



Physical Activity Among Adolescents with Cerebral Palsy: An Integrative Review

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Problem Physical activity is necessary for optimum physical and psychosocial health in the general population. It is even more important for adolescents who struggle with impairments that limit motor function. Recommendations for best practice are needed as adolescents transition into adulthood.

Purpose: An integrative review was performed to determine the state of the science regarding 1) what factors impact physical activity in adolescents with cerebral palsy, and 2) how the needs of this population have been addressed regarding physical activity.

Search Strategy: A literature search of MEDLINE, CINAHL, and PubMed was conducted using the terms cerebral palsy, mobility or activity, and adolescents. Exclusion criteria were surgical or pharmacological interventions.

Results of the Literature Search: Descriptive and intervention studies were included and evaluated for purpose, design, and key findings.

Synthesis of Evidence: Correcting the decline of physical activity in adolescents with CP may carry benefits over into adulthood. There are few studies that adapt physical activity to age and level of impairment. Several studies support approaching physical activity from a social model, focusing on participation of the person in the context of environment. There is a lack of research incorporating family-centered care. Many study designs are shallow and lack the proper instruments for assessing outcomes.

Implications for Practice: Home and community based interventions need to be developed that are individualized. More studies are needed with stronger research designs and better instruments in order to generalize results for practice.

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PHYSICAL ACTIVITY IN adolescence is believed to contribute to the development of healthy adult lifestyles (Hallal, Victora, Azevedo, & Wells, 2006). However, physical activity is often a challenge for youth with cerebral palsy with mobility impairments that limit daily living activities as well as athletic endeavors (Fowler et al., 2007). Beneficial effects of physical activity in non-disabled youth are improved cardiorespiratory fitness, muscular strength and endurance, and reduced body fat. Psychosocial effects include lower anxiety and depression and improved quality of life through better self-management and social

competence (Conchar, Bantjes, Swarts, & Derman, 2014; Maher, Williams, Olds, & Lane, 2007; WHO, 2010). While these attributes may be supportive in helping adolescents in the general population transition to adulthood, little research evidence exists to document the needs or benefits of physical activity in adolescents with cerebral palsy. Likewise, little is known about the effects of physical activity practices on self-management strategies of adolescents with cerebral palsy as they mature.

The following review of the literature was led by the desire to discover research findings to inform best practices that support maturing adolescents transitioning from child-centered to adult-centered health care. Following the guidelines of Whittemore and Knafl (2005), an integrative

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review was the method selected. The exploratory nature of this quest made this type of review more appropriate than a systematic review or meta-analysis. The integrative review can serve a wider range of purposes and can combine data from empirical and theoretical sources. At the same time it must clearly identify the problem and purpose which, for this phenomenon, was exploratory. Supporting the choice for the integrative review are its attributes cited by Whittemore and Knafl (2005), to allow “simultaneous inclusion of experimental and non-experimental research in order to more fully understand a phenomenon of concern.”

Problem and Purpose of the Review

This integrative review of the literature was designed to determine what is known about physical activity in adolescents with cerebral palsy and how the needs of this population have been addressed. Clinical trials were included in order to assess approaches and interventions. Findings and gaps in the knowledge base are discussed with implications for research and practice.

Objectives of the Review

The quest for answers to four questions drove the search for literature: 1) What studies are related to physical activity in adolescents with cerebral palsy? 2) What methods are being studied to engage adolescents with cerebral palsy in physical activity? 3) How are parents involved in the adolescent with cerebral palsy's engagement in physical activity? 4) How can healthcare providers advance the promotion of appropriate and improved physical activity for this population?

Background of the Underlying Problem

Cerebral palsy is the most common physically-limiting condition seen in children (Donkervoort, Roebroek, Wiegerink, van der Heijden-Maessen, & Stam, 2006). The condition includes a group of non-progressive disorders that affect motor function and posture resulting from injury to the fetal or infant brain. Even though cerebral palsy is not considered a progressive disorder, adolescents may show a progressive decrease in walking activity and lower levels on the Gross Motor Function Classification as they age (Bottos, Feliciangeli, Sciuto, Gericke, & Vianello, 2001; Maggs et al., 2011; Palisano, Copeland, & Galuppi, 2007). It has also been observed that teens with cerebral palsy are less physically active than their peers without the disorder (Brien & Sveistrup, 2011; Nooijen et al., 2014).

The probability of survival into later adulthood has increased for people even with severe levels of cerebral palsy. Barring major comorbidities, actual survival rates are moving toward that of the general population (Koman, Smith, & Shilt, 2004). Rising odds of survival emphasize the need to address ways to reduce consequences of sedentary life through physical activity. Significant changes in physical function over a lifetime for persons with cerebral palsy

lifetime should not be accepted as a natural part of aging (Turk, 2009). Effective programs that keep youth physically active as they transition to adult-centered health care may therefore decrease secondary conditions as these individuals age (Viner, 2008).

