Editor's Choice

Exercise and physical activity recommendations for people with cerebral palsy

OLAF VERSCHUREN[1] | MARK D PETERSON[2] | ASTRID C J BALEMANS[1,3] | EDWARD A HURVITZ[2]

1 Brain Center Rudolf Magnus and Center of Excellence for Rehabilitation Medicine, University Medical Center Utrecht and De Hoogstraat Rehabilitation, Utrecht, the Netherlands. **2** Department of Physical Medicine and Rehabilitation, University of Michigan, Ann Arbor, MI, USA. **3** Department of Rehabilitation Medicine, MOVE Research Institute Amsterdam, VU University Medical Center, Amsterdam, the Netherlands.

Correspondence to Olaf Verschuren at Brain Center Rudolf Magnus and Center of Excellence for Rehabilitation Medicine, University Medical Center Utrecht and De Hoogstraat Rehabilitation, Rembrandtkade 10, 3583TM, Utrecht, the Netherlands. E-mail: o.verschuren@dehoogstraat.nl

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ABBREVIATIONS

1RM	One-repetition maximum
ACSM	American College of Sports Medicine
HRR	Heart rate reserve
NSCA	National Strength and Conditioning Association
RCT	Randomized controlled trial

Physical activity and its promotion, as well as the avoidance of sedentary behaviour, play important roles in health promotion and prevention of lifestyle-related diseases. Guidelines for young people and adults with typical development are available from the World Health Organisation and American College of Sports Medicine. However, detailed recommendations for physical activity and sedentary behaviour have not been established for children, adolescents, and adults with cerebral palsy (CP). This paper presents the first CP-specific physical activity and exercise recommendations. The recommendations are based on (1) a comprehensive review and analysis of the literature, (2) expert opinion, and (3) extensive clinical experience. The evidence supporting these recommendations is based on randomized controlled trials and observational studies involving children, adolescents, and adults with CP, and buttressed by the previous guidelines for the general population. These recommendations may be used to guide healthcare providers on exercise and daily physical activity prescription for individuals with CP.

Many children, adolescents, and adults with cerebral palsy (CP) have reduced cardiorespiratory endurance (the capacity of the body to perform physical activity that depends mainly on the aerobic or oxygen-requiring energy systems), muscle strength, and habitual physical activity participation.[1–8] Reduced cardiorespiratory endurance and muscular weakness both pose significant risks for negative health outcomes and early, cardiovascular- and all-cause mortality.[9–12] Because people with CP have lower levels of health-related fitness (muscle strength and cardiorespiratory endurance) and reduced levels of physical activity, they are at higher risk for developing metabolic and cardiovascular diseases. This has been shown by increased cardiometabolic risk factors, including hypertension, cholesterol, HDL-C, visceral adipose tissue, and obesity in adults with CP.[13–16] Moreover, we have recently shown that in a population-representative sample of adults with CP, there were substantially increased estimates of chronic diseases, such as diabetes, asthma, hypertension and other cardiovascular conditions, stroke, joint pain, and arthritis.[17]

Globally, there is a need to encourage greater participation in physical activity, consistent with guidelines, to achieve higher fitness levels, decrease disease risk factors, and reduce secondary complications such as early functional loss.[18] The importance of physical activity and its promotion as well as the avoidance of sedentary behaviour is indisputable. Comprehensive clinical outpatient programmes, such as cardiac rehabilitation, have proven to be cost-effective and worthwhile in helping patients manage their risk for cardiovascular disease and other chronic diseases, but have done so by focusing predominantly on exercise rather than the avoidance of sedentary behaviour.[19] Physical activity is necessary for the optimal physical, emotional, and psychosocial development of all children. However, many parents, patients, caregivers, educators, and clinicians have questions regarding appropriate levels of physical activity for individuals with CP. Healthcare providers can therefore play an instrumental role in the promotion of physical activity by encouraging people with CP and their families to integrate it into daily life.

They can also provide education regarding the role of physical activity to augment traditional therapy and how it can be used to maintain physical health into and throughout adulthood. Indeed, physical activity participation can gradually replace the therapies that were such an important part of the children and adolescents' lives, especially as they transition into adulthood. Lifestyle physical activity counselling should therefore be a priority during every visit with a healthcare professional. Healthcare professionals should encourage patients (and their caregivers) to ask questions about their physical activity levels, and should provide specific counselling to assist with accessibility strategies for physical activity as well as suggestions for activity/exercise prescription.

Detailed recommendations regarding minimum standards for physical activity and sedentary behaviour have not been established for children, adolescents, and adults with CP. However, global guidelines for young people and adults with typical development have been published by the World Health Organisation (WHO).[20] To a large extent, these are based on expert recommendations rather than definitive scientific evidence, and suggest that children and adolescents should accumulate at least 60 minutes of moderate-to-vigorous intensity physical activity per day.[21] Moreover, recommendations suggest that sedentary behaviour should be limited to a daily maximum of 2 hours.[22] For adults, the recommendations call for a minimum of 30 minutes of moderate-to-vigorous intensity physical activity per day,[23] and that the amount of sedentary behaviour should be minimized as much as possible. These general recommendations, however, do not include specific suggestions for target groups like people with CP.

