Improvements in gait and motor function in an adolescent with cerebral palsy following an intensive stationary cycling intervention - A case report

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1. Background

Cerebral palsy (CP) is the most common cause of disability in childhood (1). The prevalence is 2-3 in 1000 births (2). CP comprises a group of permanent disorders caused by a non-progressive lesion in the immature brain. The primary impairments in the neuromuscular system are muscle weakness, spasticity and reduced selective muscle control. These impairments have a high impact on the ability to perform daily activities and to participate in leisure activities (3). For example, the majority of children and adolescents with CP experience difficulty in walking (4), where walking speed and endurance are reduced (5, 6). Thus, efficient and independent walking is an important therapeutic goal for many children and adolescents with CP (7).

Treadmill training has been used in adult and pediatric rehabilitation to improve the walking function in a task-specific manner (8). Evidence that treadmill training is effective in children with CP is limited and mostly based on single-subject case studies. The studies, however, show varying improvements in e.g. GMFM scores, walking speed, step length and endurance (9).

Cycling is a locomotor task that requires reciprocal flexion and extension movements of hip, knee and ankle and has alternating muscle activation of antagonist muscles in a coordinated manner similar to walking. The kinematic patterns of walking and cycling are found to be similar (10). Studies of cycling interventions have been performed in adult populations with acute, subacute and chronic stroke (11-13). The cycling intervention is found to be feasible and to improve aerobic capacity and functional performance.

Literature supporting cycling interventions for children and adolescents with CP is limited (14, 15). Williams and Pountney have demonstrated that a static bicycling programme resulted in significant improvements in functional ability as measured by GMFM in non-ambulant children with CP (15). An ongoing RCT study examines the effect of a 12-week stationary cycling intervention on children and adolescents with spastic diplegic CP (16).

The effectiveness of a cycling intervention to improve gait parameters and motor function in children and adolescents with CP is a relevant clinical question since this intervention can be conducted in a home setting. To keep costs at a minimum, it is important to be able to design interventions that are feasible in a home setting. Thus, the effects of cycling interventions need to be studied further. The purpose of this case report has been to examine the effects of an intensive stationary cycling intervention on walking speed, walking endurance, gross motor function and health-related quality of life in a 16-year-old girl with CP. Furthermore, the feasibility of a cycling intervention in a home setting has been studied.

2. Case description

2.1 Participant

The participant was a 16-year-old girl diagnosed with spastic triplegic CP and GMFCS level II. Particularly, her left-side extremities were affected. Prior to the cycling intervention, the participant had received physical therapy once a week.

Clinical observations of gait showed trendelenburg gait, internal rotation of left hip and a tendency to left foot drop. Step length was asymmetric with prolonged standing phase on the right leg. The participant often expressed feelings of fatigue and lack of energy and sometimes experienced difficulty in keeping up with her peers and being physically active. Her goals were to improve her endurance and strength in order to maintain an active lifestyle including family hikes and trips with peers. Thus, the participant was highly motivated prior to the cycling intervention. Both the participant and her parents signed an informed consent.

2.2 Outcome measures

Gait and functional performance were assessed at baseline and after a five-week period of intensive stationary cycling intervention. The outcome measures used were the Six-Minute Walk Test (6MWT) (17), the 10-Meter Walk Test (18), the Energy Expenditure Index (EEI) (19), the Sit-To-Stand Test (STST) (20), the Gross Motor Function Measure (GMFM) (21) and the Pediatric Quality of Life (PedsQL) (22). The tests were performed by the physiotherapist involved in the intervention.

