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Case Report Open Access

Exploring Yoga's Effects on Impairments and Functional Limitations for a Nine-Year-Old Female with Cerebral Palsy: A Case Report

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Abstract

Background and purpose: Cerebral Palsy (CP) is a non-progressive disorder of the central nervous system that results from a brain injury during the early stages of development. Common deficits related to CP include decreased balance, muscle strength, and flexibility which in turn can lead to functional impairments. The practice and art of yoga has been shown to improve flexibility and standing balance, as well as, increased body awareness and quality of movement in normally developing children and those with special needs. The purpose of this case report was to describe the effects of a yoga program in addition to a comprehensive physical therapy program for nine-year-old female with diplegic CP on the subject's strength, balance, flexibility, and functional mobility.

Case description: The patient was a nine-year-old female with diplegic CP who presented to physical therapy with deficits in balance, flexibility, and strength as well as functional limitations such as difficulty dressing herself, difficulty ascending and descending stairs, and difficulty riding a bike.

Interventions: In addition to a comprehensive physical therapy program, the patient participated in a six week children's yoga program to address these deficits.

Outcomes: The patient demonstrated improvement in balance, flexibility, strength, and functional mobility following the six week yoga program.

Discussion: A six week yoga program for children may result in improved strength, balance, flexibility, and functional mobility in children with diplegic CP.

Keywords: Cerebral palsy; Yoga; Adolescent; Child; Balance; Flexibility; Strength

Introduction

The Center for Disease Control and Prevention estimated that one in every 303 live births resulted in cerebral palsy (CP) and that CP is the most common cause of motor disability in children [1]. Cerebral palsy is a non-progressive lesion of the central nervous system that results from brain injury during the first two years of life. As a result of the brain injury, certain muscles may be receiving incorrect stimulus from the brain leading to increased tone, tightening/shortening of the muscles, decreased strength of the muscle, and lack of ability to control the muscle when moving. All of these changes could result in impairments including decreased balance, decreased muscle strength, and decreased flexibility [2]. In turn, these impairments could lead to functional limitations such as inability to dress independently, inability to negotiate stairs, and difficulty riding a bike or playing with peers. Furthermore, these functional limitations may impact the patient's role as a student or family member. Many of these impairments and functional limitations associated with CP can be addressed through physical therapy services [3].

Published literature on children with CP [4-7] consistently supports the use of resistance training and functional exercise to improve muscle strength in children seven years and older. In these studies, functional exercises include activities that mimic movements in daily life, for example moving from sit to stand and ascending/descending stairs. Lee et al. [6] described the effectiveness of strengthening exercises of the lower extremity to improve muscle strength and gait function [6]. Dodd et al. [4] conducted a randomized control trial (RCT) of a home based exercise program and found that a home based exercise program consisting of heel raises, half squats and step ups improved lower extremity strength after six weeks [4]. Scholtes et al. [7] also used progressive resistance exercises and reported their effectiveness on improving strength in children with CP. The RCT by Liao et al. [5] focused on the functional sit to stand exercises with a weighted vest to improve lower extremity strength in children with CP [5]. Similarities between four current studies [4-7] included the type of exercise; functional and multi-joint exercises to improve muscle strength for children with CP, and the time frame of the interventions; three times a week for five to 12 weeks. Even though the studies were very similar in some aspects, only two of the four case studies reported significant improvements in lower extremity strength [6,7]. Because these studies contained similar exercises that added limited support to the improvement of strength in children with CP after performing those exercises, the best types of exercise for the improvement of lower extremity strength in children with CP cannot be conclusively ascertained at this time.

Current literature on interventions to improve balance in children with CP includes different treatment methods, such as hippotherapy and task oriented exercise [8]. Hippotherapy used horse-back riding

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so the movement pattern of the horse will mimic the gait pattern of a human to improve posture, balance, and overall development in people not developing typically [8]. While the hippotherapy demonstrated efficacy in improving balance in children with CP [8,9], it is not always a viable treatment option due to funding, location, and resources. Task oriented exercises have also been shown to improve balance Katz-Leurer et al. [10] used a home based task oriented exercise program to improve balance in children with CP, while Salem and Godwin [11] used a task oriented strengthening program to improve standing and walking performance in children with CP. Both studies found their interventions beneficial in improving balance deficits in children with CP [10,11].