The focus of this paper is on physical activity and exercise for improving health and fitness in CP, with specific emphasis on cardiorespiratory endurance, muscle strengthening, and reduction of sedentary behaviour. The data supporting these recommendations are based on previous studies involving children, adolescents, and adults with CP, and are provided in context with the guidelines for the general population. The benefits of various approaches for initiating and administering a progressive activity programme for persons with CP, classified in Gross Motor Function Classification System (GMFCS) levels IV and V, have not been systematically evaluated. Based on a combination of scientific evidence, expert opinion, and clinical experience, we aim to highlight the complex and multidimensional aspects of physical activity and exercise to establish CP-specific recommendations.

What this paper adds

- This paper provides an overview of intervention studies including cardiorespiratory endurance training and muscle strengthening for individuals with cerebral palsy (CP).
- This paper includes prescription guidelines pertaining to volume, intensity, and duration of physical activity and exercise for individuals with CP.
- We present the first CP-specific, evidence-based physical activity, and exercise recommendations, which may be incorporated into a clinical setting.

CARDIORESPIRATORY ENDURANCE TRAINING

Given the well-established link between cardiorespiratory endurance and overall health, it is not surprising that the adaptive-response of this fitness component has been assessed in children, adolescents, and adults with CP. To provide the highest level of evidence, we carried out a comprehensive review including only randomized controlled trials (RCTs), in which participants received cardiorespiratory endurance training versus placebo or no intervention. This resulted in five RCTs (see Table I).[24–28] These studies collectively demonstrate that aerobic exercise training can lead to significant increases in cardiorespiratory endurance among individuals with CP.

An understanding of existing evidence-based intervention approaches is essential for the development of effective

Table I: Comparison of variables of cardiorespiratory endurance training across randomized controlled trials in cerebral palsy compared with American College of Sports Medicine (ACSM) guidelines

	Participants	Frequency	Intensity	Time (session)	Type
van den Berg-Emons et al.[26]	*n*=20 Age 7–13y GMFCS levels I-IV (study predates GMFCS use)	Two to four times a week 9mo	70% HRR	45min	Cycling Propelling wheelchair Running Swimming Mat exercises
Unnithan et al.[25]	*n*=13 Age 14–18y GMFCS level II/III	Three times a week 12wks	65%–75% HRmax	20–22min	Walking Uphill walking
Verschuren et al.[27]	*n*=68 Age 7–20y GMFCS level I/II	Two times a week 8mo	60%–80% HRmax	45min	Functional exercises: Running Steps-up and down Stepping over Bending Turning Getting up from the floor
Nsenga et al.[24]	*n*=20 Age 10–16y GMFCS level I/II	Three times a week 8wks	50%–65% VO_{2peak}	40min	Cycling
Slaman et al.[28]	*n*=42 Age 16–24y GMFCS level I-IV	Two times a week 12wks	40%–80% HRR	60min	Treadmill Cycling Arm cranking
ACSM[29]		Three to five times a week	64%–95% HRmax or 40%–89% HRR or 46%–90% VO_{2peak}	20–60 or more minutes per session, continuous or intermittent activity	Regular, purposeful exercise that involves major muscle groups and is continuous and rhythmic in nature

GMFCS, Gross Motor Function Classification System; HRR, heart rate reserve; HRmax, maximum heart rate; VO_{2peak}, peak oxygen uptake.

exercise programmes for people with CP. Unfortunately, to date these exist only for children, adolescents, and adults with typical development. Equally important is a thorough familiarity with the unique physical attributes and limitations of people with CP. To be able to develop universally accepted exercise prescription guidelines for children and adults with CP, we have relied on a basic and well-accepted framework of prescription nomenclature to operationalise the exercise variables from published RCTs in this population, including (1) frequency, (2) intensity, (3) time, and (4) type. We have evaluated the extent to which recent training intervention studies were consistent with current recommendations related to cardiorespiratory 'aerobic' exercise as provided by the American College of Sports Medicine (ACSM).[29] Briefly, these guidelines recommend a frequency of 5 days/week of moderate exercise or 3 days/week of vigorous exercise. For people with typical development who are deconditioned, the recommendation is to include light- to moderate-intensity exercise, and moderate and vigorous intensity. The recommendation is 20 to 60 minutes of continuous and rhythmic moderate or vigorous exercises that involve major muscle groups.

Frequency

Training frequency refers to the number of exercise sessions per week. All five RCTs[24–28] incorporated a training frequency of two to four sessions per week. For children and adolescents with typical development and healthy adults, a training frequency of at least three to five sessions per week is recommended by the ACSM to increase and maintain cardiorespiratory fitness.[29] This strategy allows for adequate recovery between sessions (24–36h).[29] From previous studies pertaining to CP, only two studies[24,25] were aligned with the ACSM guidelines for the frequency of training. Interestingly, for the remaining studies in which frequency did not meet minimal recommendations, results demonstrated that training was still effective in increasing cardiorespiratory fitness.[26–28,30] This may suggest that for people with CP who are very deconditioned, it is possible and advisable to start with one to two sessions per week and progress gradually thereafter, as adaptations occur.

