

Articles	Abbreviations: QOL, HRQOL = quality of life, health-related quality of life RCT = randomized controlled trial CP = cerebral palsy GMFCS = Gross Motor Function Classification System MAS = Modified Ashworth Scale TUG = Timed Up and Go Test GMFM-88/66 = Gross Motor Function Measure-88/66 WeeFIM = Wee Functional Independence Measure PedsQL = Pediatric Quality of Life Inventory FISSA = Fatigue Impact and Severity Self-Assessment COPM = Canadian Occupational Performance Measure BAPQ = Bath Adolescent Pain Questionnaire mBPI = modified Brief Pain Inventory 6MWT = Six-Minute Walk Test			BBS = Berg Balance Scale PEDI-CAT = Pediatric Evaluation of Disability Inventory – Computer Adaptive Test ICD-9/10 = International Classification of Diseases, Ninth/Tenth Revision, Clinical Modification ADLs = activities of daily living PACES = Physical Activity and Enjoyment Scale CP QOL = Cerebral Palsy Quality of Life Questionnaire BMI = body mass index BMD = bone mineral density NCDs = non-communicable diseases MVPA = moderate-to-vigorous physical activity FSS = Fatigue Severity Scale			
Author/Year	Purpose	Design	Subjects	Measurements	Results	Strengths/Limitations	
Adar S, 2017	<p><i>Objectives:</i> To compare the effects of aquatic exercises and land-based exercises on spasticity, QOL, and motor function in children with CP.</p> <p>To assess the morphology of spastic muscle and evaluate the morphological changes during therapy using ultrasonography.</p>	Single-blind, prospective RCT	<p>n=32, ages 4 to 17 years; subjects had spastic CP with a diagnosis of diplegia or hemiplegia.</p> <p>Aquatic group (Group 1; n=17) and land-based exercise group (Group 2; n=15)</p> <p><i>Exclusion criteria:</i> Open wounds, cardiovascular disease, orthopedic surgery within 12 months, botulinum toxin A injection to lower extremities within 6 months, or fear of water</p>	<p><i>Measurements at baseline and 6 weeks:</i> GMFCS (mobility), MAS (spasticity), TUG (gait and dynamic balance), GMFM-88 (gross motor function), WeeFIM (functional independence), and ultrasonographic assessment of the spastic gastrocnemius muscle</p> <p>Parents completed the parent proxy-report, version of the PedsQL-CP module.</p>	<p>There were significant improvements in post-treatment scores for lower extremity MAS, TUG, GMFM, and total and motor WeeFIM, with no significant differences between groups 1 and 2.</p> <p>Results indicate that aquatic exercises are as effective as land-based exercises in children with CP, with aquatic exercises being more effective in improving QOL. The authors suggest that ultrasonography is a cost-effective and simple method for the morphological evaluation of the spastic gastrocnemius muscle in children with CP.</p>	<p><i>Strengths:</i> Random allocation into groups, blinded assessors, representation of GMFCS levels I-IV, and subject retention</p> <p><i>Limitations:</i> Small sample size, shortened length of the intervention, and lack of control group for analysis of the placebo effect</p>	

<p>Akinola BI, 2019</p>	<p><i>Objective:</i> To investigate the effects of a 10-week twice weekly aquatic exercise training program on gross motor function in children with spastic CP.</p>	<p>Single-blind, prospective RCT</p>	<p>n=30, ages 1 to 12 years; subjects had spastic CP, with most being spastic quadriplegia.</p> <p>Aquatic group (n=15) and land-based exercise group (n=15)</p> <p><i>Exclusion criteria:</i> Associated neurodevelopmental conditions</p>	<p>GMFCS (mobility) was assessed at baseline, and GMFM-88 (gross motor function) was assessed at baseline, 4 weeks, 8 weeks, and 10 weeks.</p>	<p>There were significant differences between groups on all dimensions of gross motor function in favor of the aquatic exercise training program.</p> <p>Results indicate that 10 weeks of a twice weekly aquatic exercise training program caused significant improvement in gross motor function, making it effective in the functional rehabilitation of children with spastic CP.</p>	<p><i>Strengths:</i> Random allocation into groups, groups were similar at baseline, blinded assessors, representation of GMFCS levels II-V, and subject retention</p> <p><i>Limitations:</i> Small sample size and lack of control group for analysis of the placebo effect</p>
<p>Alriksson-Schmidt A, 2019</p>	<p><i>Objectives:</i> To improve the health care processes and delivery models.</p> <p>To develop, implement, and evaluate real-life solutions for Swedish health care provision.</p> <p>To evaluate existing health care and social insurance benefit programs and processes in the context of CP.</p>	<p>Protocol for a research program, MOVING ON WITH CP</p>	<p>Children and adults with CP who are enrolled in the Cerebral Palsy Follow-Up Program or adapted versions in Sweden, Norway, Denmark, Iceland, Scotland, Jordan, and New South Wales in Australia.</p>	<p>This is a protocol for a research program and there are no results to report to date.</p> <p>MOVING ON WITH CP is a multidisciplinary program that is comprised of 9 projects, which are designed to ensure that the health care of individuals with CP is evidence-based, up to date, cost effective, and fair. The research team consists of physicians, psychologists, public health scientists, physical therapists, health economists, and engineers.</p>		<p><i>Strengths:</i> Use of register-based research for a larger sample size and longitudinal data that extends over 2 decades</p> <p><i>Limitations:</i> To be discussed as the results of MOVING ON WITH CP are reported</p>
<p>Brunton LK, 2019</p>	<p><i>Objective:</i> To explore the self-reported factors that generate fatigue.</p>	<p>Retrospective study</p>	<p>n=160, mean age 22.4 years</p> <p><i>Inclusion criteria:</i> Ages 14 years or older with a</p>	<p>Responses to the FISSA (fatigue) were pooled from 2 larger studies conducted with a convenience</p>	<p>The most commonly reported factors that generate fatigue included activity-related factors, general demands of life, sleep, general health complaints, CP-</p>	<p><i>Strengths:</i> Representation of GMFCS levels I-V and inclusive age range of subjects</p>

