), Canada.	RCT (5), children with CP.	Level 1 – Good.	Range of motion, motor performance, muscle strength, EMG,	To address the lack of structured physical activity programming by providing an opportunity	Increased muscle strength, functional motor performance, range of motion and balance.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
			balance and gymnastic skill [O].	for children with CP to participate in artistic gymnastics.	
[44] Daly et al. (2020), USA.	Single subject (3), children with CP.	Level 2 – Moderate.	Gross motor-function, energy expenditure and goal attainment [O & S].	To investigate the practicability and impact of a school-based sup-ported physical activity programme, using adaptive bicycles, on cardiorespiratory fitness and gross motor function among children with CP.	Change observed in gross motor function and goal attainment.
[47] De Milander et al. (2015), South Africa.	Quasi-experimental (76), children with DCD.	Level 2 – Good.	Motor abilities [O].	To determine if a perceptual-motor intervention would improve the symptoms associated with DCD.	Significant change in balance. No overall improvement in DCD symptoms.
[48] Declerck et al. (2016), United Kingdom.	Single blinded RCT (14), youth with CP.	Level 1 – Moderate.	Adherence, enjoyment, walking ability, pain and fatigue [O & S].	To investigate enjoyment and specific benefits of a swimming intervention for youth with CP.	Increased walking distance. No change in pain or fatigue.
[50] Depiazzi et al. (2012), Australia.	RCT (12), adolescents with CP.	Level 1 – Moderate.	Aerobic capacity, body composition, pain and QoL [O & S].	To investigate feasibility of aquatic high intensity interval training for adolescents with CP.	Increased $\dot{V}O_{2\ peak}$, lean muscle mass and QoL. Decreased fat mass, psychosocial health and fatigue. No change in HR