Stretching as an intervention to treat deficits in flexibility is a largely supported, used, and understood practice in physical therapy [13]. Wiart et al. [13] found that it was difficult to make a conclusion about the effectiveness of passive stretching, active stretching, and therapeutic positioning in children with CP because of the lack of research [13]. While there was supportive evidence for the use of individual exercises and techniques to improve strength [4-7], balance [8-11], and flexibility [13] individually, there has not yet been a study that focuses on improving all three with one type of intervention particularly on both the impairment and the functional levels.

Yoga has shown effectiveness in improving balance and flexibility, as well as, increasing body awareness and improving functional mobility in typically developing children [14]. It has been proposed that yoga can also have beneficial effects on children with special needs in improving a variety of issues from balance and flexibility to improving attention and breathing, but there is little research to support this theory [15]. Several articles in the systematic review by Galatino et al. [16] reported improvements in motor planning and performance following yoga instruction for typically developing children. The authors concluded that the results for using yoga are promising, but the evidence so far is limited. In this report, the 24 studies of yoga for children included typically developing children and children with non-motor conditions, such as blindness, asthma, or ADHD; none of the studies to date included children with cerebral palsy [16]. Therefore, the purpose of this case report was to describe the effects of a yoga program in addition to a comprehensive physical therapy program for nine-year-old female with diplegic CP on the subject's strength, balance, flexibility, and functional mobility.

Case Description

History

The patient was a nine-year-old female who was diagnosed with diplegic cerebral palsy secondary to periventricular leukomalacia. She was born prematurely at 32 weeks and five days gestation by a caesarean section, secondary to lying in a breech position. She weighed 4 lbs at birth and remained in the hospital for one month after birth. The subject began walking at three years of age and ambulated for community distances with bilateral solid ankle foot orthosis (AFO) without use of an additional assistive device. During this report, the patient was not on any medications and had never had any surgeries, but she did have Botox injections to her gastrocnemius tendons bilaterally at four years old, followed by serial casting for three months. At the time of the examination, the patient presented at the GMFCS level II. She could not ride a bike, put her shoes on independently, ascend or descend stairs independently, or go through the day without falling and was presented to physical therapy for help with these functional limitations. The patient was motivated to reach these goals so she would be able to go on bike rides with her brothers, negotiate stairs at school independently, and be independent in dressing herself. At the time of the report, the patient was not involved in any extracurricular activities outside of therapy and her activity level was limited to ambulating around the home and short community distance. She lived at home with both her very supportive parents and two brothers and attended the fourth grade at a local elementary school. Because of her diagnosis, the patient has participated in outpatient physical therapy twice a week for the past six years and was due for her six month re-evaluation at the initial onset of this case report.

Both the patient and the patient's legal guardian gave verbal and written permission to participate in this case report. This case report was approved through the Institutional Review Board (IRB) as safe and appropriate.

Systems review/clinical impression

At her annual evaluation prior to the data collection for this case report, both the musculoskeletal and neuromuscular systems were impaired and all other systems were intact. A summary of those findings included deficits in lower extremity strength bilaterally, especially in the muscles of the hip and knee, decreased balance, and bilateral decreased lower extremity range of motion.

Tests & measures

Due to the impairments identified, tests and measures selected for this re-evaluation included measurements of strength, balance, flexibility, and range of motion. During the history taking portion of the exam, the patient also described several personal goals which involved gross motor function and participation in her school and home setting. Because her goals were related to daily function, the Pediatric Balance Scale (PBS) and Pediatric Evaluation of Disability Inventory (PEDI) were chosen as outcome measures due to their ability to assess functional activities [17,18].

This study was completed at an outpatient pediatric center. Data was collected by a team comprised of a student physical therapist and the supervising clinical instructor over a six week episode of care. Inter-rater reliability was tested by comparing the measurements from the first therapist and the second therapist. All ROM measurements were within plus or minus five degrees of each other, which is considered acceptable reliability according to Naylor et al. [19].