	To describe fatigue self-management strategies from the perspectives of adolescents and adults experiencing CP-related fatigue.		diagnosis of CP and the ability to complete self-report questionnaires	sample of adolescents and adults with CP.	related factors, and mental health concerns. The top 5 strategies participants reported to manage fatigue were rest or relaxation, sleeping or napping, changing or limiting their activities, being physically active, and using specific adaptations or assistive devices. Results indicate that there are potentially modifiable factors that significantly contribute to fatigue in people with CP.	<i>Limitations:</i> Convenience sampling and selection bias
Depiazzi J, 2020	<i>Objective:</i> To investigate the feasibility of aquatic high intensity interval training for adolescents with CP.	Pilot RCT	n=12, ages 12 to 17 years and classified as GMFCS level II Aquatic group (n=6) and control group (n=6) <i>Inclusion criteria:</i> Ages 12 to 17 years, born no less than 28 weeks' gestation and discharged from the hospital without an oxygen requirement, and no absolute or relative contraindications to cardiopulmonary exercise testing	<i>Measurements at baseline and 10 weeks:</i> exercise capacity (VO ₂ peak, heart rate peak), body composition (lean muscle mass, fat mass, bone density), QOL (PedsQL, COPM), and pain (BAPQ, mBPI)	The recruitment fraction was 37%. The completion fraction for baseline testing was 71%. The adherence fraction to the intervention was 99%. The intervention fidelity fraction was 93% across all intervals. The completion fraction for all components of the study protocol following randomization was 100%. Results indicate that modification of the protocol used for recruitment is required but overall feasibility and tolerability of assessment and intervention were acceptable.	<i>Strengths:</i> Random allocation into groups, blinded assessors, subject retention, and high subject- and family-reported satisfaction <i>Limitations:</i> Low recruitment fraction, small sample size, variation between subjects, and lack of statistics exploring within or between group differences
Dolbow JD, 2017	<i>Objective:</i> To examine the findings from studies exploring aquatic exercise therapy	Systematic review	n=10, published between 2005 and 2015 Electronic search of 3 databases <i>Inclusion criteria:</i> A physical activity-based intervention involving an aquatic environment or measurement thereof was given with motor		All studies showed significant improvement of 1 or more functional and/or physiological variables studied, suggesting that aquatic exercise therapy may be beneficial for children	<i>Limitations:</i> Small sample size, with 7 of the studies having 10 or fewer subjects; inability to generalize results to all children and adolescents