2.3 Intervention

The intervention took place in the participant's home. The participant did not receive any other training during the intervention period. A Monark Sparr Rehab Model 808 stationary bicycle was used. This stationary bicycle has a manual resistance load with 0 to 20 cords. A total of 19 sessions were completed in a 5-week period with 3-4 sessions per week. The duration of each session increased weekly, from 30 to 45 minutes (see table 1). Once a week, a physiotherapist observed the training and adjusted the resistance. During 9 sessions, a parent supervised the participant and offered encouragement. Each session consisted of: 1) Warm-up, 2) Strength, 3) Endurance, and 4) Cool-down. The components of strength and endurance training were designed with inspiration from (12) and (16).
The participant wore a heart rate monitor. The resting heart rate was measured every week after a 5-minute rest lying down. During the warm-up, the target heart rate was 50 % of maximum heart rate. The target heart rate range was calculated using the Karvonen Formula (23). In the strength component the participant completed 10 sets of 10 to 20 revolutions at a high resistance load (>10 cords). A resting period between each set was allowed. The endurance component consisted of continuous cycling at moderate resistance. The participant was encouraged to keep a constant cadence. The endurance training increased weekly, from 10 minutes in the first week to 25 minutes in the last week. The target heart rate range during the endurance training was 70 to 80 % of maximum heart rate. Table 1 shows the weekly progressions of the intervention.

3. Results

Results of the outcome measures, pre- and post-interventional, are shown in table 2. Post-intervention, the participant was able to walk 29.6 meters longer as measured with the 6MWT, which yields a 4.6 % increase in walking speed. In the 10-Meter Walk Test, the participant was able to walk faster with a 26.7 % increase in self-selected walking speed and a 17.6 % increase in fast walking speed. A reduction in EEI is seen at both the slow and the moderate walking

Table 1. *Progression during a 5-week period of intensive stationary cycling intervention*

	Week 1	Week 2	Week 3	Week 4	Week 5
Warm-up					
Duration	5 min.	5 min.	5 min.	5 min.	5 min.
Resistance	5 cords	5 cords	5 cords	5 cords	5 cords
Target heart rate	130	130	130	130	130
Strength					
Duration	10 min.	10 min.	10 min.	10 min.	10 min.
Resistance	12 cords	13 cords	15 cords	15 cords	16 cords
Revolutions	10	15	15	20	20
Endurance					
Duration	10 min.	15 min.	20 min.	25 min.	25 min.
Resistance	10 cords	10 cords	10 cords	10 cords	11 cords
Target heart rate	160-175	160-175	160-175	160-175	160-175
Cool-down					
Duration	5 min.	5 min.	5 min.	5 min.	5 min.
Resistance	3 cords	3 cords	3 cords	3 cords	3 cords
Total duration	**30 min.**	**35 min.**	**40 min.**	**45 min.**	**45 min.**

Table 2. *Pre- and post-intervention results*

Outcome measure	Pre-intervention	Post-intervention
6MWT	425 meters (4.3 km/h)	454.6 meters (4.5 km/h)
10-Meter Walk Test (self-selected speed)	12 sec (3.0 km/h)	9.5 sec (3.8 km/h)
10-Meter Walk Test (fast speed)	7 sec (5.1 km/h)	6 sec (6 km/h)
EEI (1 km/h)	3.35 bpm	2.45 bpm
EEI (3 km/h)	1.31 bpm	1.07 bpm
STST	11 repetitions	14 repetitions
GMFM, dimension D	76.9% (30 points)	84.6% (33 points)
GMFM, dimension E	76.4% (55 points)	86.1% (62 points)
PedsQL, Total mean	61.9	76.1
PedsQL, Physical functioning mean	62.5	78.1
PedsQL, Emotional functioning mean	60.0	75.0
PedsQL, Social functioning mean	80.0	90.0
PedsQL, School functioning mean	45.0	60.0

speed, indicating a more efficient energy consumption during walking.

The participant was able to complete 3 additional repetitions on the STST after the intervention. Improvements in gross motor function were seen according to the GMFM. In the dimension of standing (D), the participant showed a 3-point increase with improvements in one-leg balance, standing from high kneeling and standing to sitting on floor. A 7-point increase was seen in the dimension of walking, running and jumping (E) with improvements in stepping over stick, jumping, hopping and stair climbing.

Post-intervention, the total PedsQL mean improved, as did all four dimensions. The participant felt more able to be physically active, felt less pain and felt less tired. She experienced fewer negative emotions, felt more able to keep up with her peers and could concentrate more.