Adolescence brings developmental challenges for those with and without disabilities. Beyond the transition from pediatric health care to adult health care, youth typically change from a structured high school environment to more complex college or work environments, and work toward establishing independence from parents. Because the adolescent developmental stage strongly impacts adult lifestyle, it is a critical ideal time to reinforce physical activity interventions (Nooijen et al., 2014). If adolescents with cerebral palsy are involved in selecting and improving their physical activity, this provides useful skills that may help them as they transition into adulthood. The empowerment that self-management often reinforces can assist them in being an effective partner in the process (Viner, 2008).

The International Classification of Functioning, Disability, and Health, known as ICF, has refocused the perspective of disability away from “consequence of disease” to a perspective of “components of health” (Rosenbaum & Stewart, 2004). This view changes the use of negative terminology such as “handicap” to neutral terms like “alteration in physical function.” Following the same line of thinking, the purpose of physical activity can range in meaning from a method to “prevent deterioration in body composition” (Van den Berg-Emons, Van Baak, Speth, & Saris, 1998) to “engaging children in physical activity to improve a sense of well-being” (Sakzewski et al., 2012). The ICF also endorses environment and personal participation as important components of health (Rosenbaum & Stewart, 2004). Because studies with physical activity address the psychosocial domain as well as the physical (Livingston, Rosenbaum, Russell, & Palisano, 2007) they lend themselves well to interdisciplinary and community-based research that includes personal and environmental aspects of a population to design an intervention. These approaches would work with the adolescents, their families, and communities to identify and meet their health promotion and health care needs (Binks, Barden, Burke, & Young, 2007).

The Search Strategy

A computerized search of the literature was conducted using Medline, Cinahl and PubMed databases (Figure 1). The search was limited to articles in English language with no limitations placed on publication years. Key search terms were cerebral palsy, mobility or activity, and adolescents. Additional searching was done within the references of retrieved articles to add to the findings and to specifically locate randomized clinical trials. Articles related to surgical or pharmacological treatment to improve mobility or physical activity were excluded. After the final screening, thirty-two articles met inclusion criteria and were identified for review.

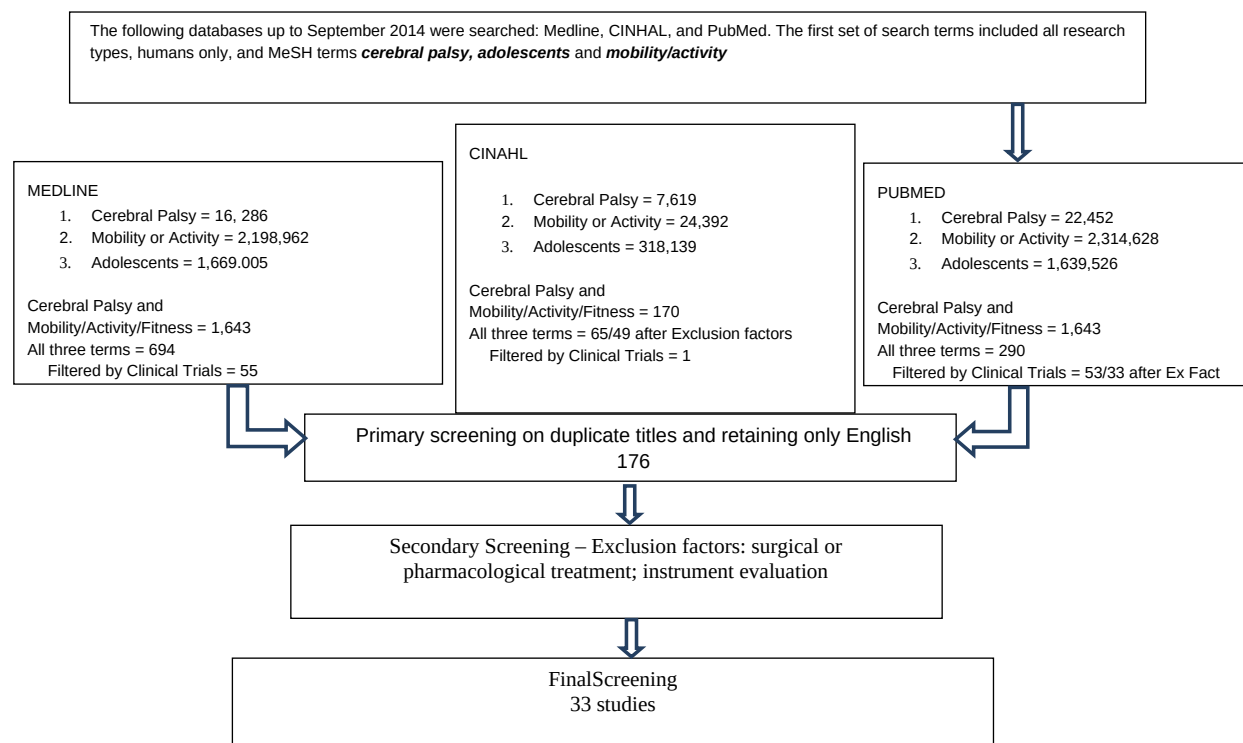


Figure 1 Search strategy for physical activity and adolescents with cerebral palsy.