	protocols in producing changes in gross motor function, cardiorespiratory performance, and gait in children and adolescents with CP.		function, gait, or physiological fitness being at least 1 measured outcome variable; all or a substantial amount of subjects had received a diagnosis of CP, with all or most of the subjects being less than 18 years old; and a patient-specific standardized test was used to assess reported outcome measures		and adolescents with CP. Fragala-Pinkham et al ⁷ showed maintenance of gross motor function improvements at follow-up exams, whereas a similar study that was 6 weeks in duration failed to maintain the reported gains. “This may indicate that the length of intervention is related to the maintenance of gross motor function improvements after cessation of the . . . program.”	with CP; and lack of uniformity in protocols and their exercises
Fragala-Pinkham MA, 2014	<p><i>Objectives:</i> To evaluate the effectiveness of a 14-week twice weekly aquatic exercise program on gross motor function and walking endurance in children with CP.</p> <p>To evaluate the effects of the program on functional strength, aerobic capacity, and balance.</p>	Prospective case series	<p>n=8, ages 6 to 18 years and classified as GMFCS level I (n=3) or III (n=5)</p> <p><i>Exclusion criteria:</i> Botulinum toxin A injection within 3 months, orthopedic surgery within 6 months, open wounds, or swallowing precautions</p>	<p><i>Measurements before, at the end of, and 1 month after the intervention:</i></p> <p><i>Primary:</i> GMFM Dimensions D and E (gross motor function) and 6MWT (walking endurance)</p> <p><i>Secondary:</i> Shuttle run test (aerobic capacity), Pediatric BBS (balance), and the Brockport modified curl-up and isometric pull-up and lateral step-ups (functional strength)</p> <p>Parents completed the Mobility and Social Cognitive Domains of the PEDI-CAT.</p>	<p>There were significant improvements in gross motor function and walking endurance across all 4 points of data collection, with significant changes from baseline to post-treatment and follow-up. There were no significant improvements in secondary outcome measures, but a trend toward improvement was observed.</p> <p>Results indicate that a 14-week twice weekly aquatic exercise program may be effective in improving mobility skills in children with CP.</p>	<p><i>Strengths:</i> Blind assessors and subject retention</p> <p><i>Limitations:</i> Lack of control group for analysis of the placebo effect, small sample size, variable length of testing sessions among subjects, and use of secondary outcome measures that are not sensitive to change in children with CP</p> <p>Authors described issues in determining optimal aerobic training intensity for aquatic exercise for children with CP.</p>

French ZP, 2019	<i>Objective:</i> To determine sex-stratified prevalence of osteoporosis among adults with CP, as compared with adults without CP.	Cross-sectional study	<p>Adults without CP (n=8,732,455), privately insured adults with CP (n=7,348), and publicly insured adults with CP (n=21,907)</p> <p>Data from the year 2016 were extracted from nationwide private and public insurance administrative claims data.</p> <p><i>Inclusion criteria:</i> Ages 18 years or older, 12 full months of continuous enrollment, and at least 1 medical service utilization in 2016</p>	<p>Diagnoses of CP and osteoporosis, including all subtypes, were identified by at least 1 medical claim of ICD-10 codes.</p> <p>To examine the prevalence of osteoporosis across age and sex, age was stratified into the following categories: 18 to 30, 31 to 40, 41 to 50, 51 to 60, 61 to 70, and >70 years of age.</p>	<p>Results indicate that women and men with CP have a higher prevalence of osteoporosis compared with women and men without CP, demonstrating the need for osteoporosis surveillance in this patient population. Both privately and publicly insured adults with CP had a higher prevalence of osteoporosis compared with adults without CP.</p>	<p><i>Strengths:</i> Large sample size and data extracted from nationwide private and public administrative claims data</p> <p><i>Limitations:</i> Data subject to inaccurate ICD-10 coding, single-claim identification for diagnoses of CP and osteoporosis, and inability to account for confounding variables or severity or type of CP</p>
Graham HK, 2016	<ul style="list-style-type: none"> • CP is the most common cause of childhood-onset, lifelong physical disability in most countries, with an estimated prevalence of 17 million people worldwide. It is the most common motor disability of childhood. • CP describes a group of permanent disorders of movement and posture that are attributed to non-progressive lesion or injury that occurred in the developing fetal or infant brain. • CP presents early in infancy and persists throughout one’s lifetime, as almost all children with CP survive into adulthood. • CP results from a primary injury in the central nervous system, but its symptoms are observed in the peripheral neuromuscular system: muscle contractures, spasticity, dystonia, changes in reflexes, and delayed and abnormal motor development. • People with CP may reduce the amount and types of activity during adolescence and early-to-mid adulthood, which can exacerbate disability owing to the progressive development of secondary impairments that, in turn, make it even more difficult to move. Habitual physical activity can prevent or reverse this decline to help to maintain function, as well as reduce associated adverse health outcomes from inactive lifestyles. • Although CP is a lifelong condition, most research has regarded it as a pediatric issue. Recognition that outcomes in adulthood may be poor has highlighted the need to take the entire life course into consideration. 					
Kolman SE, 2018	<i>Objective:</i> To determine the degree to which personal care, mobility,	Cross-sectional study	<p>n=64, ages 0 to 20 years and classified as GMFCS level IV or V</p> <p><i>Inclusion criteria:</i> Ages</p>	Caregivers completed the CP Child Questionnaire (general physical functioning and	Subjects with a higher overall QOL were found to have a higher overall health rating. Comfort and emotions were found to be significant	<p><i>Strengths:</i> Prospective design and response rate of “very good”</p> <p><i>Limitations:</i> Introduction</p>