Intensity

Intensity refers to the effort of training (i.e. relative to maximal capacity), and is often prescribed relative to predicted maximal heart rate, heart rate reserve ([HRR] the difference between a person's measured or predicted maximum heart rate and resting heart rate), and/or peak oxygen consumption (peak rate of oxygen consumption as measured during incremental exercise). Two previous studies[25,27] incorporated the maximum heart rate method to assign training intensity. The study by Verschuren et al.[27] started participants with a training intensity of 60% to 70% of maximum heart rate, and increased to 70% to 80% during the third month. The study by Unnithan et al.[25] used a training intensity of 65% to 75% of the maximum heart rate, which is also in accordance with the ACSM guidelines (64%–95%). Two other studies used a percentage of the HRR. Specifically, in the study by Slaman et al.[28] training started at 40% of HRR and increased to 80% of HRR by week 12. Participants in the study by van den Berg-Emons et al.[26] trained at 70% of the HRR throughout the programme, which is also in accordance with the guidelines. The study of Nsenga et al.[24] was also in accordance with the ACSM guidelines, with training intensities ranging from 50% to 65% of the peak oxygen consumption. Although many factors need to be considered when evaluating these studies and respective findings (e.g. functional capacity of the participants), it is important to point out that intensity of training in each of these five RCTs was aligned with current ACSM guidelines. This suggests that many individuals with CP are capable of and will benefit in fitness improvement from engaging in progressively intense aerobic exercise similar to the extent recommended for peers with typical development.

Time

All training sessions lasted for at least 20 minutes, which is in alignment with the ACSM guidelines.[29]

Type

For cardiorespiratory fitness, the ACSM recommends regular, purposeful exercise that involves major muscle groups and is continuous and rhythmic in nature.[29] The types of activities provided in the five RCTs included running, step-ups, negotiating stairs, cycling, arm ergometry exercise, propelling a wheelchair, and swimming,[24–28] and all were tailored to the specific condition of the included participants.

Summary of training parameters

Exercise participation can be performed with a high level of safety by most people, including individuals with CP. Based on the safety issues evaluated for the five RCTs, which reported no adverse events, there is a low risk of injury in children and adolescents with CP during cardiorespiratory training. In these studies[24–28] the participants exercised at least two to four times per week for a minimum 20 minutes, and at a moderate intensity of about 60% to 75% maximum heart rate, 40% to 80% of HRR, or 50% to 65% peak oxygen uptake. Three studies reported outcomes in cardiorespiratory endurance.[24,25,28] The other studies reported outcomes in aerobic performance, measured with an arm cranking/cycle test,[26] and shuttle run test.[27] The reported increases were:

- 23% for an 8-week intervention with young people (age: 14.2 [SD 1.9y]) in GMFCS levels I and II[24]
- 18% for a 3-month intervention with those (age: 15.9 [SD 1.5y]) in GMFCS levels II and III[25]
- 9% for a 3-month intervention with young adults (age: 20 [SD 3.0y]) classified in GMFCS levels I–IV[28]
- 41% for an 8-month intervention with children (age: 12.1 [SD 2.6y]) in GMFCS levels I and II[27]

- 26% for a 9-month intervention with those (age: 9.2 [SD 1.4y]) in GMFCS Levels I-III, and possibly even level IV (study predates GMFCS use).[26]

Thus, according to these studies, we can conclude that cardiorespiratory training can effectively increase cardiorespiratory endurance in children and young adults with CP. Taken together, these results suggest that greater gains in cardiorespiratory endurance may occur with training programmes of longer duration and for children and adults with CP who have greater mobility and can engage in greater doses of training.

According to the existing intervention studies, exercise prescription for people with CP should include: (1) a minimum frequency of two to three times per week; (2) an intensity between 60% and 95% of peak heart rate, or between 40% and 80% of the HRR, or between 50% and 65% of VO_{2peak}; and (3) a minimum time of 20 minutes per session, for at least eight consecutive weeks, when training three times a week, or for 16 consecutive weeks when training two times a week. Moreover, a pre-workout warm-up and cool-down could be added to reduce musculoskeletal injury.

Adherence considerations

It might be very difficult for many previously inactive individuals with CP to achieve and sustain these exercise recommendations, and thus it is important to know what is required to maintain adaptations. Moreover, and although we recommend lifelong, regular physical activity participation, it is also very important to point out that missing exercise sessions or even going through periods of complete attrition is very common. Based on research from individuals with typical development, once a regular physical activity routine is established, short lapses in routine participation will have little or only modest influence on maintenance of cardiorespiratory endurance.[29] Thus, these findings indicate that greater doses of exercise are required to improve cardiorespiratory fitness than that which is needed to simply maintain adaptations.