Both descriptive and intervention studies were included and twelve of these were randomized controlled trials.

Studies that met the inclusion criteria were reviewed by the authors and results were compiled in a table describing the purpose or hypothesis, research design, sample and setting, instrument or tool, findings and level/strength of the evidence. These elements were suggested by common attributes found in the reviewed articles. Tables were classified according to type of study with one displaying descriptive studies (Table 1) and another showing intervention studies (Table 2).

Assessment of rigor or quality of the studies was done through the levels of evidence established by the American Association of Critical Care Nurses (AACN) a pioneer in the field of evidence-based practice and their criteria are used by authors in other areas of practice. Like several assessment tools for integrative reviews, the strength of the quality of an article is evaluated on a numerical or alphabetical scale ranging from clinical trials or experimental interventions to opinions of experts. The level, or strength of the evidence for this article, is included in Tables 1 and 2, showing attributes of reviewed articles. AACN has recently changed their original numerical rating scale (Roman numerals I to VI) to an alphabetical scale A to D (Armola et al., 2009) The new scale's Level A is the strongest evidence, coming from a meta-analysis of randomized controlled trials or a rigorous meta-synthesis of qualitative work supportive of an outcome. Level B includes controlled trials, (randomized and non-randomized), giving evidence for a specific action, intervention, or treatment. Level C is rated for qualitative,

descriptive, or correlational studies. It also is assigned to systematic or integrative reviews. Peer-reviewed standards published by professional organizations or expert consensus standards are rated as level D. Manufacturer's recommendations are rated as M, the lowest level, because of the possible bias related to self-appraisal (Armola et al., 2009).

While level A publications were desired to assess the state of intervention science, the value of research that utilizes a single subject, or a simple repeated measures experimental design was recognized in this exploratory search. The changes seen when even a single participant acts as his or her own control can often show the effects of repetition of an independent variable across time, suggesting causal links and informing issues of measurement, feasibility and adherence for a future randomized control study (Horner et al., 2005).

Synthesis of Major Findings

Synthesis of the collected literature was aimed at assessing the state of the science and meets objectives of the review regarding 1) Numbers and types of studies related to physical activity in adolescents with cerebral palsy; 2) Methods studied to engage adolescents with cerebral palsy in physical activity; 3) Involvement of parents in engaging the adolescent cerebral palsy in physical activity; and 4) Strategies to promote appropriate and improved physical activity for this population.

Numbers and Types of Studies

The overall number of physical activity studies involving adolescents with cerebral palsy was relatively low and the

Table 1 Descriptive studies.

Author, Year	Purpose/Hypothesis	Research Design/ Level of Evidence	Sample	Instrument or Tool	Findings
Beckung and Hagberg (2002)	To analyze associations between neuro-impairments and participation restrictions	Longitudinal chart review in children born from 1991 to 1994; Level C	176 Children with CP	• Bimanual grading system for fine motor function (BFMF) • GMFCS	• Strong correlation between Bimanual fine motor function (BFMF) and GMFCS level • Restriction in mobility was best predicted by the GMFCS, learning disability and the BFMF
Bryanton et al. (2006)	To test the impact of a Virtual Reality (VR) program vs. Conventional exercises	Observational Study; Level C	Ten children with CP and 6 children without	• Visual Analog Scale completed by child and parent • Electro-goniometer data	• Children reported more interest and greater ROM with the VR system • Significantly more repetitions with conventional than VR • All participants took significantly longer to complete VR exercise than conventional, ankle dorsiflexion held longer
Colver et al. (2012)	To evaluate how participation of children with CP varied with environment	Descriptive Study; Level C	1174 children with CP aged 8–12	• Questionnaire	• Higher participation is associated with better environment • Environment should be a target for change (social model of disability) instead of the impairment (medical model)
Donkevoort et al. (2006)	To describe the level of functioning and study determinants of functioning	Descriptive Study; Level C	103 adolescents with CP ages 16–20	• Physical Exam • Gross Motor Function (GMF) • Questionnaires • Interviews	• Interrelationships were found between GMF, CP limb distribution, and level of education • Level of gross motor functioning and level of education are important determinants of function
Maltais, Peirrynowski, Galea, and Bar-Or (2005)	To determine relationship between PA and oxygen cost of walking	Descriptive Study; Level C	11 children with CP age 10 to 16	• Questionnaires • Fastest Walking Speed • Physical activity level(PAL) • Oxygen Uptake/Heart Rate	• Significant, negative linear relationship between PAL and net VO_2 at 60 and 75% FWS • No relationship between PAL and net VO_2 at 90% FWS • Those with low PA may have high oxygen cost of walking