	positioning, comfort, emotion, communication, and social interaction predicted overall health and QOL in individuals with non-ambulatory CP.		0 to 23 years old, diagnosis of CP, inability to ambulate, parental or guardian permission, and child assent of a minor if the subject was able to assent	QOL) based on the preceding 2 weeks.	predictors of overall health. Results indicate that factors associated with comfort and emotions, and communication and social interaction predicted overall QOL to a greater extent than personal care and transfer mobility.	of measurement bias, inability to generalize results to all non-ambulatory individuals with CP, and inconsistency of caregiver responses being indicators of overall health and QOL
Lai C-J, 2015	<i>Objective:</i> To investigate the effects of pediatric aquatic therapy on motor function, enjoyments, ADLs, and HRQOL for children with spastic CP.	Single-blind, quasi-experimental prospective study	n=24, ages 4 to 12 years and classified as GMFCS levels I-IV Aquatic group (n=11) and control group (n=13) <i>Exclusion criteria:</i> Botulinum toxin injection or surgery within 6 months; psychiatric disorder or communication disorder, such as autism or mental retardation; poorly controlled epilepsy; open wounds; or active infection	<i>Measurements at baseline and 12 weeks:</i> <i>Primary:</i> MAS (spasticity), GMFM-66 (gross motor function) and PACES (enjoyment) <i>Secondary:</i> Vineland Adaptive Behavior Scale (ADLs) and CP QOL-parent proxy scale (HRQOL)	There were significant improvements in gross motor function in the aquatic group that were greater than that of the control group, but these did not translate into improvements in secondary outcome measures. Physical activity enjoyment levels were higher in the aquatic group than the control group. Results indicate that pediatric aquatic therapy can be an effective alternative therapy for children with CP, even with poor GMFCS level.	<i>Strengths:</i> Groups were similar at baseline and subject adherence <i>Limitations:</i> Convenience sampling without randomization, small sample size, shortened length of the intervention, and lack of validation of the PACES for children with CP
McPhee PG, 2020	<i>Objectives:</i> To explore the effect of an individualized health-risk report intervention on changes in perceived	Prospective cohort study	n=31, mean age 33.7 ± 13.1 years and classified as GMFCS levels I-V	<i>Measurements at baseline, 1 week, and 2 weeks:</i> LTPA Questionnaire for Persons with SCI (physical activity) For perceived disease risk, subjective	There were no significant differences in subjects' perceived disease risk after receipt of individualized health-risk reports, and changes were not predictive of changes in physical activity. There were significant main effects for hypertension on perceived risk	<i>Strengths:</i> Representation of GMFCS levels I-V <i>Limitations:</i> Shortened length of the intervention, inability to generalize results to all adults with CP, inability to assess cognition in subjects, risk

	<p>disease risk in adults with CP.</p> <p>To assess the relationship between health-risk factors and perceived disease risk, and whether changes in perceived disease risk predict changes in physical activity.</p>			<p>questions were asked using a 7-point Likert scale (-3=very unlikely, +3=very likely).</p> <p>Response efficacy was assessed by asking subjects to rate the benefit or harmfulness of physical activity for removing the threat using a 1-7 scale (1=harmful, 7=beneficial).</p>	<p>of heart disease, and for waist circumference and BMI on perceived risk of obesity.</p> <p>Results indicate an individualized health-risk report intervention did not change perceived disease risk or physical activity behavior.</p>	<p>of recall bias, and lack of validation of the LTPA Questionnaire for Persons with SCI in adults with CP</p>
Mus-Peters CTR, 2019	<p><i>Objective:</i> To provide an overview of the current scientific literature on BMD in ambulatory persons with mild to moderate CP (GMFCS levels I-III).</p>	Systematic review	<p>n=16, published up to June 2017; n=465, ages 1 to 65 years</p> <p>Electronic search of 3 databases</p> <p><i>Inclusion criteria:</i> Study of a diagnostic group of CP classified as GMFCS levels I-III, use of BMD as an outcome measure, classification as an observational study or the inclusion of baseline measurements of an intervention or experimental study, results on BMD compared with reference data and presented as an average Z-score, and written in English, German, French, or Dutch</p>	<p>There was moderate evidence for low BMD of the total proximal femur in children with GMFCS level III and of the total body in children with GMFCS level II. There was conflicting evidence for low BMD of the distal femur in children with GMFCS level II and of the lumbar spine in children with GMFCS level III. There was no evidence for low BMD in children with GMFCS level I, adults, or in other parts of the body.</p> <p>Results indicate that deficits in BMD are not restricted to non-ambulatory people with CP.</p>	<p><i>Strengths:</i> Retrieval of studies on BMD from various countries</p> <p><i>Limitations:</i> Inclusion of studies with inconsistent methods for measuring BMD and small sample size per GMFCS level; influence of muscle and joint contractures on BMD measurements; and selection bias due to subject recruitment from single sites</p>	
Nooijen CF, 2014	<p><i>Objective:</i> To assess physical behavior, including physical activity</p>	Cross-sectional study	<p>n=48, ages 16 to 24 years; subjects had spastic unilateral or bilateral CP.</p> <p><i>Exclusion criteria:</i></p>	<p>Physical activity was measured over 72 hours, using VitaMove, an ambulatory</p>	<p>On average, subjects spent 48 minutes per 24 hours less being physically active and 80 minutes per 24 hours more being sedentary, as compared</p>	<p><i>Strengths:</i> Groups were similar at baseline</p> <p><i>Limitations:</i> Technological challenges,</p>