MUSCLE STRENGTHENING

The health benefits of enhancing muscular fitness have become well established.[31] Higher levels of muscular strength are associated with significantly better cardiometabolic risk factor profiles,[32–34] lower risk of all-cause mortality,[35] fewer cardiovascular disease events,[35] and lower risk of developing functional limitations.[36] As CP results from an injury to motor regions of the developing brain, muscle weakness is a primary impairment and there is strong evidence showing that children with CP are significantly weaker than children with typical development.[7,8]

In the past, strength training was considered to be contraindicated in people with CP because it was thought to increase muscles stiffness, and result in an increase in spasticity and a decrease in range of motion. However, studies[37–39] have found no change in spasticity during or after training, which supports the current belief that strength training for persons with spasticity is not contraindicated. There is even some evidence of improved spasticity with targeted strength training,[40] and therefore, in conjunction with cardiorespiratory fitness, it is imperative to include strategies that target muscle strength in children, adolescents, and adults with CP. As for children with typical development, resistance training has the potential to offer observable benefits in terms of increased strength among children, adolescents, and adults with CP. A recent systematic review demonstrated that strengthening interventions produce large improvements in strength and physical performance among individuals with CP.[41] However, as there is a paucity of strong evidence from RCTs regarding the use of resistance training in persons with CP,[42] we report the extent to which training protocols from the most recent RCTs were consistent with the evidence for effective resistance training, as reflected in the training guidelines of the National Strength and Conditioning Association (NSCA)[43] and the ACSM.[29] To maintain the highest level of evidence for these recommendations, we carried out a comprehensive review including only RCTs. We have limited our evaluation to resistance training for the lower extremity, as most of the RCTs in people with CP have incorporated training interventions for these muscles (Table II).

Frequency

For children and adolescents with typical development and healthy adults, recommendations call for a training frequency of two to three times per week on nonconsecutive days.[43] In five RCTs[38,44–47] that included children, adolescents, and adults with CP, the frequency of the training for children with spastic CP was three times a week, and in one RCT[48] the frequency was twice weekly. Therefore, the frequencies of the training were in accordance with the evidence-based NSCA and ACSM guidelines.

Intensity and volume

According to the NSCA guidelines for young people, novice individuals should use a load that allows no more than 10 to 15 repetitions for one to two sets to be completed, without undue muscle fatigue.[43] Depending on the individual's needs, goals, and abilities, the programme can be progressed over time to include greater volumes with heavier loads for large muscle groups, to maximise gains in muscle strength. For the intermediate and advanced individuals, the load should be sufficient to allow 6 to 12 repetitions before muscle fatigue, for two to four sets.

For adults, gains in muscular hypertrophy and strength result from using a resistance equivalent to 60% to 80% of the individual's one-repetition maximum (1RM).[49] Training intensity may be modified based on a targeted number of repetitions, or by increasing loading within a prescribed repetition-maximum range (e.g. 8- to 12-repetition maximum [RM]).[29] Because it is often challenging or unsafe to ascertain a true 1RM among individuals with CP, using

Table II: Comparison of variables of muscle strength training across randomized controlled trials in cerebral palsy compared with National Strength and Conditioning Association and American College of Sports Medicine guidelines

	Participants	Frequency	Intensity	Time/duration)	Type
Dodd et al.[44]	*n*=21 Age 8–18y GMFCS level I/II/III	Three times a week	Three sets of 8–12 repetitions to fatigue	6wks	Multi-joint exercises (heel raises, half squats and step-ups)
Liao et al.[45]	*n*=20 Age 5–12y GMFCS level I/II	Three times a week	One set of 10 repetitions at 20% 1RM One set of repetitions until fatigue at 50% 1RM One set of 10 repetitions at 20% 1RM	6wks	Multi-joint exercises (sit-to-stand) loaded (using weight vest)
Lee et al.[46]	*n*=18 Age 4–12y GMFCS level II/III	Three times a week	Two sets of 10 repetitions	5wks	Multi-joint exercises (squat to stand, lateral step up, stair up and down) loaded (using weight cuffs), single joint exercises
Scholtes et al.[38]	*n*=51 Age 6–13y GMFCS level I/II/III	Three times a week	Three sets of eight RM	12wks (6wks of PRE)	Multi-joint exercises (leg press) and loaded (using a weight vest)
Taylor et al.[48]	*n*=48 Age 14–22 GMFCS level II/III	Two times a week	Three sets of 10–12 repetitions	12wks	Weight machines
Maeland et al.[47]	*n*=12 Age 27–69 GMFCS level II/III	Three times a week	Four sets of 12–15 repetitions (week 1–2) Four sets of 4–6 repetitions (week 3–8)	8wks	Seated leg press (single joint)
Garber et al.[29] & Faigenbaum et al.[43]		Two to three times a week	One to three sets of 6–15 repetitions of 50%–85% RM	8–20wks	Single and multi-joint exercises

GMFCS, gross motor function classification system; RM, repetition maximum; PRE, progressive resistance exercise.

the latter repetition maximum method to assign intensity is the most feasible, safe, and effective strategy. In a recent position stand by the ACSM,[29] progression in training volume and intensity was deemed necessary for strength improvement, even among elderly populations – a recommendation that has since been supported by two large meta-analyses.[50,51]

Volume of training refers to the total number of work sets performed per session (i.e. not including warm-up sets). There has been substantial debate concerning the appropriate operational definition of training volume within the resistance exercise literature, making this a difficult parameter to replicate in research. A widely accepted definition is volume load, which takes into account the total number of performed sets, repetitions, and weight (kg) lifted (i.e. total repetitions [no.] × external load [kg]). Although this is a readily used classification, it is a challenging parameter to prescribe and monitor. Therefore, total number of sets performed per muscle group is a much easier way to track total work performed during training.