The following is a summary of the tests and measures chosen and reasons why they were chosen for this case report. Strength was measured using a hand held dynamometer called a microFET® (2012 Hoggan Health Industries). This instrument was chosen to provide a more objective measure of strength than the conventional manual muscle testing. The microFET instrument was also chosen because it has been used in previous research to monitor the progression of strength. Furthermore, given the short time frame of six weeks and the fact that it typically takes 8-12 weeks for children to build muscular strength enough to improve by ½ a manual muscle test grade [20], the microFET dynamometer would be sensitive enough to show improvements in strength where manual muscle testing might not. Balance was tested by the Pediatric Balance Scale because of the functional components the test measures. Flexibility was measured by the passive 90/90 hamstring test because this report mainly focused on flexibility of the lower extremity and this test was a good indicator of hamstring flexibility [21]. Range of motion was measured using a standard goniometer which was considered a validated and reliable assessment tool [22]. The

PEDI outcome measure was chosen because of its focus on measuring daily function and mobility outside of the clinic.

Muscle strength: Lower extremity strength was measured using a microFET handheld dynamometer at the first therapy session during week one and the last therapy session during week seven. Hip flexion, hip abduction, and knee extension were measured in a seated position, while hip extension and knee flexion were measured in prone. The position for the strength testing was the same position used for manual muscle testing as described in Hislop and Montgomery [22] and the dynamometer was placed where the clinician would place their hand to apply force during conventional manual muscle testing. Per the microFET protocol, the position was held for five seconds and the dynamometer reported the average amount of force over those five seconds. The average measurement was reported by the dynamometer in pounds of force.

Intra-rater reliability is considered moderate to excellent for the microFET hand held dynamometer with intra-rater correlation coefficients (ICC) ranging from .93 to .99 [23,24]. Results indicated the patient exhibited decreased strength in bilateral hip flexors, hip extensors, and hip abductors. A summary of the strength measurements reported in pounds of force can be found in Figure 1.

Balance: Balance was measured using the Pediatric Balance Scale (PBS) which is a derivative of the Berg Balance Scale to measure balance in school age children with mild to moderate motor impairments. Rules for administering the test as set forth by the creators of the PBS were followed during administration. Fourteen different items are tested including sit to stand, transfers, standing/sitting unsupported, standing with feet in various positions, turning, retrieving objects off the floor, alternating feet on top of a stool, and reaching forward.

The participant was allowed three trials and was given a score from zero to four depending on her ability to perform the task with a score of 56 exhibiting the highest score. Studies report that the PBS has a high inter-rater reliability with an ICC of .99 [25]. When used with children with cerebral palsy, the PBS also has a high concurrent reliability with the Functional Reach Test and the Timed Up and Go [17]. Validity of the PBS has not been reported. Upon initial testing, the patient's total score on the PBS was a nine out of 56, which places her in the impaired balance category.

Muscle length: Muscle length of the hamstrings muscle was measured using the passive 90/90 test as described by Reese and Bandy [21]. This measurement was taken with the patient in supine with the hip and knee flexed at 90 degrees. The second therapist then passively extended the knee to end range and the first therapist took the corresponding measurement of knee extension using a standard goniometer. Hamstring length testing using the passive 90/90 knee extension test for children with CP has an ICC ranging from .55 to .97 [26]. The specific measurements are listed in Figure 2. Based on the findings of the muscle length test, patient demonstrated decreased hamstring flexibility.

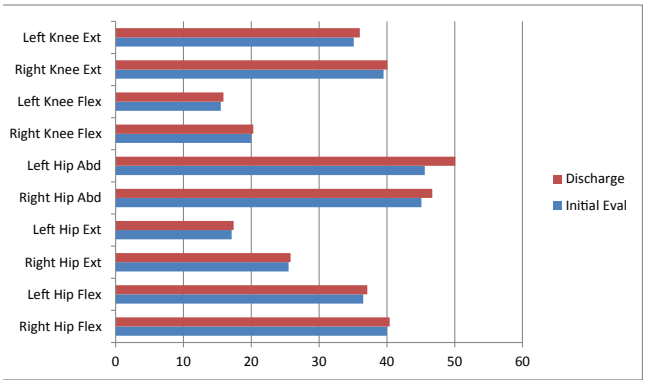

Figure 1: Lower Extremity Strength (in pounds).