	and sedentary behavior, of ambulatory adolescents and young adults with spastic CP.		Disabilities other than CP that affect physical activity or physical fitness, contraindications to maximal exercise, severe cognitive disorders, partly or fully dependent on a manual wheelchair, or physical activity level higher than 15.6% of 24 hours	monitoring system, and body-fixed accelerometers. Activity monitor data of 32 able-bodied persons, ages 14 to 29 years, were used as a reference. Data for subjects with CP were expressed as a percentage of the reference data.	with able-bodied controls. There were no significant differences in physical behavior for subjects with GMFCS levels I and II. Results indicate that ambulatory adolescents and young adults with CP are less physically active and spend more time sedentary compared with able-bodied persons.	resulting in a loss of data; small sample size for GMFCS level III; influence of wearing an activity monitor on activities of daily life; inconsistency of activity monitor wearing duration between subjects and able-bodied controls; and overestimation of physical activity due to selection bias
Oude Lansink ILB, 2018	<i>Objectives:</i> To describe the course of fatigue over a 3-year follow-up period in adults with CP. To investigate the association between known determinants of fatigue and change in fatigue.	Prospective cohort study	n=23, mean age 38 years and classified as GMCFCS levels I-V <i>Inclusion criteria:</i> Ages 18 years or older and able to respond to questions with some degree of independence	<i>Measurements at baseline and 3 years:</i> FISSA (fatigue), BMI and waist circumference (body composition) GMFCS (mobility), motor impairment (i.e. spastic or mixed), and topographical distribution (i.e. unilateral or bilateral) were reported at baseline.	There were no significant differences in mean FISSA scores from baseline to follow-up, even though scores increased 7.7 points. Known determinants of fatigue, such as BMI and waist circumference, were not predictive of change in FISSA scores. Results indicate that fatigue appears to be relatively stable within adults with CP over time.	<i>Strengths:</i> Validation of the FISSA for adults with CP and representation of GMFCS levels I-V <i>Limitations:</i> Convenience sampling, small sample size, poor response rate, various techniques for measuring body composition, and undetermined minimal clinically important difference of the FISSA
Peterson MD, 2013	<ul style="list-style-type: none"> Functional deterioration has been attributed to both chronic inactivity and secondary conditions common among adults with CP. <p><i>Sarcopenia</i></p> <ul style="list-style-type: none"> Individuals with CP are unable to maximally recruit target musculature during voluntary activity, which influences the association between muscle size and strength. In a population that is already acknowledged for their motor impairments, premature early sarcopenia and weakness lead to declines in function, beyond that which is expected for typical aging adults. Muscle atrophy is associated with weakness, frailty, and disability, and failure to prevent its progression with physical activity may impede optimal quality of life and lead to early mortality. <p><i>Obesity</i></p> <ul style="list-style-type: none"> Studies have identified an increased prevalence of obesity among children with CP and a higher prevalence of dyslipidemia and 					

	<p>hypertension among those that are obese.</p> <ul style="list-style-type: none"> • Mortality records have demonstrated a two to threefold greater prevalence of coronary heart disease among adults with CP, as compared with the general population. Therefore, individuals with CP are at increased risk for cardiometabolic health decline, in addition to the muscle dysfunction that is associated with their condition. <p><i>Sedentary Behavior</i></p> <ul style="list-style-type: none"> • Habitual physical activity has a protective role in reducing the heightened health risk in adults with CP, so identifying strategies to increase physical activity is a vital step in preserving their function, health, and optimal quality of life. • Sedentary behavior is a predictor of chronic disease and mortality, and it is acknowledged to accelerate sarcopenia. • Weakness and obesity contribute to the degree of sedentary behavior, as well as gross motor decline. 					
Peterson MD, 2015	<i>Objective:</i> To examine estimates of chronic conditions in a population-representative sample of adults with CP.	Cross-sectional study	n=207,615, of which 1,015 had CP Data between 2002 and 2010 were extracted from medical conditions files of the Medical Expenditure Panel Survey, an ongoing, nationally representative survey of the United States' civilian noninstitutionalized population.	Surveys are conducted by interviews with a single respondent of the household. A diagnosis of CP was identified by at least 1 medical claim of ICD-9 codes.	The prevalence rates of chronic conditions were significantly greater among adults with CP, including diabetes, asthma, hypertension, other heart conditions, stroke, emphysema, joint pain, and arthritis. Age, sex, weight, physical disability, overall health, and physical activity were also associated with chronic conditions. Results indicate that adults with CP have significantly higher odds of developing chronic conditions compared with adults without CP.	<i>Strengths:</i> Large sample size and data extracted from a nationally representative survey <i>Limitations:</i> Failure to determine a causal relationship between CP and chronic conditions, reliance on self-reported data from household members, inability to generalize results to all adults with CP, and poor response rate
Roostaei M, 2017	<i>Objective:</i> To review the literature on the effects of aquatic intervention on gross motor skills for children with CP.	Systematic review	n=11, published up to January 2016 Electronic search of 6 databases <i>Inclusion criteria:</i> Ages 1 to 21 years with a diagnosis of CP; gross motor skill studied as a dependent variable, using any measurement tool assessing gross motor abilities such as rolling, sitting, creeping, standing, walking, and wheelchair mobility; all types of aquatic intervention programs; full text peer-reviewed articles; and any study design		Aquatic interventions, which include strengthening and aerobic exercises, have the potential to improve gross motor function. Those with significant improvements lasted 6 to 16 weeks, with a frequency of 2 to 3 times per week and 45 to 60 minutes per session. Results indicate that the effects of aquatic intervention on gross motor skills and walking speed	<i>Limitations:</i> Publication bias, such as the failure to report or publish studies with negative results, and inclusion of studies with low-level study design and PEDro scores