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
					$_{peak}$, bone density, satisfaction or pain present.
[52] Dimitrijevic et al. (2012), Serbia.	RCT (27), children with CP.	Level 1 – Moderate.	Gross motor function [O].	To investigate the effect of an aquatic intervention on the gross motor function and aquatic skills of children with CP.	Increased gross motor function at 6-weeks but not at 9-weeks.
[57] Eek et al. (2008), Sweden.	Pre-post (16), children with CP.	Level 2 – Moderate.	Muscle strength, gross motor function, gait, joint range of motion and spasticity [O & S].	To investigate the influence of muscle strength training on gait outcomes in children with CP.	Improved hip and knee flexor strength and gross motor function. No change in ankle or knee extensor strength.
[61] Fong et al. (2013), Hong Kong.	RCT (44), children with DCD.	Level 1 – Good.	Static balance, reactive balance control and isokinetic leg strength [O].	To investigate the effect of short-term intensive taekwondo training on the isokinetic knee muscle strength and reactive and static balance control of children with DCD.	Improved balance. Mixed findings for isokinetic leg strength and no change in reactive balance control.
[63] Ferguson et al. (2013), South Africa.	Quasi-experimental (27), children with DCD.	Level 2 – Moderate.	Body composition, motor skills, functional strength, power and aerobic fitness [O].	To compare the efficacy of Neuromotor Task Training and Nintendo *Wii Fit* training interventions on the motor performance, isometric strength and	Improved total motor performance and total functional strength in NTT group. Increased balance in both groups. No change in dexterity.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
				cardiorespiratory fitness (aerobic and anaerobic capacity) of children with DCD.	
[67] Fragala-Pinkham et al. (2014), country not reported.	Prospective time series group design (8), children with CP.	Level 2 – Good.	Gross motor function, walking endurance, functional strength, muscular endurance, aerobic capacity and balance [O].	To evaluate the effectiveness of a14-week aquatic exercise programme on gross motor function and walking endurance in children with CP.	Improved walking endurance and gross motor function. No change in aerobic capacity, muscular strength or endurance or balance.
[68] Gatica-Rojas et al. (2017), Chile.	Single group pre-post (10), children with CP.	Level 2 – Moderate.	Spasticity and balance [O].	To determine whether a Nintendo *Wii Balance Board* exercise programme could reduce spasticity in ankle plantar flexors and improve the static standing balance in young people with SCP.	Reduced spasticity in ankle plantar flexors. Mixed findings for static balance.
[70] Getz et al. (2012), Israel.	Pre-post (17), children with CP.	Level 2 – Moderate.	Metabolic cost, walking speed and gross motor function [O & S].	To evaluate the effects of aquatic compared to a land-based intervention programmes on metabolic cost of walking, gross motor function and	Increased steady state walking speed and self-selected walking speeds. No change in gross motor function.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
				locomotor performance in children with CP.	
[72] Gorter et al. (2009), Netherlands.	Repeated measures (13), children with CP.	Level 2 – Moderate.	Metabolic cost, walking speed and gross motor function [O & S].	To investigate differences in aerobic endurance and walking capacity before and after participating in a functional physical training programme.	Improved aerobic capacity, walking distance and speed sustained at follow-up, improved ambulation post intervention.
[75] Hegarty et al. (2019), country not reported.	Pre-post (9), children with CP.	Level 2 – Moderate.	Strength, walking performance and aerobic capacity [O].	To evaluate the effects of a conventional strength training intervention, with broad strengthening focus of the lower limbs, on overall walking ability for children with CP.	Increased walking and aerobic capacity. Increased isometric joint strength.
[76] Hilderley et al. (2020), Canada.	Randomised feasibility trial (22), children with CP.	Level 1 – Moderate.	Gross motor skills, occupational performance, walking capacity, functional lower limb strength, PA participation, goal attainment and motor learning [O & S].	To assess trial feasibility and compare effectiveness of sports skills movement training to conventional lower limb strength training for improving advanced gross motor skills of children with CP.	Increased motor skills and occupational performance in BeFast (skills) group. No increase in motor skills in BeStrong (strength) group. No overall changes in strength. No overall changes in PA participation.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
[84] Jelsma et al. (2013), country not reported.	Single subject blinded design (14), children with CP.	Level 2 – Moderate.	Functional mobility, balance and gross motor function [O].	To study the impact of training using the Nintendo *Wii Fit* in 14 children with spastic hemiplegic CP.	Increased balance. No change in running speed, agility, or functional mobility.
[85] Johnson et al. (2014), country not reported.	Multiple-baseline, multiple-probe, single-subject (3), children with CP.	Level 2 – Moderate.	Gross motor ability measure, agility, speed and power [O].	To evaluate the optimal duration and effects of plyometric training on the gross motor abilities of 3 boys with unilateral spastic CP.	Increased running speed, gross motor ability, upper extremity power and agility. No changes in lower extremity power.
[86] Jorgic et al. (2014), Serbia.	Single cohort design (15), children with CP.	Level 2 – Moderate.	Range of motion [O].	To determine the effects of the applied program of swimming and aquatic exercise on improving the flexibility of children with CP.	Increased shoulder flexion and abduction. No changes in shoulder extension, or hip abduction or extension.
[89] Kane and Staples (2016), Canada.	Pre-post (10), children with coordination difficulties.	Level 2 – Moderate.	Motor development [O].	To examine the effects of a multi- disciplinary program that emphasized parent participation on motor skill performance and PA.	Increased fundamental motor skill. Approximately 10 minute increase in daily moderate-to-vigorous PA.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
[92] Keawutan et al. (2018), Australia.	Cross-sectional (58), children with CP.	Level 3 – Moderate.	Physical activity, motor function and QoL [O & S].	To compare QoL according to ambulatory status and to investigate association with habitual PA in children with CP aged 5 years.	No relationship between PA and QoL after controlling for motor function.
[93] Kelly and Legg (2009), country not reported.	Pre-post (6), children with CP.	Level 2 – Moderate.	Energy expenditure, strength, skill performance and perceived satisfaction [O & S].	To investigate what effects, specific to energy expenditure, muscle strength, and perceived satisfaction and perceived performance of a functional motor goal resulted from a community exercise programme using both aerobic and anaerobic components for children with CP.	Increased satisfaction with motor skills performance. Decreased energy expenditure index scores. Mixed evidence on effect on muscle strength.
[94] Kenyon et al. (2010), USA.	Case study (1), adolescent with CP.	Level 3 – Moderate.	Power and strength [O].	To describe the development, implementation, and outcomes of a fitness-related intervention programme that addressed the sport-	Increased anaerobic power, speed, agility, muscle strength, and gross motor function.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
				specific goals of an adolescent with CP.	
[96] Knights et al. (2016), country not reported.	Pre-post (n/a), youth with CP.	Level 2 – Moderate.	Cardiovascular fitness, QoL, power and body composition [O & S].	To evaluate the effects of an internet-platform exergame cycling programme on cardiovascular fitness of youth with CP.	Increased cardiovascular fitness. No change in arm power, body measurements or QoL.
[100] Kruse et al. (2019), country not reported.	RCT (22), children with CP.	Level 1 – Moderate.	Muscle size, range of motion, strength and power [O].	To investigate the effects of 8 weeks of functional PRE and high-intensity circuit training on the mechano- morphological properties of the plantar flexor muscle-tendon unit in children with spastic CP.	Increased vastus lateralis thickness. No change in active torque or plantar flexor strength.
[101] Lakes et al. (2019), USA.	Pre-post (8), children with CP.	Level 2 – Moderate.	Body composition, bone health, grip strength, voluntary motor control, executive function and habitual PA [O & S].	To evaluate the feasibility and the effects of a new therapeutic ballet intervention specifically designed for children with CP.	Increased bilateral gait patterns and inhibitory control. No changes in BMI, body fat or bone density. No change in moderate-to-vigorous PA. Mixed effect on handgrip strength.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
[102] Lauruschkus et al. (2015), Sweden.	Qualitative interviews and focus groups (6), children with CP.	Moderate.	Not applicable for this study	To explore the experiences of children with CP regarding participation in physical activities, and to describe facilitators and barriers.	Being active makes children feel good, enables feelings of belonging, and relieves pain.
[103] Lauruschkus et al. (2017), Sweden.	Inductive qualitative (25), parents of children with CP.	Moderate.	Not applicable for this study	To explore how parents of children with CP experience their child's participation in physical activities and to identify facilitators and barriers for being physically active and reducing sedentary behaviour.	Perceived benefit for increased motor ability and protection from deteriorating function.
[104] Leineweber et al. (2016), country not reported.	Cross-sectional (8), children with CP.	Level 3 – Moderate.	Postural sway [O].	To examine the effects of intense exercise on the postural stability of children with CP.	Decreased postural stability in the sagittal plane. No change in frontal plane.
[105] Leunkeu et al. (2012), country not reported.	Assessment and controlled training study (24), children with CP.	Level 2 – Moderate.	Aerobic fitness [O].	To assess the reproducibility and validity of the 6-minute walk test with gas collection, and to evaluate effectiveness of	Increased $\dot{V}O_{2\ peak}$, $\dot{V}E$ peak, HR_{peak}, and walking distance.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
				a walking programme in children with CP.	
[106] Liao et al. (2007), Taiwan.	Single blind block randomised (20), children with CP.	Level 1 – Moderate.	Motor skills, gait speed, knee extensor strength, strength and physiological cost [O].	To investigate effectiveness of a functional strengthening programme, the loaded sit-to-stand resistance exercise, for children with CP.	Increased gross motor function. Decreased physiological cost index score. No differences in knee extensor strength or gait speed.
[107] Liusuwan et al. 2007), USA.	Pre-post (19), adolescents with spinal cord dysfunction.	Level 2 – Moderate.	Strength and aerobic capacity [O].	To determine whether the health promotion activities conducted through the BENEfit programme would reduce weight, improve body composition characteristics (increase lean muscle tissue and/or reduce fat tissue), increase strength, increase fitness, and improve nutritional understanding and food choice habits.	Increased work capacity, aerobic efficiency and shoulder strength. No change in $\dot{V}O_{2\,max}$, maximal HR or peak shoulder flexion.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