According to the NSCA guidelines for novice trainees, the load should be sufficient to allow no more than 6 to 15 repetitions before muscle fatigue, and performed for one to three sets.[43] Three trials specified that fatigue was reached within 8 to 12 repetitions.[38,44,48] One trial used two sets of 10 repetitions.[46] Given the low weights that were used in this study, training appeared to be of a very low intensity. Another trial used four sets of 4 to 6 repetitions for the last 6 weeks of an 8-week training programme.[47] One trial specified that the exercise was performed until fatigue, which resulted in participants completing between 20 and 100 repetitions, and obviously was not in accordance with the guidelines.[45] Although many factors need to be considered when evaluating these studies (e.g. exercise technique), it seems, based on the information provided in the six RCTs, that training intensities and volumes were aligned with the NSCA guidelines in only three studies.[38,44,48]

Time/duration

The NSCA guidelines state that a short-term resistance programme for young people should last 8 to 20 weeks.[43] The duration of resistance training programmes included in this overview were between 5 weeks and 8 weeks in four studies.[44–47] In two studies the duration was 12 weeks.[38,48] The programme by Scholtes et al.[38] also lasted for 12 weeks, and yet the first 6 weeks were used for build-up and practice,[52] leaving 6 weeks of intervention according to the guidelines for intensity and volume.

Most people with CP are not used to strenuous exercise and they may need time to adapt to this level of activity. Therefore, we recommend a few weeks of strength training familiarization simply to reach the recommended training volumes and intensities. Longer interventions with progressive intensities (e.g. 12–16wks) may be needed to experience significant or meaningful improvements in strength. Importantly, and as with cardiorespiratory endurance, greater doses of resistance exercise are required to improve muscle strength than is needed to maintain these improvements.[53]

Type of exercises

All four RCTs in children with CP[38,44–46] used multi-joint exercises (e.g. lateral step-ups, squatting) rather than single joint exercises (e.g. knee extension). The two RCTs that included adults[47,48] incorporated selectorized weight machines or the seated leg press, and consisted mainly of single joint exercises. Single-joint resistance training may be more effective for very weak individuals or for children, adolescents, and adults, particularly at the beginning phases of training, as well as for adults who tend to compensate when performing bilateral, multi-joint exercises. Children, adolescents, or adults with CP who are not able to walk independently might also benefit from strength training, but they may lack the selective motor control needed to perform single-joint exercises.

Summary of training parameters

Most of the training parameters in the resistance training RCTs targeted the lower limbs, and were performed according to the NSCA or ACSM guidelines.[43] However, three important parameters that were used in the training programmes that were evaluated in the RCTs were not consistent with the NSCA or ACSM guidelines: (1) the mode of exercise, (2) the intensity, and (3) the duration of the training programme.

As is generally accepted for any novice trainee, prescription of resistance exercise for persons with CP should include a 'familiarization' period, in which very low dosage training (i.e. minimal volume and intensity) occurs twice a week for at least 2 to 4 weeks. We would suggest that simple, single-joint activities be used during this period. However, in children with CP, this is complicated by the varying ability to isolate joint motion, especially at the ankle. After the familiarization phase of training, it may be expected that individuals with CP could safely benefit from gradual increases in dosage to accommodate improvements in strength, endurance, and function. Complex, multi-joint activities (like step-ups and sit-to-stand exercises) could also be added at this time. We recommend performing one to four sets of 6 to 15 repetitions, and gradually progressing to meet the demands of improved muscular fitness. It is also important that the programmes last sufficiently long to incorporate these two phases of training. Assuming a minimum of 8 weeks to experience changes in strength with simple activities, we would suggest a programme of at least 12 to 16 weeks to maximise the likelihood of a training effect in people with CP (Table III). Because it might be very difficult to adhere to these exercise regimens, it is important to know what is needed to maintain the achieved adaptations. Resistance training-induced improvements in muscle strength reverse quickly with complete cessation of exercise.[29] Intensity appears to be an important component of maintaining the effects of resistance training on muscle strength;[54] however, the extent to which different combinations of frequencies, volumes, and intensities can lead to maintenance of adaptation remains unknown.