					are variable in children with CP who are ambulatory. Session length and frequency and type of activities may be factors influencing intervention effectiveness.	
Ryan JM, 2018	<i>Objective:</i> To examine the risk, burden, and management of NCDs among people with CP.	Systematic review	n=36, published up to August 2017 Electronic search of 3 databases <i>Inclusion criteria:</i> The prevalence of risk factors for, and the burden and management of, cardiovascular diseases, diabetes, cancers, and respiratory diseases, and subjects of any age, any type of CP, and any functional ability		There was inconsistent evidence that people with CP had higher prevalence of metabolic risk factors, such as hypertension, hyperlipidemia, and obesity, but strong evidence that they participated in low levels of physical activity compared with people without CP throughout the lifespan. All studies reporting on the risk of NCDs found an increased risk among adults with CP. Results indicate that people with CP are at increased risk of NCDs, which may be a direct result of reduced participation in physical activity and screening programs.	<i>Limitations:</i> Inclusion of studies with small sample size and without direct comparison of the prevalence of risk factors between people with and without CP
Ryan JM, 2015	<i>Objective:</i> To describe light, moderate, and vigorous physical activity and sedentary behavior in preadolescent children with and without CP and compare physical activity and sedentary	Cross-sectional study	n=33, ages 6 to 10 years and classified as GMFCS levels I-III; subjects had spastic and non-spastic CP. <i>Exclusion criteria:</i> Severe intellectual disability or surgery within 6 months	Physical activity was measured over 7 days, using the RT3 accelerometer. Activity monitor data of 33 age- and sex-matched children were used as a reference.	Children with CP spent more time in sedentary behavior and less time in total activity, moderate activity, vigorous activity, and MVPA than able-bodied controls. Significantly more children with typical development achieved 90 minutes of MVPA daily than children with CP, but both groups were physically active for 60 minutes daily. Results indicate that	<i>Limitations:</i> Convenience sampling, inability to generalize results to all children with CP, inconsistency of physical activity between weekends and week days, and use of a single set of cut-points to classify physical activity intensity among all children

	behavior between the 2 groups.				preadolescent children with CP spend less time in moderate and vigorous activity and more time in sedentary behavior than children with typical development.	
Ryan JM, 2014	<p><i>Objectives:</i> To investigate the prevalence of overweight/obesity and elevated blood pressure among a cohort of ambulatory children with CP.</p> <p>To investigate the association between physical activity, sedentary behavior, overweight/obesity, and blood pressure in children with CP.</p>	Cross-sectional study	<p>n=90, ages 6 to 17 years and classified as GMFCS levels I-III; subjects had spastic and non-spastic CP.</p> <p><i>Exclusion criteria:</i> Intellectual disability or surgery within 6 months</p>	<p>Body composition was characterized by BMI, waist circumference, and waist-height ratio. Blood pressure was measured with the Omron 705 IT blood pressure monitor, and physical activity was measured over 7 days, using the RT3 accelerometer.</p>	<p>The prevalence of overweight/obesity in the cohort was 18.9%, and the prevalence of blood pressure values in the hypertensive and pre-hypertensive ranges were 10.5% and 11.6%, respectively. Children with overweight/obesity tended to have elevated blood pressure. Systolic blood pressure was positively associated with waist circumference, and elevated blood pressure values were associated with physical inactivity and increased sedentary behavior.</p> <p>Results indicate that a high proportion of children with CP have elevated blood pressure values, which is associated with overweight/obesity.</p>	<p><i>Strengths:</i> Validation of the Omron 705 IT blood pressure monitor in children</p> <p><i>Limitations:</i> Convenience sampling, use of a single set of cut-points to classify physical activity intensity among all children, and inability to diagnose hypertension with 1 measurement</p>
Turk MA, 2009	<ul style="list-style-type: none"> • The most commonly reported age-related changes and secondary conditions involve pain, fatigue, physical performance, and the musculoskeletal system. • Mortality among people with CP seems to be related to the severity of impairments, as survival of higher functioning adults, even those with mild-to-moderate CP, is close to that of the general population. • The general health of adults with CP is self-reported as good or satisfactory to excellent, which is comparable to adults without CP; self-perceived health ratings and life satisfaction may be related to the prevalence of pain or to functional changes over time, but not to the severity of impairment. • Pain is the most consistent health condition in adults with CP, being reported in a number of samples and at a variety of ages. • Pain can cause, or be caused by, increased spasticity, weakness, falls, or progression of contractures or deformities. 					