Maher et al. (2007)	Comparing PA in adolescents within the levels of CP and between CP and their non-disabled peers using normative data sets	Longitudinal descriptive comparative study; Level C	Convenience sample of 118 of 11–17 yo with CP	• Physical Activity Questionnaire for Adolescents (PAQ-A)	• PA participation was related to level of gross motor function • PA decreased with increasing age • Lower average levels of PA were reported by those with CP compared with those of the same age without CP
Palisano et al. (2007)	To self-characterize performance of physical activities by adolescents with cerebral palsy	Longitudinal repeated measures descriptive study; Level C	156 adolescents with CP, M = 14.8 years; GMFCS levels 1 through 5	• Gross Motor Function Classification System (GMFCS) • Activities Scale for Kids (ASKp) • mobility questionnaire	• Changes in GMFCS over time were not significant • Physical abilities varied by classification level • Played on team sports with class none of the time: 7% of level 1, 38% of level 2/3, 53% of level 4/5
Palisano et al. (2009)	To describe how youth with CP experience mobility in their daily lives	Phenomeno-logical Study; Level C	10 youth 17 to 20 years of age	• In-depth interviews	• Mobility becomes more important as teens transition to adulthood • Improved mobility helps foster self-sufficiency, making choices, safety, efficiency • Complaints include constant need to plan ahead and dissatisfaction with public transportation • Social self-efficacy is linked with independence
Rosenbaum et al. (2007)	Assessed QOL and HRQOL	Descriptive Study; Level C	203 adolescents with CP	• HUI3 • QOL questionnaires	• Negative relationship between health status & motor function • HUI3 scores explain only a small proportion of the variance in QOL scores • QOL and HRQOL are separate constructs and should be considered as separate dimensions
Tieman et al. (2004)	Examine changes in mobility over time	Longitudinal Study; Level C	62 children with CP	• GMFCS • Questionnaire	• Impairments continue to change over a lifetime • Mobility changes over time in a non-linear pattern affected

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Table 1 (continued)

Author, Year	Purpose/Hypothesis	Research Design/ Level of Evidence	Sample	Instrument or Tool	Findings
van Wely et al. (2012)	To assess ambulatory activity of children with CP and identify important characteristics	Cross-sectional study; Level C	62 children with CP; aged 7 to 13	● Activity Diary ● StepWatch Activity Monitor	by developmental stage and environment ● Disability, age, and sport club participation were associated with ambulatory activity ● Children were less active on weekend days than school days ● All did not meet recommendations of daily steps
Verschuren et al. (2009)	To examine the relation between physical fitness and motor function	Descriptive Study, Level C	68 children with CP, mean age of 12	● Variety of motor function tests ● GMFM	● Functional muscle strength is related to gross motor activity ● Adherence to exercise depends on motivation and variation

number of articles selected appropriate to the search significantly lower ($n = 32$). The topics and research methods were diverse, including qualitative and quantitative methods. Articles were included that defined physical activity, explored participant perspective and examined a variety of interventions.

No interventions were found that compared physical activity across developmental stages. Changes in mobility can be seen over time and may be due to the child's growth and changes in environment as they move from home to school to work (Tiemann et al., 2004). There is a lack of knowledge of how interventions affect PA across the lifespan (Turk, 2009) and longitudinal research is needed to track progress into adulthood (Palisano et al., 2009).

In five studies, physical activity was found to be associated with Gross Motor Function Classification (GMFC) levels. These investigators suggest that level of function may influence physical activity and GMFC levels should be taken into account when planning interventions. One author suggests that GMFC levels be used when adapting or modifying treatments or interventions (Donkervoort et al., 2006). By contrast, one research report showed no differences in physical activity level between teens who used devices to aid walking or wheelchairs and those who did not (van Eck et al., 2008). This lack of consistency in findings with other studies may be explained by the investigators' acknowledgement of an overrepresentation of high-functioning teens (70% were Gross Motor Function Classification System level I).

As opposed to older conventions in therapy that one should "never strengthen spasticity" (Damiano, 2006), strength training was supported in adolescents with spastic cerebral palsy (Dodd, Taylor, & Graham, 2003; Williams & Pountney, 2007). A home-based strength-training program used inexpensive equipment and resulted in positive effects on walking, running, and jumping (Dodd et al., 2003). In contrast, an outcome of two studies showed muscle strengthening is not an effective intervention for improving mobility (McNee, Gough, Morrissey, & Shortland, 2009; Scholtes et al., 2010). Although current thought does not consider spasticity to be a contraindication for strength training, one study urged further research to determine negative effects on muscle length (Scholtes et al., 2011).

Three studies investigated effects of physical activity on quality of life (Demuth, Knutson, & Fowler, 2012; Rosenbaum, Livingston, Palisano, Galuppi, & Russell, 2007; Sakzewski et al., 2012). Across studies, different instruments were used to measure quality of life but evidence supported a positive influence of physical activity on quality of life.

Ideally, these studies would include rigorous multi-centered clinical trials with large sample sizes and sensitive instruments designed to measure properly defined outcomes. However, this line of inquiry is in its early stages without refined measurement tools, geared toward children with severe motor impairment (Bryant, Pountney, Williams, &

Edelman, 2012). At this time, instruments are not geared to the age and level of impairment (Rimmer, Chen, McCubbin, Drum, & Peterson, 2010).