[111] McNee et al. (2009), United Kingdom.	Pre-post (13), children with CP.	Level 2 – Moderate.	Muscle size, strength, balance, functional mobility and gait patterns [O & S].	To investigate the effect of plantar flexor strengthening on muscle volume, gait, and function in 13 ambulant children with spastic CP.	Increased medial and lateral gastrocnemius volumes. No differences in ankle range of motion, gait or function.
[112] Maher et al. (2016), Australia.	Cross-sectional survey.	Level 3 – Moderate.	PA, motor function and QoL [S].	To examine the associations between PA, health-related QoL and happiness in young people with CP.	Increased predicted physical QoL, social quality of life, and happiness. PA not associated with emotional or school QoL.
[113] Mak et al. (2018), Australia.	RCT (42), children with CP.	Level 1 – Moderate.	Attention, mindfulness, behaviour, strength, flexibility, submaximal motor capacity, mobility, QoL and pain [O & S].	To investigate the efficacy of an embodied mindfulness-based movement programme (MiYoga), targeting attention in children with CP.	Increased attention. No change in strength or power, psychological outcomes, pain, executive function or behaviour.
[114] Maltais et al. (2016), Canada.	Pre-post (8), children with CP.	Level 2 – Moderate.	Cognitive inhibition [O].	To assess, for ambulatory children with CP, the effect of acute, intense aerobic exercise on cognitive functions such as the inhibition	Improved reaction time.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
				function, precision and processing speed.	
[115] Mann et al. (2016), USA.	Secondary cross-sectional analysis (128), children with CP.	Level 3 – Moderate.	Gross motor function and QoL [O & S].	To examine the relationship of PA and walking performance to QoL in ambulatory children with CP.	PA was positively associated with physical and total QoL.
[116] Mattern-Baxter et al. (2009), USA.	Pre-post (6), children with CP.	Level 2 – Moderate.	Gross motor function, functional skills, aerobic capacity and balance [O & S].	To examine whether an intensive, short-term locomotor treadmill training program helps children with CP younger than 4 years of age improve their gross motor skills related to ambulation, walking speed, and endurance.	Increased motor function, independent functional skills and walking speed.
[117] Mattern-Baxter et al. (2020), country not reported.	Prospective multi-site RCT (19), children with CP.	Level 1 – Moderate.	Functional skills, self-rated health, walking ability and gross motor skills, [O & S].	To compare the effect of low-intensity vs high-intensity treadmill training on walking attainment and overall walking activity in children with CP.	Increased ambulatory motor function (low intensity) and walking independence (high intensity) post intervention.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
[125] Mitchell et al. (2016), Australia.	Matched-pairs RCT (101), children with CP.	Level 1 – Moderate.	Aerobic capacity, functional strength, physical activity, mobility, participation and life habits [O & S].	To determine the efficacy of web-based training on activity capacity and performance in children with unilateral CP.	Increased walking distance and composite functional strength. No change in mobility or activity participation.
[126] Mohanty et al. (2015), country not reported.	RCT (30), children with CP.	Level 1 – Moderate.	Cardiovascular fitness, gross motor skills and balance [O].	To compare the effects of dynamic cycling, static cycling and conventional exercises in cardiovascular endurance, balance and walking ability in CP children.	Decreased resting HR. Increased walking distance and balance. No change in gross motor function dimensions.
[128] Mombarg et al. (2013), Netherlands.	RCT (29), children with poor motor performance.	Level 1 – Moderate.	Motor coordination, balance; speed and agility [O].	To investigate the effects of training with the *Wii Balance Board* on balance and balance-related skills of children with poor motor performance.	Increased balance. No differences in running speed or agility.
[130] Moreau et al. (2013), country not reported.	RCT (16), children with CP.	Level 1 – Moderate.	Muscle architecture, muscle function, functional walking performance and speed [O].	To determine whether velocity training, which includes resistance training at increasingly higher velocities, would induce specific muscle	Increased self-selected walking speed and fast walking speeds, increased peak velocity and power, and functional walking.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
				adaptations not observed with strength training.	
[133] Myrhaug and Ostensjo (2014), Norway.	Cross-sectional survey (121), parents of children with CP.	Level 3 – Good.	Not applicable for this study	To describe motor training and PA among pre-schoolers with CP in Norway, and assess associations between child, parent, and motor intervention characteristics, and parent-reported child benefits from interventions.	Manual stretching has high parent-reported benefits. Gross motor skills most reported benefit over fine motor skills.
[135] Nsenga et al. (2013), country not reported.	Non-RCT (20), children with CP.	Level 2 – Moderate.	Cardio-respiratory fitness [O].	To examine the ability to enhance the cardio-respiratory fitness of children with CP by cycle ergometer training.	Increased cardiorespiratory fitness.
[141] Peens et al. (2008), South Africa.	RCT (56), children with DCD.	Level 1 – Moderate.	Manual dexterity, ball skills, balance skills, self-concept and anxiety [O & S].	To determine the most effective method in enhancing motor proficiency and self-concept of 7- to 9-year-old children with DCD.	Increased motor proficiency. No change in self-concept in motor-based intervention.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
[142] Pickering et al. (2013), United Kingdom.	Creative qualitative (35), children with CP.	Moderate.	–	To explore the effect of participation in adapted cycling on QoL for children with CP.	Cycling strengthens and improves health and general bodily functions. Adapted cycling enabled social participation.
[147] Ramstrand and Lygnegard (2012), Sweden.	Randomised crossover (18), children with CP.	Level 1 – Moderate.	Balance [O].	To evaluate if use of an activity promoting computer game, used in the home could influence balance related outcome measures in children with CP.	No change in rhythmic weight shift or centre of pressure.
[148] Retarekar et al. (2009), country not reported.	Single subject (1), child with CP.	Level 3 – Moderate.	Performance and satisfaction, gross motor function, submaximal aerobic capacity, energy expenditure and PA [O & S].	To evaluate the effects of an aquatic aerobic exercise programme for a child with CP.	Increased walking endurance, gross motor skills, mobility performance in home and community environments. Decrease in energy expenditure.
[149] Scholtes et al. (2010), Netherlands.	RCT single blinded (49), children with CP.	Level 1 – Moderate.	Mobility and muscle strength [O].	To evaluate the effectiveness of functional PRE strength training on muscle strength and mobility in children with CP.	Increased muscular strength and six-repetition maximum. No change in spasticity or mobility.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
[150] Scholtes et al. (2012), Netherlands.	RCT single blinded (49), children with CP.	Level 1 – Moderate.	Walking ability, participation in daily activities, strength, spasticity and range of motion [O & S].	To evaluate the effectiveness of functional PRE training on walking ability in children with CP.	Increased muscular strength and six-repetition maximum. No change in anaerobic power, walking ability, participation in daily activities, spasticity or passive range of motion.
[151] Schranz et al. (2018), Austria.	Randomised prospective controlled pilot study (22), children with CP.	Level 1 – Moderate.	Strength, range of motion, spasticity, and multiple mobility [O & S].	To develop a clinically applicable home-based high-intensity exercise programme and investigate the difference between high-intensity and PRE training in children with spastic CP.	Increased total isometric strength, mean and maximal muscle power in high-intensity group. Results diminished in follow-up. Improved mobility in resistance training group.
[157] Stribling and Christy (2017), USA.	Case study (1), child with CP.	Level 3 – Moderate.	Postural control and balance [O].	To investigate the effect of creative dance instruction on postural control and balance in an 11-year-old with spastic triplegic CP.	Increased balance.
[162] Tsai (2009), Taiwan.	Quasi-experimental (27), children with DCD.	Level 2 – Moderate.	Motor abilities, reaction time and response accuracy and inhibitory control [O].	To use ecological intervention to investigate the efficacy of table-tennis training on treating both problems with	Improved motor ability and inhibitory control.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
				attentional networks and motor disorder in children with DCD.	
[165] van Vulpen et al. (2017), Netherlands.	Double baseline design (22), children with CP.	Level 2 – Moderate.	Walking capacity, power, gross motor function and strength [O].	To evaluate the effect of functional high-velocity resistance training (power-training) to improve muscle strength and walking capacity of children with CP.	Increased peak power and lower limb muscle strength after training period.
[166] van Vulpen et al. (2018), Netherlands.	Double baseline design (22), children with CP.	Level 2 – Moderate.	Goal attainment, parent-reported mobility performance, functional and motor skills [O & S].	To evaluate the effect of functional power-training on parent-reported mobility and achievement of individual goals on activity and participation level in young children with CP.	Improved fundamental motor skills and goal attainment.
[169] Walsh and Scharf (2014), country not reported.	Case study (1), child with CP.	Level 3 – Moderate.	Gross motor function, strength, endurance, posture, mobility and gait patterns and gait analysis [O & S].	To describe the effects of an ice skating programme on the ambulation, strength, posture and balance of a child with CP.	Improved motor function, strength and endurance, functional mobility and standing posture. Some decline in strength and functional mobility at follow-up.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
[171] Williams and Pountney (2007), United Kingdom.	Non-randomised, same-subject (11), children with CP.	Level 2 – Moderate.	Function and postural ability [O].	To determine whether a muscle-strengthening programme of exercise on a static exercise bicycle (adapted to provide additional postural sup- port) would improve function in standing and walking for young people with CP who are non-ambulant.	Improved cycling ability for duration of pedalling, speed and resistance.
[176] Zverev and Kurnikova (2016), Russia.	Quasi-experimental (n/a), children and adolescents with CP.	Level 2 – Moderate.	Safety, balance, and mobility [O & S].	To assess the feasibility of a community-based adapted group aquatic programme and its impact on balance in children and adolescents with CP.	Improved balance.