	<ul style="list-style-type: none"> • There is a decrease in the functional status of adults with CP with aging, with some reporting modest-to-significant decreases in self-care tasks, especially in dressing and walking. • Adults with CP reportedly participate to a limited extent in health screening and wellness activities, likely due to attitudinal and environmental barriers. 					
van der Slot, WMA 2012	<p><i>Objectives:</i> To investigate the prevalence and co-concurrence of chronic pain, fatigue, and depressive symptoms in adults with spastic bilateral CP.</p> <p>To explore associations of chronic pain and fatigue with depressive symptoms and daily functioning.</p>	Cross-sectional study	<p>n=56, ages 25 to 45 years and classified as GMFCS levels I-IV; subjects had spastic bilateral CP.</p> <p><i>Exclusion criteria:</i> Any multimorbidity with lasting effects on physical activity or contraindicated for a progressive maximal ergometer test, full dependence on electric wheelchair propulsion, legal inability, or severe cognitive impairment according to medical files</p>	<p>Data were collected with questions on chronic pain and administration of the FSS (fatigue), Multidimensional Fatigue Inventory (fatigue), Center for Epidemiological Studies Depression Scale (depression), and Assessment of Life Habits 3.0 (daily functioning).</p> <p>Data of Dutch healthy samples were used as a reference.</p>	<p>75% of adults with spastic bilateral CP reported chronic pain, or pain lasting more than 3 months, compared with 39% of the reference group. Severity and nature of fatigue were higher in adults with spastic bilateral CP, and they had significantly more depressive symptoms. Co-concurrence of chronic pain, fatigue, and depressive symptoms was higher, too, but it did not seem to be associated with difficulties in daily functioning.</p> <p>Results indicate that adults with spastic bilateral CP are severely affected by chronic pain, fatigue, and depressive symptoms.</p>	<p><i>Strengths:</i> Subjects were similar to a representative cohort from the same geographic region</p> <p><i>Limitations:</i> Small sample size, selection bias, and overestimation of depressive symptoms due to methods of assessment</p>
van Gorp M, 2020	<p><i>Objective:</i> To describe the health status, prevalence of impairments, and level of activities and participation in adults with CP.</p>	Systematic review and meta-analysis	<p>n=65, published between 2000 and 2018; n=28,429, mean age 32 years</p> <p>Electronic search of 7 databases</p> <p><i>Inclusion criteria:</i> Reported on the most frequently studied outcomes; at least 3 studies reported on an outcome using similar methods of assessment, enabling comparison and meta-analysis; study design was descriptive, observational, or experimental; full-article peer-reviewed journal articles written in English; described individuals with CP only or in case-control design; described ≥ 25 adults who were</p>		<p>Mean overall BMI was 25.1, and 22.6% of individuals with CP were obese. Epilepsy, asthma, and hypertension were the most prevalent comorbidities. The estimated occurrence of pain was 65.1%, and an overall FSS score of 4.1 indicated fatigue. The proportions of adults with CP who were employed and living independently were 39% and 29%, respectively.</p>	<p><i>Strengths:</i> Large sample size</p> <p><i>Limitations:</i> Publication bias, with the omission of inconclusive trials and non-English language publications; inability to generalize results to regions other than North America, Western Europe, Asia, or Australia; and inapplicability of results</p>