Methods to Engage Adolescents with Cerebral Palsy in Physical Activity

The descriptive literature supports a social model, studying the person in the context of environment, versus a medical model, which focuses on the context of disability (Colver et al., 2012; Palisano et al., 2009; van Wely, Balemans, Becher, & Dallmeijer, 2014). Study findings reported that environmental variables (accessibility, attitude, adaptations) were found to be as effective for improving self-help skills and mobility as conventional therapeutic interventions focused on changing the child (Colver et al., 2012). This population appears to enjoy variety and new experiences as much as typically developing teens and wants experiences that differ from a therapy session. One report mentioned that everyday equipment such as bikes and treadmills might be a new experience for adolescents with cerebral palsy (Bryant et al., 2012). Virtual reality systems also hold interest and motivate longer sessions of physical activity (Bryanton et al., 2006). Barriers to physical activity include a variety of factors such as physical (inaccessibility), programmatic (lack of knowledgeable staff), attitudinal (over-emphasis on competition and winning), as well as a lack of understanding for personal and environmental factors (Colver et al., 2012; Donkervoort et al., 2006; van Wely, Becher, Balemans, & Dallmeijer, 2012). Several investigators recommend these areas as targets for change.

A gap exists in studies developing and testing creating interventions that involve family and adolescents from planning through implementation. This was unexpected since personal preference and lifestyle were recommended factors to be taken into consideration with assessing interest and barriers (Rosenbaum & Stewart, 2004). Because adherence to exercise depends on “individual motivation and variation in activities” (Verschuren, Ketelaar, Gorter, Helders, & Takken, 2009), a glaring omission in the evidence was the lack of individual participation in the planning stages. When goals include life-long fitness, the involvement of adolescents in choice of healthy and enjoyable activities improves the likelihood they will be sustained over time (Palisano, 2012).

Involvement of Parents

Despite the acknowledged importance of family involvement espoused by rehabilitation scientists and practitioners working with youth, no studies were found dedicated to this issue related to adolescents with cerebral palsy. This review and those of other reviewers find that there is very little research that is being taken from the clinical site to the community (Fowler et al., 2007; Rimmer & Rowland, 2008). For most adolescents, social participation is a key factor in their developmental stage. Physical activity should occur in

everyday settings in the home and community. For the adolescent with cerebral palsy, environmental and personal factors need to be explored (Donkervoort et al., 2006) and should be included in the social settings of community and home.

Strategies to Promote Physical Activity for this Population

The literature thus far has only cited philosophy from rehabilitation science and previous studies regarding youth in general, making it difficult to recommend strategies specific to the adolescent with cerebral palsy. While it is reasonable for many of these findings to be applicable in this special population, there are unique difficulties that make direct application less possible. In one respect, this opens wide opportunity for interdisciplinary research and development of intervention strategies. On the other hand, these complexities make it essential for approaches to take into account the challenges and barriers identified by descriptive and qualitative studies. Even more important is the necessity for consideration of the emerging adult as a product of adolescence. Considering the adolescent developmental tasks involved with the transition to adulthood, their engagement and self-determination are crucial in carrying out any intervention (Standal, 2014; World Health Organization (WHO), 2007).

Children with cerebral palsy were found to experience more activity during school days than when they are not in school (van Wely et al., 2012). However, little research was found that explored daily physical activity of teens with cerebral palsy at home, in school, or in the community (Fowler et al., 2007). No studies were found that tested interventions to maintain or improve physical activity as adolescents leave the structured school environment and enter adulthood.

This area of inquiry seems well suited to community-based participatory research involving adolescents, parents, and families because needs are defined by groups of stakeholders who have lived with the problem. These kinds of studies stand in contrast to those involving much of medical care, where professionals do not live with the day-to-day experiences of clients with problems like cerebral palsy (Standal, 2014). This approach differs markedly from situations in which health care providers plan and implement their own idea of what is best for the client. Newer community-based approaches are receiving support from federal as well as nonprofit, nongovernmental organizations, such as the Patient-Centered Outcomes Research Institute (PCORI). Family and patient centered care requires understanding the perspective and wishes of the client, empowering the individual to improve health.

Conclusions

Mobility is a complex issue with multiple factors meaning that studies of adolescents with cerebral palsy must

Table 2 Intervention studies.