Intellectual and learning disabilities

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
[1] Ahmed and Mohamed (2011), Saudi Arabia.	RCT (84), children with ADHD.	Level 1 – Moderate.	Motor skills, attention, and classroom behaviour [O & S].	To investigate the effect of regular aerobic exercises on behavioural, cognitive and psychological problems related to ADHD.	Significant improvements in motor skills, attention and classroom behaviour. No change in task orientation, emotional or oppositional behaviour.
[2] Amini et al. (2016), Iran.	Semi-experimental cross-sectional (16), children with DS.	Level 2 – Moderate.	Balance [O].	To examine the effect of backward walking on postural stability of DS patients.	Improved general and anterior-posterior balance. No change in medial-lateral balance.
[4] Armitano et al. (2015), USA.	Pre-post (16), children with ID/DS.	Level 2 – Moderate.	Cardiovascular endurance, muscular endurance, flexibility, and strength [O].	To assess the effectiveness of an eight-week surfing intervention for 16 children with disabilities.	Increased aerobic capacity, core body and grip strength, anecdotal self-confidence, shoulder range of motion, anecdotal social development, anecdotal improvement in other PA activities. Decrease in anecdotal anxiety. No change in upper body strength or flexibility.
[9] Baran et al. (2013), Turkey.	RCT (38), children with ID.	Level 1 – Moderate.	Physical fitness and soccer skills [O & S].	To examine the effect of participation in a UNS soccer training program on fitness and skilled	Improved fitness and soccer skills.

				performance compared to the fitness and skilled performance of a control group in soccer for youth with and without intellectual disability.	
[11] Bellamy et al. (2020), Australia.	Cohort (10), children with ID.	Level 3 – Moderate.	Body composition, HR, aerobic capacity, and PA [O].	To establish the feasibility of a school-based group exercise intervention for children with moderate to severe ID.	Increased weight mid intervention and follow-up. No change in aerobic capacity, BMI, or waist circumference.
[12] Benzing et al. (2018), Switzerland.	RCT (46), children with ADHD.	Level 1 – Moderate.	HR, perceived exertion, cognitive engagement, and enjoyment [O & S].	To advance our current understanding by investigating whether acute PA selectively affects the three core EFs (inhibition, switching and working memory) in children with ADHD.	Increased HR, perceived exertion and reaction times.
[13] Benzing and Schmidt (2019), Switzerland.	RCT (51), children with ADHD.	Level 1 – Good.	Executive function, motor skills, ADHD symptoms [O & S].	To investigate the effects of cognitively and physically demanding exergaming on executive functions, ADHD symptoms, and motor abilities.	Increased motor ability, reaction times and switching. No change in ADHD effects or updating or accuracy.

[16] Borremans et al. (2009), Finland.	Quasi-experimental (20), adolescents with Asperger Syndrome.	Level 2 – Moderate.	Motor competence, physical fitness, and descriptive questionnaire [O & S].	To examine the efficacy of an exercise programme as part of an ongoing vocational training programme for adolescents with Asperger Syndrome on motor competence and physical fitness.	Increased physical fitness and motor competence.
[17] Bowling et al. (2017), USA.	RCT (103), children with behavioural health disorder.	Level 1 – Good.	Exercise exposure and behavioural self-regulation [O & S].	To examine if an aerobic cyber-cycling intervention integrated into physical education resulted in improvements in behavioural self-regulation and classroom functioning among children with mental health disabilities attending a therapeutic day school.	Acute response of PA reduced odds of hyperactivity and emotional lability.
[18] Bremer et al. (2015), Canada.	Weight-list control experiment (8), children with ASD.	Level 1 – Good.	Body composition, motor proficiency, adaptive behaviour, and social skills [O & S].	To examine the effectiveness of a fundamental motor skills intervention at improving the motor skills, adaptive behaviour, and social skills of 4-year-old children with ASD.	Increased total motor quotient. No change in social skills or problem behaviour.

[21] Bustamante (2016), USA.	RCT (35), children with ADHD.	Level 1 – Moderate.	Parent-reported mental health, social skills, behaviour and executive functions [O & S].	To test the feasibility and impact of a 10-week after-school exercise program for children with ADHD and/or disruptive behaviour disorders living in an urban poor community.	Improved verbal and visuospatial working memories. Improved effect on hyperactivity.
[24] Capio et al. (2018), Hong Kong.	Pre-post cohort (20), children with DS.	Level 2 – Moderate.	Motor skills, balance, and working memory [O].	To understand the relationship between FMS proficiency and balance ability in children with DS and thereby support evidence-based programmes for this population.	Improved FMS and balance. No change in short-term memory.
[27] Casey et al. (2010), country not reported.	Small cohort (8), children with ID.	Level 3 – Moderate.	Percentage body fat [O].	To use DXA to measure the effects of a 16-week swim training programme following ACSM guidelines on percent body fat in adolescents with ID .	Increased body fat percentage.
[28] Chang et al. (2014), Taiwan.	Non-randomised pre-post pilot (27), children with ADHD.	Level 2 – Good.	Motor ability and restraint inhibition [O].	To examine whether an aquatic exercise intervention that involves both aerobic and coordinative exercises	Improved mobility assessment and accuracy.

				influences restraint inhibition in children with ADHD.	
[29] Chang et al. (2012), country not reported.	RCT (40), children with ADHD.	Level 1 – Good.	Perceived exertion, HR and executive functions [O & S].	To examine whether a single bout of aerobic exercise could improve executive function in children with ADHD.	Increased acute HR. Positive effect on executive function.
[35] Chou and Huang (2017), Taiwan.	Non-randomised pre-post (49), children with ADHD.	Level 2 – Good.	Reaction speed and physical fitness [O].	To investigate whether a yoga exercise intervention influenced the sustained attention and discrimination function in children with ADHD.	Improved accuracy rate and response accuracy. Improved reaction time.
[36] Chuang et al. (2015), country not reported.	Randomised crossover (n/a), children with ADHD.	Level 1 – Good.	Reaction time and motor inhibition [O].	To investigate the impact of acute exercise on reaction time and response preparation during a Go/No Go Task in children with ADHD.	Improved reaction time.
[41] Collins and Staples (2017), country not reported.	Pre-post cohort (35), children with ID.	Level 3 – Good.	Aerobic functioning, muscular strength, endurance and body composition [O].	Rationale: because children with ID are at an increased risk of diseases related to inactivity, it is important to improve health-related physical fitness to complete activities of	Improved aerobic functioning, muscular strength and endurance