			18 years or older at the time of the first measurement or at follow-up; reported on outcomes of functioning; study samples were population based or rehabilitation based, or samples addressed a substantial subgroup of individuals with CP	Results indicate that adults with CP are fatigued, and a majority experience pain, are ambulant, and have little or no difficulty with manual ability.	to older adults with CP	
Verschuren O, 2016	<ul style="list-style-type: none"> Children and adults with CP spend 76% to 99% of their waking hours being sedentary, fewer than 18% engage in light physical activity, and 2% to 7% in MVPA. Children and adolescents should accumulate at least 60 minutes of MVPA per day, while the recommendation for adults is at least 30 minutes. It is advised to increase MVPA and replace sedentary behavior with light physical activity, but for GMFCS levels IV and V, decreasing sedentary behavior might be the only possible intervention. <p><i>Cardiorespiratory Endurance Training</i></p> <ul style="list-style-type: none"> Results of studies with a training frequency of 2 to 4 sessions per week have been shown to be effective in increasing cardiorespiratory fitness, suggesting that sessions can start at 1 or 2 times per week and progress gradually thereafter. Training sessions should last at least 20 minutes and be at a moderate intensity of 60% to 75% maximum heart rate, 40% to 80% heart rate reserve, or 50% to 65% peak oxygen uptake. These values are in accordance with the American College of Sports Medicine guidelines. Programs should be at least 8 consecutive weeks when training 3 times per week or 16 consecutive weeks when training 2 times per week. Exercises for cardiorespiratory endurance training include running, step-ups, stair negotiation, cycling, arm ergometry exercise, propelling a wheelchair, and swimming. A warm-up and cool-down should be implemented to reduce musculoskeletal injury. <p><i>Muscle Strengthening</i></p> <ul style="list-style-type: none"> Higher levels of muscular strength are associated with significantly better cardiometabolic risk factor profiles, lower risk of all-cause mortality, fewer cardiovascular disease events, and lower risk of developing functional limitations. Frequency of strength training should be 2 to 3 times per week on nonconsecutive days for 12 to 16 weeks. People with CP need to be given time to adapt to strenuous exercise and maintain their gains, calling for longer interventions. It can be unsafe to establish a 1-repetition maximum for people with CP, so it is more feasible to increase their load within an 8- to 12-repetition maximum. Exercises should build upon minimal volume and intensity toward 1 to 4 sets of 6 to 15 repetitions. 					
Whitney DG, Alford AI, 2019	<i>Objective:</i> To determine the prevalence of fracture among a large sample of privately insured adults with CP, as compared with adults without CP. To determine if	Cross-sectional study	n=5,500,000, of which 5,555 had CP; ages 18 to 64 years Data from the year 2016 were extracted from nationwide single private payer administrative claims data. <i>Inclusion criteria:</i> Ages	Medical conditions, including CP, all-cause fracture at any location, cardiometabolic diseases, and osteoporosis, were identified by at least 1 medical claim of ICD-10 codes.	Adults with CP had odds of any fracture that were more than 2 times higher than adults without CP. After adjusting for cardiometabolic diseases and osteoporosis, these odds remained significantly elevated. Prevalence of fracture was higher, too, across all regions of the body. Results indicate that adults with	<i>Strengths:</i> Large sample size and data extracted from nationwide private administrative claims data <i>Limitations:</i> Inability to determine severity of CP, fracture history, or cause of fracture from cross-sectional data; underestimation of

	the elevated presence of NCDs, including cardiometabolic diseases and osteoporosis, moderates the association between CP and fracture.		18 years or older, 12 full months of continuous enrollment, and at least 1 medical service utilization in 2016		CP have higher odds of all-cause fracture compared to adults without CP, highlighting the need for earlier detection of fracture risk.	fracture prevalence due to higher functioning sample; and unmeasured confounding variables
Whitney DG, Kamdar NS, 2019	<i>Objective:</i> To determine the prevalence of high-burden medical conditions and to descriptively characterize health care resource utilization and costs among adults with CP, as compared to adults without CP.	Cross-sectional study	n=5,555, ages 18 to 64 years Data from the year 2016 were extracted from nationwide single private payer administrative claims data. <i>Inclusion criteria:</i> Ages 18 years or older, 12 full months of continuous enrollment, and at least 1 medical service utilization in 2016	Medical conditions, including CP, pain, all-cause fracture at any location, and NCDs, were identified by at least 1 medical claim of ICD-10 codes. Annual all-cause health care resource utilization and health care costs were identified by medical and outpatient pharmacy claims that were represented as standardized reimbursement and patient out-of-pocket costs.	Adults with CP had a higher prevalence of all medical conditions compared to adults without CP, except for malignant cancer. They had a higher prevalence of having at least 1 service utilized in 2016, and the standardized reimbursement and patient out-of-pocket costs were higher for them for total, medical, and pharmacy claims. Results indicate that adults with CP have higher prevalence of various high-burden medical conditions compared to adults without CP, resulting in excess healthcare costs and visits.	<i>Strengths:</i> Large sample size and data extracted from nationwide private administrative claims data <i>Limitations:</i> Inability to determine severity of CP and generalize results to the CP population, single claim identification for diagnoses of CP and high-burden medical conditions, natural errors of administrative claims data, inability to determine the temporal sequence of high-burden medical conditions, and inflation of cost data compared to other health plans

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