Author, Year	Purpose/Hypothesis	Research Design/Level of evidence	Sample/Setting	Instrument or Tool	Findings
Brien and Sveistrup (2011)	Hypothesis: A five-day 90-min per day intervention program would result in functional improvements that would be maintained at 1 week and 1 month	Single-subject repeated measures multiple baseline design; Level B	4 male adolescents at a mean age of 16	• Community Balance and Mobility Scale (CB&M) • 6-min walk test (6MWT), Timed up and Down Stairs (TUDS) • GMFM-Dimension E	• All participants showed positive significant changes in balance from baseline through follow-up • In the 6MWT, all participants showed significant changes • TUDS had no changes in level and trend of the data • For GMFM-E no change from baseline to follow-up • Sig differences found in GMFM-88D scores between bike and control groups, and treadmill and control • Follow-up assessments showed decline • No significant difference found for GMFM-66 or -88E • Children reported they enjoyed the opportunity to use a bike or treadmill • Beneficial influence of exercise in pediatric emotional well-being and parental treatment expectations was found • Child's perception is important when examining change in emotional well-being • Difficult to recruit for after-school activities with increased burden of care • Experimental group significantly increased strength more than control • Strength training has positive effects on walking, running, stair climbing and jumping • Benefits of training continued 3 months after program finished • Cycling has potential to strengthen muscles without enhancing abnormal muscle activity • Use of cycling with electrical stim may enhance benefits
Bryant et al. (2012)	Determine the effect of a six-week exercise intervention on gross motor function	Parallel group, Randomized controlled trial ; Level B	35 children with CP; aged 8–17	• GMFM-88 D and E • GMFM-66	• Sig differences found in GMFM-88D scores between bike and control groups, and treadmill and control • Follow-up assessments showed decline • No significant difference found for GMFM-66 or -88E • Children reported they enjoyed the opportunity to use a bike or treadmill • Beneficial influence of exercise in pediatric emotional well-being and parental treatment expectations was found • Child's perception is important when examining change in emotional well-being • Difficult to recruit for after-school activities with increased burden of care • Experimental group significantly increased strength more than control • Strength training has positive effects on walking, running, stair climbing and jumping • Benefits of training continued 3 months after program finished • Cycling has potential to strengthen muscles without enhancing abnormal muscle activity • Use of cycling with electrical stim may enhance benefits
Demuth et al. (2012)	To assess the health-related QOL following cycling intervention	Multi-site, single-blinded, Randomized controlled trial ; Level B	62 children with CP; aged 7 to 18	• PedsQL • PODCI	• Sig differences found in GMFM-88D scores between bike and control groups, and treadmill and control • Follow-up assessments showed decline • No significant difference found for GMFM-66 or -88E • Children reported they enjoyed the opportunity to use a bike or treadmill • Beneficial influence of exercise in pediatric emotional well-being and parental treatment expectations was found • Child's perception is important when examining change in emotional well-being • Difficult to recruit for after-school activities with increased burden of care • Experimental group significantly increased strength more than control • Strength training has positive effects on walking, running, stair climbing and jumping • Benefits of training continued 3 months after program finished • Cycling has potential to strengthen muscles without enhancing abnormal muscle activity • Use of cycling with electrical stim may enhance benefits
Dodd et al. (2003)	Evaluated the effect of a home-based, 6-week strength-training exercise program	Repeated measures, Randomized clinical trial ; Level B	21 people with spastic diplegic CP	• GMFCS • GMFM-D • Timed Stair Test • Self-selected walking speed	• Sig differences found in GMFM-88D scores between bike and control groups, and treadmill and control • Follow-up assessments showed decline • No significant difference found for GMFM-66 or -88E • Children reported they enjoyed the opportunity to use a bike or treadmill • Beneficial influence of exercise in pediatric emotional well-being and parental treatment expectations was found • Child's perception is important when examining change in emotional well-being • Difficult to recruit for after-school activities with increased burden of care • Experimental group significantly increased strength more than control • Strength training has positive effects on walking, running, stair climbing and jumping • Benefits of training continued 3 months after program finished • Cycling has potential to strengthen muscles without enhancing abnormal muscle activity • Use of cycling with electrical stim may enhance benefits
Lauer, Johnston, Smith, and Lee (2007)	Biomechanical analysis of cycling in adolescents with and without CP	Randomized controlled trial ; Level B	10 adol with TD and 10 adol with CP	• Recumbent stationary bike • Electromyographic Activation Patterns	• Sig differences found in GMFM-88D scores between bike and control groups, and treadmill and control • Follow-up assessments showed decline • No significant difference found for GMFM-66 or -88E • Children reported they enjoyed the opportunity to use a bike or treadmill • Beneficial influence of exercise in pediatric emotional well-being and parental treatment expectations was found • Child's perception is important when examining change in emotional well-being • Difficult to recruit for after-school activities with increased burden of care • Experimental group significantly increased strength more than control • Strength training has positive effects on walking, running, stair climbing and jumping • Benefits of training continued 3 months after program finished • Cycling has potential to strengthen muscles without enhancing abnormal muscle activity • Use of cycling with electrical stim may enhance benefits