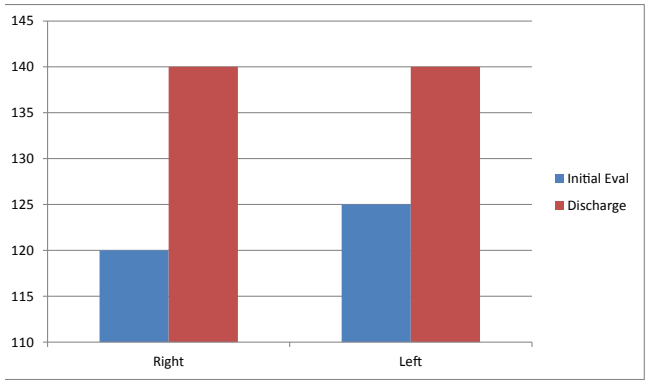

Figure 2: Hamstring Length (in degrees).

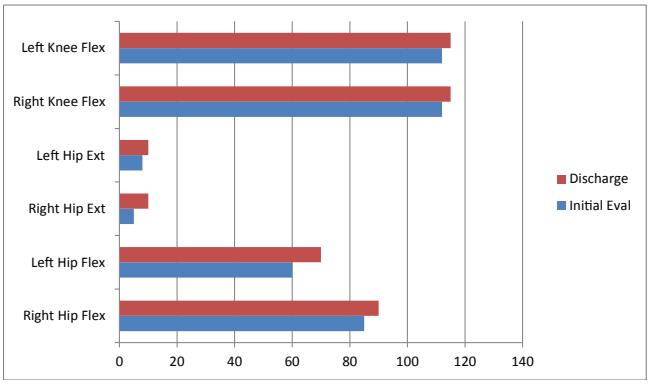

Figure 3: Lower Extremity Range of Motion Measurements (in degrees).

Range of motion: During the initial evaluation the patient's hip, knee, and ankle range of motion (ROM) were measured with a standard goniometer according to the protocol as described by Reese and Bandy [21]. These measurements were taken at week one and again at week seven. Hip, knee, and ankle bilateral active range of motion measurements in the sagittal plane were taken with the patient in supine position with the exception of hip extension which was measured in prone. Hip internal and external rotation was measured with patient in prone with hip at zero degrees and knee flexed to 90°. All ROM measurements were taken with two therapists to obtain in order to isolate muscle groups without compensatory movements. One therapist blocked compensatory movements by stabilizing the pelvis and trunk while the other therapist took the ROM measurements using a goniometer. It would have been possible to obtain the same measurements by asking the patient to stop at the point in the range before compensatory movements began to take over for the motion, but since two therapists were available, both were used to obtain the active measurements. The patient demonstrated deficits in hip flexion and hip extension bilaterally, as well as decrease knee flexion bilaterally. A summary of ROM measurements is shown in Figure 3.

Functional outcomes

Functional outcomes were measured using the Pediatric Evaluation of Disability Inventory (PEDI) at the first and last therapy sessions. The PEDI is a tool that uses parent observation to assess key functional abilities in areas of self-care, mobility, and social function [25]. Typically, the PEDI is used to assess children age six months to seven years; however it can also be used on children with functional abilities that are lower than a seven year old as was the case in this report [25]. Given the limited time frame of this report, the PEDI was chosen over the outcome measure the Gross Motor Function Measure (GMFM) because research supported evidence that the PEDI was more sensitive to changes in function over time [18].

Evaluation, Diagnosis, Prognosis

The impairments in balance, strength, ROM, and flexibility found in the initial examination were consistent with the patient's diagnosis of diplegic cerebral palsy. These impairments lead to functional limitations such as the inability to stand still, run, jump, ride a bike, dress independently, and ascend/descend stairs. Furthermore, these functional limitations resulted in disability consisting of the inability to play with her brothers or other peers or participate in daily school activities independently. According to the *Guide to Physical Therapist Practice*, the patient's diagnosis was practice pattern 5C: Impaired motor function and sensory integrity associated with non-progressive disorders of the central nervous system-congenital origin or acquired in infancy or childhood [3]. The patient's prognosis was good based on her age, motivation, and age appropriate cognitive level, ability to follow commands, lack of co-morbidities, and her extremely supportive family. The patient's goals for physical therapy were to be able to get dressed independently, ascend/descend stairs at school independently, and to decrease the number of falls she experienced daily.

Clinical impression

At the time of initial evaluation for this case report several impairments were noted; deficits in ROM of the hip, knee, and ankle bilaterally, as well as, decreased flexibility in the hamstring tendons bilaterally. The patient also presented with decreased strength throughout bilateral lower extremities and impaired balance. Given these impairments, yoga, which incorporates strength, flexibility, and balance into all poses, appeared to be an appropriate intervention because it addressed each individual deficit. The patient was chosen for this case report due to her willingness to participate, her ability to understand and follow directions, her availability, and her functional limitations.