Table III: Recommendations for exercise and physical activity prescription among people with cerebral palsy

	Recommendation
Exercise	
Cardiorespiratory (aerobic) exercise	
Frequency	Start with 1–2 sessions a week and gradually progress to three sessions a week
Intensity	>60% of peak heart rate, or >40% of the heart rate reserve, or between 46% and 90% VO_{2peak}
Time	A minimum time of 20min per session, and for at least 8 or 16 consecutive weeks, depending on frequency (2 or 3 times a week).
Type	Regular, purposeful exercise that involves major muscle groups and is continuous and rhythmic in nature
Resistance exercise	
Frequency	2–4 times a week on non-consecutive days
Intensity	1–3 sets of 6–15 repetitions of 50%–85% repetition maximum
Time	No specific duration of training has been identified for effectiveness. Training period should last at least 12–16 consecutive weeks
Type	Progression in mode from primarily single-joint, machine-based resistance exercises to machine plus free-weight, multi-joint (and closed-kinetic chain) resistance exercises. Single-joint resistance training may be more effective for very weak muscles or for children, adolescents or adults who tend to compensate when performing multi-joint exercises, or at the beginning of the training
Daily physical activity	
Physical activity (moderate to vigorous)	
Frequency	≥5d/wk
Intensity	Moderate-to-vigorous physical activity
Time	60min
Type	A variety of activities
Physical activity (sedentary)	
Frequency	7d/wk
Intensity	Sedentary (<1.5 METs)
Time	<2h/d or break up sitting for 2min every 30–60min
Type	Non-occupational, leisure-time sedentary activities such as watching television, using a computer, and/or playing video games

METs, metabolic equivalent of tasks.

PHYSICAL ACTIVITY ACROSS THE ACTIVITY CONTINUUM

Although it is well established that physical activity (defined as any bodily movement that results in energy expenditure[55]), cardiorespiratory endurance, and muscle strength are all important for health, evidence also suggests that these are not the only activity-related lifestyles that contribute to health or disease risk. Recent studies have consistently shown that a large amount of sedentary behaviour, as distinct from a lack of moderate to vigorous physical activity, is also associated with an increased risk of coronary heart disease, hypertension, diabetes, obesity, mortality, and some cancers in the people with typical development.[56,57] Sedentary behaviour (defined as any waking behaviour characterized by an energy expenditure of 1.5 metabolic equivalents of task [METs] or less while in a sitting or reclining posture[58]) and physical inactivity had previously been seen as two sides of the same coin. They are, however, different constructs on the activity continuum, and have separate contributions to chronic health outcomes.

The physical activity pattern across the continuum for children, adolescents, and adults with CP is therefore important. The increasing number of published studies using objective measurement methods for assessing physical activity in people with CP makes it timely to scrutinise the results from these studies. When combining the findings from recent studies that have looked objectively at the physical activity levels of children, adolescents, and adults with CP,[59–63] we found that children and adults with CP spend 76% to 99% of their waking hours being sedentary, fewer than 18% engaged in light physical activities, and 2% to 7% in moderate to vigorous activities (only present in GMFCS Levels I-III) (see Fig. 1).

Of course, the greatest health risks manifest among persons not meeting physical activity guidelines *and* participating in large volumes of sedentary time. The emphasis over the last two decades has been on encouraging moderate to vigorous exercise for children and adolescents with CP. The notion of emphasizing increases in moderate to vigorous physical activity *and* replacing sedentary behaviour with light physical activity may be beneficial for health in children and adolescents with CP.

Focusing on the non-exercise segment of the activity continuum involves interventions to promote breaks in sedentary time, and replacement with light-intensity activities. With respect to regular fragmentation of sitting or other sedentary behaviours in a free-living context, this requires an approach that encompasses participation throughout the entire day. Thus, fragmentation of sedentary behaviour is very different from encouraging physical activity or exercise participation. A recent study[64] showed that transitioning from a seated to a standing position may contribute to the accumulation of light activity and reduce sedentary behaviour among children with CP. Most clinicians do not consider this type of counselling for patients who need to increase physical activity, as the idea of breaking up sedentary behaviour is not generally thought of as an 'intervention', and yet it merits evaluation because of the viability across the entire CP population.

BASELINE PHYSICAL ACTIVITY

Physical activity guidelines recommend that moderate to vigorous activity be added to baseline levels of activity.[20] Baseline activity includes all light activities (1.5–3 METs). However, the concept of baseline physical activity has been insufficiently defined. We therefore suggest zero activity as a place to begin discussion for people with CP. As the operational definition of 'baseline activity' is at present equivocal, and moreover as evidence supports that light-intensity physical activities are healthier than sedentary activities, there is an obvious need to rethink the true starting point for studying physical activity behaviours among people with CP.