				daily living and improve health.	
[46] Davis et al. (2011), USA.	Pre-post (25), children with ID.	Level 2 – Good.	Health related fitness [O].	To assess the effectiveness of the Motivate, Adapt, and Play (MAP) adapted exercise programme by assessing the health-related fitness of children with mild-to-moderate ID before and after a specifically designed 8-week exercise programme.	Improved cardiovascular endurance, upper body strength and flexibility. No differences in BMI.
[49] Dehghani and Gunay (2015), Turkey.	RCT (22), children with ID.	Level 1 – Poor.	Motor proficiency [O].	To assess the effect of balance training on static and dynamic balance in children with mild ID.	Improved static and dynamic balance.
[51] Dickinson and Place (2014), United Kingdom.	RCT (100), children with ASD.	Level 1 – Moderate.	$\dot{V}O_{2\ max}$ and BMI [O].	To assess if a computer-based activity programme could improve fitness levels (as reflected in cardiopulmonary function) of autistic children, and achieve a reduction in their BMI.	Increased $\dot{V}O_{2\ max}$, abdominal strength and leg power, improved BMI. No change in flexibility.
[53] Dorsan et al. (2014), Turkey.	Quasi-experimental (22), mentally retarded children.	Level 2 – Poor.	Balance, speed, power and flexibility [O].	To examine the effect of 12 weeks of dance	Improved power, speed and flexibility. No change in balance.

				education on the values of physical fitness at children with mental retardation.	
[54] Duronjic and Valkova (2010), Czechia.	Pre-post (5), pre-schoolers with ASD.	Level 2 – Moderate.	Motor skills [O].	To assess the motor skills performance of pre-schoolers with ASD after PA activity intervention.	Mixed results in motor skill development.
[56] Edwards et al. (2017), Australia.	Pre-post (11), children with ASD.	Level 2 – Moderate.	Gross motor skills [O & S].	To investigate whether play-based active video games intervention can improve the actual or perceived object control skills of children with ASD relative to typically developed children.	No improvements in motor skill development.
[58] Ekins et al. (2019), Germany.	Quasi-experimental (15), children with ID.	Level 2 – Moderate.	Behaviour, cognitive, social and practical competencies, and motor skills [O & S].	To examine the physiological, symptom specific and cognitive effects of a multi-modular Drums Alive Kids Beats® Intervention in children with diverse abilities.	Improvements in abdominal and leg strength, coordination and balance, and change in monitored behaviour. No change in aerobic capacity, upper body strength, social or practical competencies, cognitive competencies, or observed behaviour.
[59] Emami et al. (2019), Iran.	RCT (45), children with learning disabilities.	Level 1 – Good.	Motor proficiency, attention, working memory, problem-	To examine whether a motor intervention program, based on the	Improved fine and gross motor skills, Improved

			solving, and planning [O].	three elements of attention, balance and coordination, could enhance both motor abilities and executive functions (i.e., sustained attention, working memory, and problem-solving) of children with learning disabilities.	attention and working memory.
[60] Faber Taylor and Kuo (2009), USA.	Single-blinded controlled trial, within subject (17), children with ADHD.	Level 3 – Moderate.	Concentration, attention, vigilance [O].	To examine the impacts of natural environments on attention in children with ADHD.	Improved concentration after walk in the park.
[66] Fragala-Pinkham et al. (2011), country not reported.	Non-randomised controlled trial (12), children with ASD.	Level 2 – Good.	Cardiovascular endurance, muscular endurance, swimming skills, and mobility skills [O].	To evaluate the effectiveness of a 14-week aquatic exercise programme for children with ASD.	No change in cardiovascular endurance, muscular endurance or mobility skills.
[69] Gawrilow et al. (2016), Germany.	Randomised post-test trial (47), children with ADHD.	Level 3 – Moderate.	Inhibitory control [O].	To examine the role of physical activity in determining the affect and executive functioning of children with symptoms of ADHD.	Improved inhibitory control.
[71] Ghaeeni et al. (2015), Iran.	Quasi-experimental (16), children with DS.	Level 2 – Moderate.	Static balance [O].	To study the effect of 8 weeks core stability	Improved static balance.

				training on static balance of the children with DS.	
[73] Gupta et al. (2011), country not reported.	RCT (23), children with DS.	Level 1 – Moderate.	Lower limb muscle strength and balance [O].	To determine the effect of exercise training on strength and balance in children with DS.	Improved strength and overall balance.
[74] Hassani et al. (2020), Iran.	RCT (30), children with Autism.	Level 1 – Moderate.	Motor proficiency [O].	To compare two programmes (physical literacy and adapted PA) on motor skills.	Improved motor skills, balance and bilateral coordination.
[77] Hilton et al. (2014), USA.	Single group pre-post (7), children with ASD.	Level 2 – Moderate.	Behavioural manifestations of executive function and motor proficiency [O & S].	To investigate the effectiveness of a Makoto arena training intervention on response speed, executive function, and motor performance in school-age children with ASD.	Improved strength, agility, reaction speed and working memory.
[78] Huang et al. (2020), Taiwan.	RCT (51), children with learning disability.	Level 1 – Moderate.	Sustained attention, determination test [O & S].	To examine the effects of acute aerobic exercise on sustained attention and discriminatory ability of children with and without learning disabilities.	Exercise significantly benefited performance in sustained attention and discriminatory ability, particularly in higher accuracy rate and shorter reaction time.
[79] Hung et al. (2016), Taiwan.	Post-test (34), children with ADHD.	Level 3 – Moderate.	Cognitive performance [O].	To examine the effects of acute, moderate intensity exercise on task	Improved working memory due to smaller switching costs.

				switching in children with ADHD.	
[80] Ilbeigi et al. (2016), Iran.	Quasi-experimental (20), mentally retarded boys.	Level 2 – Poor.	Balance [O].	To compare the effects of the trial rope skipping method on the static and dynamic balance of mentally retarded children aged 10 to 17 years.	Improved static and dynamic balance from rope skipping.
[81] Ilhan et al. (2013), Turkey.	Pre-post with control (145), children with mental retardation.	Level 2 – Poor.	QoL [S].	To assess the effect of special physical education and sports activities done regularly on the QoL of the children with mental retardation.	Regular sports activities resulted in an increase in all subscales for QoL.
[82] Isik and Zorba (2018), Turkey.	RCT (50), students with ID.	Level 1 – Moderate.	Motor proficiency [O].	To investigate the effects of Hemsball on the motor proficiency of students with ID.	Improved balance and upper limb coordination.
[87] Kachouri et al. (2016), Tunisia.	Quasi-experimental (20), boys with ID.	Level 2 – Moderate.	Strength and balance [O].	To investigate the effect of a combined strength and proprioception training programme on muscle strength and postural balance in children with ID.	Improved strength and static postural balance.