Interventions

Interventions included two one-hour individual physical therapy sessions per week which consisted of progressive resistance and endurance exercises, stretching exercises and meaningful play in functional positions like standing, half kneeling, and quadruped. See Table 1 for a summary of these activities. Interventions also included a one hour long session of yoga in a group setting one time per week for six weeks. The subject attended 10 out of the 12 individual therapy sessions and six out of six group yoga sessions.

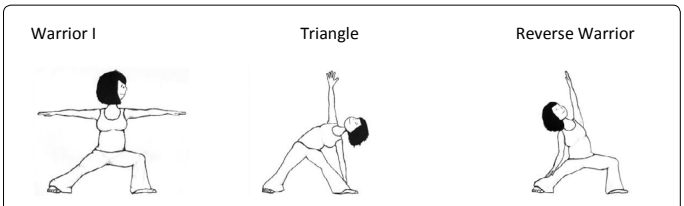

Figure 4: Yoga Progression of holding poses – Done one time on right and left side [27].

The type of yoga used was from the school of yoga known as viniyoga [16]. This is a therapeutic approach to yoga that adapts the practice to specific needs of the individual. It incorporates repetitions into and out of different postures as well as statically holding postures and focusing on breath with movement. This form of yoga is also highly adaptable and therefore good for subjects with limitations and impairments [16].

The yoga program was taught by a certified yoga instructor and was based on the publication by Calhoun and Calhoun [27]. Each session consisted of a series of eight to ten yoga poses held from 20-30 seconds depending on the pose. Due to the patient's balance deficits, she required external support to maintain several of the poses, so a wooden chair was placed in front of her to hold on to if necessary. It was also difficult for the subject to motorically plan how to get into a few of the positions so she required moderate assistance with the PT performing up to 50% of the work to assume the position and maintain the pose. See Figure 4 for a sample of yoga holding poses.

Outcomes

Strength: The patient's improvement in strength, as measured by the microFET hand held dynamometer, is outlined in Figure 1. All strength measurements improved by at least .3 pounds of force. The most notable improvement in strength is the patient's hip abductors on her left lower extremity which improved by 4.4 pounds of force. The patient continued to have deficits in strength when comparing right versus left lower extremity, with the right lower extremity (RLE) stronger than the left lower extremity (LLE) throughout. When numbers are compared throughout each muscle group, the patient demonstrated decreased force production in her hip extensors and knee flexors bilaterally.

Balance: The patient's balance, as measured by the Pediatric Balance Scale, improved ten points from a score of nine to a score of 19 out of 56 possible points. While this score demonstrated an improvement in balance, it still placed the patient in the impaired balance category. The minimal clinically important difference (MCID) for the PBS has not been established to date [17], but it was interesting to note some of the specific areas of improvement. Those areas that improved by two points were the sit to stand and the stand to sit, standing unsupported with feet together, and turning to look behind the right and left shoulder while standing. The transfers' portion and the standing unsupported portion of the test also improved by one point each.

Intervention Focus	Related Activities
Endurance	Progressive speed and duration treadmill walking, relay races in quadruped, crab walking, tall kneeling, retro walking
Flexibility	Therapy ball prone and supine stretches, foam roll stretching in supine
Strength	Step ups, step overs, activities in tall kneeling and tall half kneeling, sit←→stand, sidestepping, push/pull on scooters
Balance/Coordination	Standing ball toss, standing on foam with UE movement, standing with one foot on 2" step, alternating tapping feet on 2" step

Table 1: PT Interventions.

Flexibility: The patient's improvement in flexibility as measured by the passive 90/90 hamstring test can be found in Figure 2. Flexibility in her RLE improved by 20°, while flexibility in her LLE improved by 15 degrees. A decrease in the difference in muscle length between the right and the left lower extremities is also noted with final measurements at 140° each. Flexibility as measured by ROM can be found in Figure 3. Improvements in ROM are noted in hip flexion, hip extension and knee flexion bilaterally and hip abduction on the left. All other ROM measurements remained unchanged. While her ROM measurements did show improvements, the patient's ROM were still impaired bilaterally throughout. Impairments in ROM were especially noted in her hip flexion and hip extension. Her hip flexion was 45° on the right and 65° on the left, which is below normal; her hip extension was 5° bilaterally below the norms for those muscle groups. In addition, impairments in knee flexion were noted as she was 18 degrees below the norm for that muscle group.