Too much time spent in sedentary behaviour, especially when accrued in long, continuous bouts, is detrimental to cardiometabolic health.[57,65,66] Thus, specific interventions aimed at reducing sedentary behaviour in people with CP should be considered as a viable, initial target to prevent further cardiovascular complications. Indeed, evidence suggests that frequently interrupting sedentary time may have beneficial effects on metabolic health and haemostasis,[66,67]

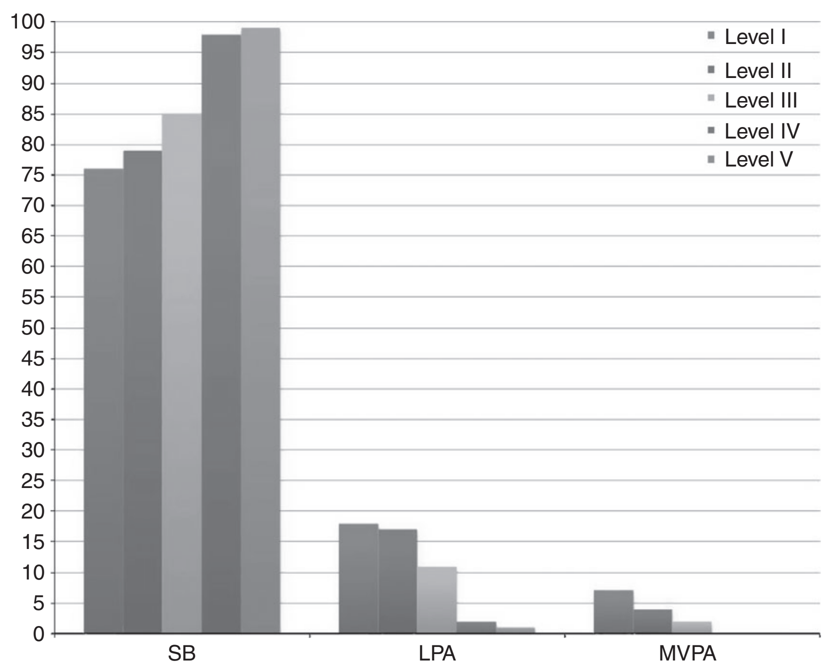

Figure 1: Percentage of time spent in sedentary, light, and moderate to vigorous physical activities across all Gross Motor Function Classification System levels. SB, sedentary behaviour; LPA, light physical activity; MVPA, moderate to vigorous physical activity.

suggesting that both the amount and patterns of sedentary behaviour contribute to changes in health.

For individuals that participate in high volumes of sedentary behaviour and also engage in little or no physical activity, the initial dose of activity should include relatively low intensities and of limited duration, with sessions (also called bouts) spread throughout the day and week. Particularly important for individuals who are severely deconditioned, an effective training prescription balances appropriate training stress (at the right training intensity) with adequate recovery. Although exercise intensity must be prescribed above a minimum threshold to sufficiently challenge the body to adapt greater cardiorespiratory endurance,[29] it is equally important to provide adequate recovery to ensure optimal adaptations. When this strategy is not adopted, an abnormal training response may occur and a state of overtraining may lead to a diminished return of effectiveness, excessive soreness, fatigue, and/or even injury. Health professionals should be aware of these early warning signs of overtraining and modify the physical activities accordingly, as proper conditioning requires a balance between stress/stimulus and recovery. Therefore, successful training programming should incorporate overload, and yet must avoid the combination of excessive overload plus inadequate recovery. The earlier that overtraining can be detected, the sooner the person with CP will be able to recover. Therefore, frequent evaluations are recommended.

Efforts to promote baseline activities are justifiable and a small but growing body of evidence demonstrates that physical activity provides health benefits for people with CP. Prior research on the relationship between activity and health has focused on the value of moderate to vigorous activity. Given the emerging benefits of light intensity activities, and the existing confusion of what constitutes baseline activities, it is time to start developing alternative operational definitions and descriptions of physical activity that are specific to this population. There is insufficient evidence about whether doing more baseline activity results in health benefits, and yet this may well be the best way to initially fragment sedentary behaviour and lead to sustainable behaviour changes in the most sedentary individuals with CP. Although this is likely applicable for all children with CP, it is especially relevant for children classified in GMFCS levels IV and V, as reducing sedentary behaviour might be the only viable intervention. Encouraging people with CP to replace sedentary time with baseline activities is sensible for several reasons:

- Increasing baseline activity leads to increased energy expenditure, which, over time, can help with maintaining a healthy body weight.
- Some baseline activities are weight-bearing and may improve muscle and bone health.
- Encouraging baseline activities helps build a lifestyle in which physical activity is the social norm, and where excessive sedentary lifestyles are discouraged.
- Short episodes of activity are appropriate for people who are previously inactive and have started to gradually increase their level of activity.
- It interrupts prolonged periods of sedentary time which are harmful for health.

Describing the amount of activities needed to maintain and foster health is complicated. The dose–response relationship between volume of moderate and vigorous aerobic activities and all-cause mortality is non-linear, with the most rapid reduction in risk occurring at the smallest increased increment of activity volume, among the most sedentary individuals. Thus, for people who participate in extremely high volumes of sedentary behaviour and are also completely inactive (e.g. most people with CP), even small increases in the volume of activity may lead to profound health gains.

Recent evidence has demonstrated that replacing sedentary behaviour with some light-intensity activity may confer profound health benefits.[68] From a public health perspective, it is more important to understand the dose-response relationships between sedentary, light-intensity, and moderate-intensity activities, and respective health outcomes, than for outcomes associated with vigorous activities. It is quite plausible that light- and moderate-intensity activities are important at the lower end of the dose-response curve, in which benefits are gained or lost more quickly. On the other hand, vigorous activities may be more important at the high end of the curve, where changes in relative risk are slower.