[88] Kadri et al. (2019), Tunisia.	RCT (40), adolescents with ADHD.	Level 1 – Moderate.	Attentional inhibitory control, and sustained and selective visual attention [O & S].	To investigate the effects of a one-and-a-half-year-long Taekwondo intervention on cognitive function in adolescents with ADHD.	Increased selective attention.
[90] Kang et al. (2011), South Korea.	Randomised prospective trial (28), children with ADHD.	Level 1 – Moderate.	ADHD symptoms, executive functions, educational development, and social skills [S].	To understand if sport improves attention symptoms, social competency, and cognitive functions in children with ADHD.	Improved cooperativeness, cognitive function and decreased inattention. No differences in assertiveness and hyperactivity.
[95] Khalil and Elkins (2009), Iran.	RCT (44), children with ID.	Level 1 – Moderate.	Lung functions [O].	To investigate the effect of aerobic exercise on lung function in children with ID.	Improved FEV lung function.
[97] Kong et al. (2019), China.	Quasi-experimental (44), children and adolescents with ID.	Level 2 – Moderate.	Body composition, flexibility, balance, agility, coordination, strength, power and aerobic fitness [O]	To investigate the effects of Tai Chi on anthropometric parameters and physical fitness among children and adolescents with ID.	Improved cardiovascular fitness and trunk endurance in aerobic dance group. Decreased BMI in aerobic dance group. Improved lower limb power and limb coordination in Tai Chi group.
[98] Kosari et al. (2013), Iran.	Quasi-experimental (20), children with AD/HD.	Level 2 – Poor.	Speed, agility, balance, coordination, and strength [O].	To examine the effect of the selective physical exercises on gross motor activities of children with ADHD.	Improved running speed, agility and strength. Improved balance and bilateral coordination.

[99] Kozlowski et al. (2020), country not reported.	Pre-post (58), children with autism.	Level 2 – Good.	Body composition, flexibility, endurance, power, and aerobic capacity [O].	To test the feasibility of a high-intensity exercise programme for children with ASD and without ID, and associated changes in physical performance.	Improved trunk endurance and leg power, increased moderate-to-vigorous PA. No change in cardiovascular fitness, upper body endurance or flexibility.
[108] Lee et al. (2017), South Korea.	Block randomised controlled design (12), children with ADHD.	Level 1 – Poor.	Executive functions [O].	To investigate the effects of exercise on neuropsychological variables of executive function and physiological variables with electroencephalography in children with ADHD.	Increased executive functions.
[109] Ludyga et al. (2017), Switzerland.	Non-random crossover (16), children with ADHD.	Level 2 – Moderate.	Executive functions, attention, and inhibitory control [O].	To investigate the acute effects of aerobic and coordinative exercise on behavioural performance and the allocation of attentional resources in an inhibitory control task.	Improved attention and reaction time.
[110] Ludyga et al. (2020), Switzerland.	Non-random crossover (16), children with ADHD.	Level 2 - Moderate	Cognitive flexibility [O].	To investigate cognitive flexibility and task-related HR variability following moderately intense aerobic exercise and after watching a video in both children with ADHD and healthy controls.	Improved cognitive flexibility.

[119] Mazzoli et al. (2021), Australia.	Cluster RCT (24), children with ID.	Level 1 – Moderate.	Inhibition, working memory, and physical activity [O & S].	To investigate the effects of a 5-week active breaks intervention on cognitive functions and on-task behaviour in schoolchildren with ID.	Improved working memory, stepping time and decreased time spent sitting. No effect in relation to other cognitive factors.
[121] Memarmoghaddam et al. (2016), country not reported.	RCT (36), children with ADHD.	Level 1 – Moderate.	Cognitive and behavioural inhibition [O].	To examine the effectiveness of a selected exercise programme on the executive function of children with ADHD.	Improved cognitive and behavioural inhibition.
[122] Miklos et al. (2020), Hungary.	RCT (150), children with ADHD.	Level 1 – Moderate.	Executive function and attention [O].	To examine the effect of acute moderate PA on the executive functions and attention performance of (1) typically developing children (without psychological, psychiatric or neurological diagnosis and/or associated treatment stated in their medical history); (2) treatment-naïve ADHD children; and (3) medicated children with ADHD.	Mixed effects on executive function and attention performance across groups.

[123] Milligan et al. (2019), country not reported.	Non-random CT (86), youth with learning disabilities.	Level 2 – Good.	Attention and habitual activity [O & S].	To further our understanding of the impact of a mindfulness-based martial arts training intervention on attentional control.	Decreased parent-reported inattention post-intervention.
[124] Mirela et al. (2015), Romania.	Pre-post (3), children with DS.	Level 2 – Moderate.	Balance and coordination [O].	To improve the recovery and compensation of psychomotor status to children with DS.	Improved static and dynamic coordination.
[129] Moraru et al. (2014), Romania.	Pre-post (3), children with DS.	Level 2 – Poor.	Joint flexibility, muscle elasticity and force, and balance [O].	To design and implement a system of exercises and use them as a programme adapted to the physical and psychological features of children, given their motivation for PA.	Increased leg and abdominal force. Increased spine mobility and standing balance.
[134] Ninot and Maiano (2007), France.	Cohort (48), individuals with ID.	Level 2 – Moderate.	Self-perception [S].	To examine the effects of the type of athletic programme (integrated versus segregated) and of the type of sport (basketball versus swimming) on two domains of perceived competence (athletic competence and social	Segregated and inclusive basketball led to significantly lower general self-worth than PE group. No change in self-perception.

				acceptance), and general self-worth.	
[136] Ortiz-Ortiz et al. (2019), Mexico.	RCT (22), children with DS.	Level 1 – Poor.	Body composition and isometric strength [O].	To determine the effect of a physical fitness programme on body composition and isometric strength in children with DS.	Reduced medial calf skinfold and increased isometric strength. Decrease in BMI.
[137] Ozer et al. (2012), Turkey.	Randomised comparative intervention (38), youth with ID.	Level 1 – Good.	Competence and problem behaviours, social cognition, and attitudes [S].	To investigate the effects of a Special Olympics Unified Sports soccer programme on psychosocial attributes of youth with and without ID.	Improved social cognition and competence with decreased problem behaviours.
[138] Ozmen et al. (2007), Turkey.	RCT (30), children with mental retardation.	Level 1 – Moderate.	Cardiovascular fitness and body composition [O].	To investigate the effects of a school-based cardiovascular fitness training programme in children with mental retardation.	Increased cardiovascular fitness. No difference in body composition
[139] Pan et al. (2016), Taiwan .	Crossover RCT (32), children with ADHD.	Level 1 – Moderate.	Motor skill proficiency, social behaviour and executive functions [O & S].	To assess the effects of a 12-week table tennis exercise on motor skills, social behaviours, and executive functions in children with ADHD.	Improved strength and agility, total motor control and coordination. Decrease in social problems, attention problems and aggressive behaviours. No change in anxiety or depression, or rule breaking behaviour.