PEDI: Functional skills and caregiver assistance as measured by the PEDI showed improvements in the self-care domain and mobility domain based on the initial and final raw scores obtained from the subject's mother. In part one, the functional skills category, the patient's self-care initial score was 177 and after six weeks the final score was 187, exhibiting a ten point improvement in the patient's self-care. This was nearly clinically significant according to Iyer et al. who stated the MCID for the PEDI is 10.9 in the functional skills portion [28]. In part two of the PEDI, the caregiver assistance category, the patient initially scored a 79 and after six weeks her score improved by six to an 85, meaning she required less caregiver assistance during self-care, mobility, and social function. According to Iyer et al, the MCID for the caregiver assistance portion of the PEDI is 11 [28], which indicated that the patient's improvement of six points was not clinically significant. The most notable areas of improvement included the self-care domain of both the functional skills and the caregiver assistance portions of the PEDI.

Following the conclusion of this seven week study, the patient will continue skilled PT twice a week. While the patient did enjoy yoga each week, the facility will not be continuing the program so the patient will not be able to continue her yoga practice in this setting.

Discussion

The purpose of this report was to describe the effects of a yoga program in addition to a comprehensive physical therapy program for a child with diplegic CP on the subject's strength, balance, flexibility, and functional mobility. The significance of this report was to provide support to bridge the gap between the research of health benefits of yoga and the benefits of yoga for children with CP in regards to impairments and functional limitations. The outcomes included mild improvements in strength, flexibility, and balance, as well as improvements in functional mobility as measured by the PEDI. These results indicated that a yoga program in addition to a comprehensive physical therapy program may have beneficial effects on the impairments and functional mobility of children with CP.

Previous research on yoga with children reported benefits for typically developing children and children with a variety of health problems. Studies that addressed the musculoskeletal effects of yoga found benefits primarily in stress management and obesity [16], however children with motor impairments were not included. In this case report, small improvements were noted in the subject's lower extremity strength and flexibility, indicating possible benefits for the inclusion of yoga for children with motor impairments.

Additionally, other studies focused on the effects of various interventions on impairments or functional limitations, but few focused on both. Studies that focused on the effects of interventions [4-7] provided evidence to support the importance of improving strength impairments in children with CP. In comparison to previous research [4-8,13], this case report showed improvements in strength, balance and flexibiltiy following the PT and yoga interventions. This in turn allowed the patient to demonstrate improvement in functional mobility as measured by the PEDI.

The strength of this case report was that it investigated a novel combination of available interventions; PT and yoga. Following the study, improvement in body structure and function components, as well as, functional mobility was documented. Thus, this case report focused on improving impairments and the impact on function rather than just improving impairments.

Limitations to this of case report include a lack of follow up data so conclusions about the long term effects of a yoga program cannot be drawn. This case report also focused on impairments and functional limitations, and did not gather any data about the qualitative effects of a yoga program. The qualitative data could include the parent's perceptions of how the yoga program was affecting their child's behavior, mood, and social skills or how the child felt about participating in the program and their perceived effectiveness. Additionally, this is a case report; therefore, due to a single subject design there was the inherent lack of generalizability to a larger population, lack of a control group, and no blinding to the subject or rater throughout the report.

In the future, research designs could study a yoga program with increased intensity and to explore yoga's effectiveness over a longer period of time for children with CP. Future research on the effects of yoga could also include qualitative aspects of the impact of yoga on a child's self-esteem, social skills, group participation, and parental satisfaction.

Conclusion

Although this case report has limitations, it does provide a creative and feasible alternative to traditional physical therapy for children with CP. Since children with CP are often life-long episodic participants in physical therapy, it is important for physical therapists to provide alternative, appealing exercise options to keep the patient motivated and engaged. This report provided support for integrating yoga into a plan of care for a child with CP to address impairments in strength, balance, flexibility and functional limitations. The outcomes of this case report suggest that a six week yoga program in conjunction with physical therapy may be beneficial in improving the strength, balance, flexibility and functional limitations of a child with CP.

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