Maher, Williams, Olds, and Lane (2010)	To determine effectiveness of an 8-week internet-based, PA intervention	Repeated measures, blinded assessment, Randomized Controlled Trial ; Level B	41 adolescents with CP, M = 13 y 7 m	• Activity Monitors • Multimedia Activity Recall for Children and Adolescents (MARCA)	• Intervention group showed no greater increase in physical activity than comparison group • No significant differences for outcomes at 20 weeks • Positive short term pattern for improvement
McNee et al., 2009	Program of strengthening exercises will result in muscle hypertrophy, normalization of gait, and improvement in walking	Longitudinal Study; Level C	13 children with CP; M = 10 y 11 m	• Number of heel raises/Timed up and go Test • 3-D gait analysis • Gillette Functional Assessment Questionnaire • Functional Mobility Scale	• Muscle hypertrophy occurred demonstrating strength increases by this factor and not by motor learning alone • Strength increased but no significant change in walking function • Number of heel raises increased
Nooijen et al. (2014)	To assess activity and sedentary behavior of adoles and YAs with CP through the Learn2Move intervention that promotes daily physical activity	Longitudinal, multi-center Randomized controlled trial ; Level B	48 ambulatory persons aged 16–24 with spastic CP and 32 control	• VitaMove ambulatory monitoring system • Physical Activity Scale for Individuals with Physical Disabilities (PASIPD)	• Physical behavior did not differ between participants with GMFCS levels I and II • YAs with CP are less physically active and spend more time sedentary compared to able-bodied persons ($p < .001$)
Reid, Hamer, Alderson, and Lloyd (2009)	Determine neuromuscular outcomes of eccentric strength-training	Randomized parallel group trial; Level B	14 children with CP; M = 11 y	• Dynamometer • EMG	• Improved Eccentric torque throughout range of motion • EMG activity decreased with training similar to typically developing adolescents • Intervention had no statistically significant effect on primary mobility outcome
Scholtes et al. (2010)	Evaluate the effectiveness of functional progressive resistance exercise on muscle strength and mobility	Repeated measures, single-blind, Randomized controlled trial ; Level B	51 children with spastic CP, M = 10 y 5 m	• GMFM-66 • Sit to Stand Test • Lateral Step-Up Test • Soreness on a Likert scale	• Statistically sig effect on secondary outcomes of muscle strength, knee extensor, hip abductor, and six-repetition maximum strength • No effect on spasticity • Significant improvements in muscle strength
Scholtes et al. (2011)	Evaluate effectiveness of PRE on walking ability	Cross-sectional, Randomized Controlled Trial ; Level B	51 children with CP, M = 10 y 5 m	• 10-m walk Test • 1-min Fast Walk Test • Time Stair Test • Children's Assessment of Participation and Enjoyment (CAPE) Questionnaire	• No significant effect on the measured aspects of walking • Spasticity is not a contraindication for strength training • Need to determine if negative effects on muscle length
Sakzewski et al. (2012)	Determine if constraint-induced movement is more effective than bimanual training in improving	Randomized trial but no control; Level B	63 children with CP, M = 10 y 2 m	• KIDSCREEN-52 • CPQOL-Child	• Domain-specific changes in QOL were noted at three weeks post intervention

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Table 2 (continued)

Author, Year	Purpose/Hypothesis	Research Design/Level of evidence	Sample/Setting	Instrument or Tool	Findings
	QOL				• Either approach positively influenced children's perception of well-being in areas relating to function, participation, and physical health • Targeted muscle strength increased 27% • Strengthening exercise did not improve objective measures of mobility • Participant perception of mobility did improve
Taylor et al. (2013)	Individualized resistance training improves the physical mobility of young people with cerebral palsy	Single-blind, Randomized controlled trial ; Level B	48 adol with CP; M = 18 yo	• GMFM-66: D and E • Functional Assessment Questionnaire	• Physical fitness increased peak aerobic power • Fat mass increased in control group • PA may prevent deterioration in body composition
Van den Berg-Emons et al. (1998)	To assess whether a 9-month, aerobic program is effective in increasing the level of daily PA	Paired, Repeated measures; Randomized controlled trial ; Level B	20 children with spastic CP; 10 in experimental group; 10 in control	• Chair scale • HR • TEE:SMR or TEE:RMR	• Positive effect on social participation in domestic life (activities in and around home) at 12 months but no other areas demonstrated a significant positive effect • Expanding activities around the home more practical than expanding activities in community such as sports.
van Wely et al. (2014)	To determine effects of 6-month PA program on social participation, self-perception, and QOL	Multi-center, parallel group, repeated measures Randomized controlled trial ; Level B	49 children with spastic CP randomized to the intervention or control	• Life Habits for Children • Children's Assessment of participation and Enjoyment • Harter's Self Perception Profile for Children • CPQoL Questionnaire	• Improvements with aerobic and anaerobic capacity, agility, strength of LE • Significant increase in perceived athletic competence for training group but no change over time for appearance
Verschuren et al. (2007)	To evaluate the effect of an 8-month training program with standardized exercises	multi-centered randomized controlled trial ; Level B	86 children with CP; 7–18 yo	• 10-m Shuttle Run Test • Muscle Power Sprint Test • TNO-AZL Questionnaire for Children's Health-Related Quality of Life (TACQOL)	• Performance of ADLs was highest for GMFCS of 1 and decreased with increasing GMFCS level • Intellectual disability had a significant influence on ADLs • Mobility is determined by motor function; ADLs by intellectual function
Vos et al. (2014)	To describe trajectory of mobility performance and ADLs	Longitudinal, repeated measures Study; Level C	424 participants with CP aged 1–20	• Vineland Adaptive Behavior Scale (VABS) • IQ Scores • GMFCS	• Positive results for functional resistance exercise on ADLs and participation • GMFM scores showed significant
Wang et al. (2013)	To look at the effects of PSE music combined with exercise	Prospective, assessor-blind, stratified, Randomized controlled trial ; Level B	36 children with spastic diplegia 5–13 yo	• GMFM-D and E • Functional Skills Scale • PEDI	