[140] Pan et al. (2019), Taiwan.	Controlled pre-post (30), children with ADHD.	Level 2 – Good.	Motor skills and executive functions [O & S].	To examine the effect of a 12-week table tennis exercise on motor skills and executive functions in children with ADHD.	Increased locomotor and object control skills. Improved executive function.
[143] Piepmeier et al. (2015), USA.	Post-test (14), children with ADHD.	Level 3 – Moderate.	HR, perceived exertion, cognitive performance [O & S].	To examine the effect of acute exercise on cognitive performance by children with and without ADHD.	Improved inhibition, no change in problem-solving, set shifting or planning.
[144] Pontifex et al. (2013), country not reported.	Within participants (20), children with ADHD.	Level 3 – Moderate.	Executive functions [O].	To examine the effect of a single bout of moderate-intensity aerobic exercise on preadolescent children with ADHD using objective measures of attention, brain neurophysiology, and academic performance.	Increased response accuracy, stimulus-related processing and regulatory processes.
[145] Rahmat and Hasan (2013), country not reported.	RCT (31), people with mental retardation.	Level 1 – Poor.	Core stability, muscular endurance, power, balance and aerobic capacity [O].	To determine the effects of core stability exercises programme on physical fitness of children with mental retardation.	Improved cardiovascular endurance, agility and balance.
Ramer et al. (2020), USA.	RCT (35), children with ADHD or	Level 1 – Moderate.	Classroom behaviour [S].	To examine effects of a 10-week after-school physical activity	No effect on attentional control.

	disruptive behavioural disorders.			programme on academic performance of 6- to 12-year-old African American children with behaviour problems.	
[152] Silva et al. (2015), Brazil.	Cross sectional (28), individuals with ADHD.	Level 3 – Moderate.	Attention [O].	To quantify the effect of PA on the attention of children with ADHD.	Improved performance in attention tasks
[153] Silva et al. (2020), country not reported.	RCT (20), children with ADHD.	Level 1 – Moderate.	Mental health, cognitive flexibility, attention, motor coordination, flexibility and abdominal strength [O & S].	To verify the effects of a swimming–learning programme on mental health parameters, cognition and motor coordination in students with ADHD.	Improved abdominal endurance, coordination and flexibility of lower limbs, cognitive flexibility and selective attention. Decreased depression scores. No change in overall flexibility, anxiety or jumping velocity,
[154] Smith et al. (2013), USA.	Pre-post (14), young children with ADHD.	Level 2 – Good.	Motor proficiency, cognitive inhibition, planning and organisation, working memory, and behaviour [O & S].	To pilot a before-school PA intervention for reducing ADHD symptoms in young children.	Improved motor proficiency, shifting and response inhibition, and decreased inattention. Mixed findings for overall teacher-parent-staff perceived improvement.
[155] Soori et al. (2020), country not reported.	RCT (43), adolescents with ADHD.	Level 1 – Moderate.	ADHD severity, body composition, sprint ability, dietary intake, lactate, and interleukins-13 and -16 [O & S].	To evaluate the effect of high intensity interval training on clinical, as assessed by the Conners' Parent Rating Scale, and anthropo-	Decreased BMI and body fat mass. Decreased ADHD severity.

				metric measures, and laboratory parameters of adolescents with ADHD.	
[158] Suarez-Manzano et al. (2018), Spain.	Pre-post (21), youth with ADHD.	Level 2 – Moderate.	Cognition [S].	To analyse the acute effect of 16 minutes of high-intensity interval training on cognition of ADHD youth.	Improved attention and concentration.
[159] Sumanryanti et al. (2019), country not reported.	Group pre-post (15), children with ID.	Level 2 – Moderate.	$\dot{V}O_{2\ max}$, leg muscle strength, and static balance [O].	To examine the effects of the adaptive activity circuit training of six weeks performed three times per week on the cardiorespiratory fitness ($\dot{V}O_{2\ max}$), leg muscle strength, and balance of intellectually disabled children.	Increased $\dot{V}O_{2\ max}$ and leg muscle strength.
[160] Taylor et al. (2019), United Kingdom.	Quasi-experimental (12), children with AD/HD.	Level 2 – Moderate.	ADHD severity and behaviour [S].	To examine the effect of exercise sessions developed to engage children with ADHD.	Teacher-reported general increase in engagement in classroom-based learning activities.
[161] Toscano et al. (2018), Brazil.	RCT (64), children with ASD.	Level 1 – Moderate.	Body composition, cholesterol, health and wellbeing, satisfaction and ASD symptoms [O & S].	To examine the effects of a 48-week exercise-based intervention on the metabolic profile, autism traits, and perceived QoL in children with ASD.	Increased high-density and decrease in low-density cholesterol. Increased parent-reported physical and psychological health. No substantial changes in body mass or BMI.

[163] Tse et al. (2019), country not reported.	RCT (40), children with ASD.	Level 1 – Moderate.	Sleep, inhibition control and working memory [O & S].	To examine the impact of PA on sleep quality and cognition in children with ASD.	Improved weekday sleep efficiency but no change in weekday or weekend sleep duration or weekend efficiency. Increased inhibition control. No change in working memory.
[164] Ulrich et al. (2011), USA.	RCT (46), children with DS.	Level 1 – Moderate.	Leg strength, body composition, balance and PA [O].	To investigate the PA and health-related outcomes of teaching children with DS to ride a 2-wheel bicycle.	Increased knee flexion and moderate-to-vigorous PA participation. Decrease in body fat sustained at 12-months. Experimental group experienced no change in BMI compared to control group increase.
[167] Verret et al. (2012), Canada.	Non-randomised CT (21), children with ADHD.	Level 2 – Moderate.	Gross motor skills, body composition, flexibility, muscular endurance, HR, behaviour and attention [O & S].	To explore the effects of a moderate-to-high intensity PA programme on fitness, cognitive functions, and ADHD-related behaviour in children with ADHD.	Improved muscular capacity and raw motor skills. Improved information processing and decreased total, thought, and social problems. No change in anxiety and depression and rule-breaking behaviour.
[170] Weerdmeester et al. (2016), Netherlands.	Stratified RCT (73), children with ADHD.	Level 1 – Moderate.	Sustained attention and impulsivity, motor skills and gaming frequency [O & S].	To assess the feasibility and effectiveness of a full-body-driven intervention videogame targeted at decreasing ADHD symptoms, specifically inattention,	Improved teacher-rated ADHD symptoms, however decreased sustained attention and increased impulsivity. No difference in motor skills.

				hyperactivity, impulsivity, and motor deficiency.	
[173] Xu et al. (2020), China.	Pre-post (22), children with ID and developmental disabilities.	Level 2 – Moderate.	Physical fitness [O].	To examine whether participation in an adapted rhythmic gymnastics programme could have a positive impact on levels of physical fitness among children with ID and developmental disabilities.	Improved muscular strength and flexibility. No difference in lower limb power or BMI.
[174] Yilmaz et al. (2009), country not reported.	Pre-post (16), children with mental retardation .	Level 2 – Moderate.	Running speed, muscular strength and endurance, agility, balance and aerobic endurance [O].	To determine the effects of water exercises and swimming on physical fitness of children with mental retardation.	Improved cardiovascular endurance, strength, agility and balance.
[175] Ziereis and Jansen (2015), Germany.	3-arm RCT (43), children with ADHD.	Level 1 – Moderate .	Working memory and motor performance [O].	To determine whether PA improves cognitive performance in children with ADHD.	Improvement in verbal working memory.