In general, people with CP should strive to meet the public health recommendations for daily participation in moderate-to-vigorous physical activity, and it should be developmentally appropriate, enjoyable, and involve a variety of activities. Moreover, they should participate in less than 2 hours/day of non-occupational, leisure-time sedentary activities such as watching television, using a computer, and/or playing video games. However, for a subset of the population with CP with excessive frailty, deconditioning, and/or mobility restriction, it is virtually impossible to meet the optimal recommendations of 60 minutes of moderate to vigorous physical activity. It may also be very challenging for some individuals with CP to engage in less than 2 hours of non-occupational sedentary time. Future research is needed to explore how these guidelines can be applied to individuals with CP, in particular individuals classified in GMFCS levels IV and V.

DISCUSSION AND CONCLUSION

Risk for future cardiovascular disease in children and young adults is difficult to define, given that no hard endpoints, such as disease, cardiac events, or death, have yet occurred. Tracking is a method that offers the opportunity to describe the development of a characteristic over time, and involves both the longitudinal stability of the variable and the ability of one measurement to predict the value of a subsequent measurement.[69] The findings from recent tracking studies in the general population provide enough evidence to suggest that the risk factors present early in life are stable over time.[70–73] This has important clinical implications, especially the work showing that a physically active lifestyle starts to develop very early in childhood and the stability of physical activity is moderate or high along the life course from adolescence to adulthood.[70]

Whether the level of physical fitness and muscle strength in children with CP during childhood tracks into, and is predictive of, mortality in adulthood remains to be determined. This would be possible only by performing longitudinal studies, and to date these studies have not been performed among persons in this population. Including health-related outcomes in future registries for people with CP will be vital to provide healthcare professionals and researchers the first-hand information about certain conditions, both individually and as a group, and over time will increase our understanding of these conditions.

It is imperative that we keep in mind that the sustainability of physical activity depends on lifestyle behavioural change. For people with CP it might be extremely difficult to achieve the exercise recommendations and physical activity guidelines. Personal and environmental barriers to exercise and physical activity have been identified previously by children and their parents.[74] Not only does the physical disability impose restrictions, but parents or partners may experience time constraints, stress, and financial and psychological burdens that may hinder their ability to commit to such intense recommendations.[75]

Identifying individuals who could benefit from an exercise intervention is important to prevent long-term health risks. Cardiopulmonary exercise testing is considered to be the criterion standard for the assessment of exercise tolerance and cardiorespiratory endurance in people with various medical conditions, as well as in healthy individuals.[76] Exercise testing results can be used to assist clinicians in identifying which patients might be at risk for poor health outcomes, and those who could benefit from an exercise intervention. However, despite the obvious relevance, clinical exercise testing is dramatically underused because of a lack of understanding and training on test administration and interpretation. Clinicians and their staff should encourage patients with CP to be physically active and recommend exercise testing to patients when the child, adolescent, or adult experiences limitations in activities because of physical exhaustion. Clinicians must become aware of the importance of exercise among higher-risk populations such as those with CP, but also regarding the guidelines for how to design patient-tailored exercise programming. The first step in the process is to determine the extent to which patients are physically fit or deconditioned. When fitness is objectively determined through exercise testing, the next step (and possibly the most important one) is to determine whether any deconditioning is a result of inactivity, nutritional status, disease-specific pathophysiology, or a combination of these factors.[77] For children and adults with CP there is a core-set of established, clinically feasible exercise tests, with an established level of evidence of the clinimetric properties for each outcome measure.[78–80]

Most current evidence concerning the benefits of physical activity and exercise comes from trials that recruited ambulatory children and adolescents with CP. Implementation of programmes based on this evidence is not straightforward, as practical applications of the findings typically are not included. By understanding the barriers and motivators to physical activity, we may be better able to advise patients to participate. Two recent studies were performed that combined counselling through motivational interviewing and fitness training in children[81] and adolescents[28] with CP. Both studies included children and adolescents that were classified in GMFCS levels I-III (except for one participant who was classified in level IV). Unfortunately, both studies were ineffective in stimulating more favourable physical behaviour. The promotion of physical activity in more children with disabilities or adults with CP will certainly represent an even greater challenge.

Children with CP are raised in an environment where physical activity primarily occurs through formal physical therapy sessions and organized sports events for children with disabilities. Their interactions with health professionals are generally related to symptom management, daily function, increased tone, and decreased range of motion. These are important concerns, especially during the developmental years, but there is often little discussion of healthy lifestyles that involve physical activity and sedentary behaviour reduction. There has been greater awareness of these issues over the past several years, hopefully leading to greater discussion at the patient/healthcare provider level. Yet there is much work to be done to promote the encouragement of physical activity as a part of basic clinic and therapy centre protocols for individuals with CP. Guidelines such as these will greatly contribute to improving knowledge about and comfort with this discussion, and should be used to inform future intervention studies.

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