Williams and Pountney (2007)	To determine whether muscle-strengthening would improve function	Non-randomized, same-subject ABA design for 18 weeks; Level B	12 children with CP at a GMFCS level of IV or V, aged 11–15	● Resistance Pedaling Test ● GMFM-66	improvement for PSE group than the no-music group ● All participants pedaled longer and harder by end ● Youth with severe CP can increase functional skills ● No correlation between improvements in cycling and function ● Passive and active ankle dorsiflexion increased significantly ● Improvements in joints, motor control, and functional capability in balance and mobility ● Computer games were engaging
Wu, Hwang, Ren, Gaebler-Spira, and Zhang (2011)	Investigate combined passive stretching and active movement training with games using a portable rehab robot	Pilot Study; 3 × a week for six weeks, Level C	12 Children with CP	● Modified Ashworth Scale (MAS)/Modified Tardieu Scale (MTS) ● Selective Control Assess-Lower Extremity (SCALE)	● Passive and active ankle dorsiflexion increased significantly ● Improvements in joints, motor control, and functional capability in balance and mobility ● Computer games were engaging

Key Terms and Acronyms: Gross Motor Function Classification System (GMFCS); Gross Motor Function Measure (GMFM); Pediatric Evaluation of Disability Inventory (PEDI); Health Utility Index Mark 3 (HUI3); Bimanual grading system for fine motor function (BFMF); Community Balance and Mobility Scale (CB&M); 6-min walk test (6MWT); Timed up and Down Stairs (TUDS); Pediatric Quality of Life (PedsQL); Pediatric Outcomes Data Collection Instrument (PODCI); Multimedia Activity Recall for Children and Adolescents (MARCA); Gillette Functional Assessment Questionnaire (GFAQ); Functional Mobility Scale (FMS); Physical Activity Scale for Individuals with Physical Disabilities (PASIPD); EMG; Children's Assessment of Participation and Enjoyment (CAPE) Questionnaire; Cerebral Palsy Quality of Life (CPQOL-Child); Total Energy Expenditure: Sleeping Metabolic Rate (TEE:SMR); Total Energy Expenditure: Resting Metabolic Rate (TEE:RMR); Questionnaire for Children's Health-Related Quality of Life (TACQOL); Vineland Adaptive Behavior Scale (VABS); Modified Ashworth Scale (MAS); Modified Tardieu Scale (MTS); Selective Control Assess-Lower Extremity (SCALE).

eventually incorporate a variety of measures to test interrelationships between physical, developmental, and psychosocial domains. Outcomes must be clearly specified and care taken to determine if intervention effects are explained in the context of numerous other variables. For example, when exploring mobility, interventions that only focus on muscle strength may not fully reveal the hidden benefits of the intervention for other domains. In studies where the interventions show no improvement in physical fitness, there still may be value for other outcomes such as improved mood and self-confidence.

From the descriptive research surveyed in this review it is clear that a sense of well-being is lower among teens with cerebral palsy and quality of life interventions may have a long-lasting impact (Livingston et al., 2007). Whether or not increasing physical activity has a significant effect on improving quality of life remains a proposition informed by related studies of other populations and supported by the few studies presented here. More research in this domain is recommended.

When examining the design of the studies, some concerns were noted. Some studies acknowledged small sample size or convenience samples, research instruments lacking specificity. The cross-sectional nature and lack of baseline data in some studies hampered ability to test improvement over time (Verschuren et al., 2011). Some articles addressed important information about physical activity but did not elaborate on how this information could be used in practice. For example, one study found that resistance training improves strength but does not explain how strength is related to gait or walking patterns. Another study measured steps walked but recommendations were limited to advising patients to increase physical activity on weekends.

A basic limitation of this review was the lack of studies that addressed the unique needs of maturing adolescents preparing for transition in their health care needs. Although the studies are helpful in determining some needs concerning physical activity in this population, the lack of studies related to health promotion practices during the adolescent's transition into adult health care made it difficult to find evidence-based specific recommendations.

Summary

This integrative review of thirty-two studies provides an overview of the current research concerning physical activity in the adolescent with cerebral palsy. Among the methods being studied to engage adolescents with cerebral palsy in this activity are the use of home-based programs, computerized games incorporating physical activity, resistance training, and walking regimens. There is a clear need for interventions that are participant-directed rather than those that are conceived in isolation by the health-provider or researcher. Parental involvement in these studies was limited to carrying out parts of the intervention or the evaluation tool but the potential benefits of greater involvement for both the youth and the parents are under-explored.

Beyond the logical benefit of improving physical activity during this developmental stage, lies the long term advantage for youth with limited mobility to carry these behaviors over into adulthood. The ultimate goal of such patient-centered research and health promotion is to prevent the present decline in health and function that is often seen as adolescents move into adulthood.

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