Sensory impairments

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
[22] Caliskan et al. (2011), Turkey.	RCT (46), children with severe VI.	Level 1 – Poor.	BMI and percentage body fat [O].	To compare 3-months percentage body fat and BMI in children enrolled in goalball and movement education.	Significant decreases in BMI and percentage body fat among goalball participants.
[30] Chen and Lin (2011), Taiwan.	RCT (16), adolescents with VI.	Level 1 – Poor.	Perceived exertion, body composition, flexibility and aerobic capacity [O & S].	To investigate the impact of rope jumping exercise on the health-related physical fitness of visually impaired students.	No change in balance or flexibility.
[55] Dursun et al. (2015), Turkey.	Pre-post (40), children with VI or HI.	Level 2 – Moderate.	Psychological wellbeing, self-concept and sleep quality [S].	To evaluate the effects of an ice skating programme on the self-concept, behavioural and emotional problem domains, and sleep quality of children and adolescents with VI or HI.	Improved quality of sleep, self-concept, emotional distress, and behavioural difficulties. Decline in self-concept, (increased) peer problems and hyperactivity in VI adolescents.
[83] Jazi et al. (2012), Iran.	RCT (19), children with VI.	Level 1 – Moderate .	Balance [O].	To determine whether balance training effects the dynamic balance of children with VI.	Improved balance.
[118] Mavrovouniotis et al. (2013), Greece.	RCT (16), blind children.	Level 1 – Moderate.	Static and dynamic balance [O].	To examine the effect of a programme with Greek	Improved static and dynamic balance.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
				dances and Pilates on the balance ability of children who are blind.	
[127] Mohanty et al. (2019), India.	Single-blind waitlist controlled study (83), children with VI.	Level 2 – Moderate.	Flexibility, strength, endurance, speed, coordination, peak expiratory flow and body composition [O].	To deliver and assess the efficacy of a 16-week yoga programme for children with VI.	Improved respiratory flow, hand speed and coordination, and flexibility.
[132] Mueller and Ackley-Holbrook (2016), USA.	Pre-post (12), children with SI.	Level 2 – Moderate.	PA barriers, self-efficacy, and health-related physical fitness [O & S].	To document the impact of a recently developed school running programme on the health-related physical fitness and self-efficacy of students with SI.	Improved running performance. No change in $\dot{V}O_{2\ max}$, muscular fitness, body composition, self-efficacy, or flexibility.
[156] Soori et al. (2019), Iran.	RCT (20), HI children.	Level 1 – Moderate.	Bimanual coordination, static balance and dynamic balance [O].	To investigate the effect of 8 weeks of perceptual–motor training on bimanual coordination performance and static and dynamic balancing in students with HI.	Improved coordination and static and dynamic balance.
[168] Vranesic-Hadzimehmedovic and Memisevic	Pre-post (24), children with VI.	Level 2 – Moderate.	Flexibility, strength and balance [O].	To examine the effects of a four-month exercise programme in improving	Improved flexibility and balance. No change in strength.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
(2018), Bosnia and Herzegovina.				gross motor skills of children with VI.	

Mixed disabilities

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
[38] Clapham et al. (2020), USA.	Causal-comparative design (91), children with mixed disabilities.	Level 3 – Good.	Physical fitness and psychological outcomes [O & S].	To explore the effects of a surfing intervention on physical fitness measures in children with disabilities.	Moderate-large effects across various measures. Improvements in aerobic functioning, core strength, muscular endurance, bone mineral density, fat free mass, percentage body fat, flexibility, and parent-reported self-confidence, social development and anxiety levels.
[45] Davis et al. (2017), Australia.	Semi-structured interview/ qualitative (9), children with CP and ID.	Moderate.	-	To identify important domains of QOL for these children and adolescents.	Movement and physical activity are an important QoL domain.
[62] Favazza et al. (2013), USA.	Cluster RCT (233), pre-school age children with disabilities.	Level 1 – Good.	Motor skill development and perceived benefits [O & S].	To examine the effectiveness of the Young Athletes programme to promote	Improved all aspects of motor skill development, significant effect for teacher-rated gross motor skills, parent and teacher-

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
				motor development in preschool-aged children with disabilities.	perceived benefits in gross and fine motor skills, social and play skill improvements. No effect for teacher-rated fine motor skills.
[64] Fragala-Pinkham et al. (2008), USA.	A-B design (20), children with disabilities.	Level 2 – Moderate.	Cardiovascular endurance, muscle strength and motor skills [O].	To evaluate the effectiveness and safety of a group aquatic aerobic exercise programme for children with disabilities on cardiorespiratory endurance.	Increased cardiovascular endurance. No difference in strength or motor skills.
[65] Fragala-Pinkham et al. (2009), USA.	Summative evaluation cross sectional (22), children with disabilities.	Level 3 – Moderate.	Parental reported outcomes and safety [O & S].	To describe an adaptive ice-skating programme designed by paediatric therapists.	Parent and coach-reported improvements in strength, self-esteem and confidence, balance, and group interaction.
[91] Katz-Leurer et al. (2009), Israel.	RCT (20), Children with CP and severe traumatic brain injury.	Level 1 – Moderate.	Aerobic capacity, strength, energy expenditure, upper limb function, and flexibility [O].	To evaluate the feasibility and the ability to recruit and retain children with severe traumatic brain injury or CP, and their families, to a simple home-based exercise programme and to	Improved functional balance, maintained at 6-weeks follow-up.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
				assess the immediate and short-term effects of such intervention on reducing impairment and improving function.	
[120] Mazzoni et al. (2009), Canada.	RCT (26), children with special needs.	Level 1 – Moderate.	Mobility, independence and, self-perceptions [O & S].	To examine the effect of an existing rehabilitation therapy service climbing programme on perceptions of self for children with special needs.	Increased efficacy, with no effects in athletic/social competence or global self-worth.
[131] Moss et al. (2020), country not reported.	Qualitative – semi-structured interviews (6), children and young people with disabilities.	Good	-	To explore members' experiences of a community-based wheelchair basketball club and its impact on daily life.	Improved strength and independence in daily life.
[172] Willis et al. (2018), Norway.	Realist-evaluation ethnography (31), children and youth with disabilities.	Good	-	To describe the association between context, mechanisms and outcome(s) of a participation-focused PA intervention to understand what works,	Participation led to feelings of happiness. Participation improved aspiration, social development, independence and social competence, whilst gaining health and functional benefits through participation.

Ref #, author (date), country	Study type (sample size), population	Level and quality of evidence	Outcomes measured [O = Objective; S = subjective]	Aims	Key findings.
				in what conditions, and how.	