4. Discussion

Overall, the participant showed improved walking speed, walking endurance, gross motor function and health-related quality of life after an intensive 5-week stationary cycling intervention. Recently, Oeffinger et al. have established minimum clinically important differences (MCIDs) in outcome measures like GMFM, PedsQL and gait parameters for ambulatory children with CP (24). When MCIDs are used in the interpretation of the results in this case report, no MCID is reached in walking speed as measured with the 6MWT, whereas large MCIDs are reached in walking speed as measured by the 10-Meter Walk Test. On short distances the participant has obtained an observable increase in walking speed. However, the 6MWT is used as a measure of walking endurance, and even a small increase in walking speed has increased the distance by almost 30 meters. This could be important to the participant as she is now able to walk longer distances (e.g. to and from school, 2x3 km).

Moreover, the participant showed a reduction in energy consumption during walking. By contrast, one study found that a resisted leg cycling programme only improved walking endurance and not walking speed in individuals with chronic stroke (12). In the study by Sullivan et al., treadmill walking seemed most effective. This might be explained by the specificity of walking on a treadmill. Furthermore, the resisted leg cycling may have targeted muscle endurance in particular. This may be seen from the fact that some of the participants in the study by Sullivan et al. reached the highest resistance level so that the number of repetitions had to be increased in order to progress the exercise. To improve walking speed, it is important to target muscle strength (25). The improvements on the STST in this case report may indicate increased muscle strength in the lower limbs.

The results from the GMFM yield an approximately medium MCID in dimension D, whereas a large MCID is reached in dimension E. Similarly, the study by Williams and Pountney found gross motor improvements after a 6-week static bicycling programme in non-ambulant children with CP. They reported equal improvements in dimension D and E of GMFM (15). Items in dimension D involve static balance and transfers. The small improvements in dimension D in this case report may be explained by the fact that the cyclic intervention does not target static balance and postural control in an upright position. The improvements, however, seem meaningful to the participant as she is now able to complete some transfers with less or no support, using her arms. Finally, the improvements in the PedsQL reach medium MCIDs in the dimensions of physical, emotional and social functioning.

Furthermore, an intensive cycling intervention in a home setting seems feasible. The participant in this case report showed high compliance. She felt that she was able to participate in this kind of high intensity training and experienced physical gains. Before a home setting intervention is set up, it is important to consider family resources and time constraints (15) since the family may be needed to provide encouragement. The participant felt that she was able to work harder and with more discipline when supervised.

This study is limited in design, it has no follow-up period, and the assessments are not blinded. Furthermore, no measures of range of motion (ROM), spasticity and muscle strength were performed. The functional gains in walking endurance and speed may be explained by changes in ROM and muscle strength. However, this case report offers some insight into the effectiveness of a stationary cycling intervention on gait and function in an adolescent with CP. Further RCT-studies including spatial and temporal gait parameters are required to accumulate evidence of the effectiveness of cycling interventions in children with CP.

In conclusion, an intensive stationary cycling programme could be a feasible and effective intervention for children and adolescents with CP. In this case report, the participant showed improvements in gait and motor function. To verify these results, further research is needed.

References

1. Koman LA, Smith BP, Shilt JS: Cerebral palsy. Lancet. 2004;363(9421):1619-1631.
2. Surveillance of Cerebral Palsy in Europe (SCPE): A collaboration of cerebral palsy registers. Dev Med Child Neurol. 2000;42:816-824.
3. Beckung E, Carlsson G, Carlsdotter S, Uvebrant P: The natural history of gross motor development in children with cerebral palsy aged 1 to 15 years. Dev Med Child Neurol. 2007;49(10):751-756.
4. Hutton J, Pharoah P. Effects of cognitive, motor, and sensory disabilities on survival in cerebral palsy. Arch Dis Child. 2002;86:84-89.
5. Abel M, Damiano D. Strategies for increasing walking speed in diplegic cerebral palsy. J Pediatr Orthop. 1996;16:753-758.
6. Bottos M, Feliciangeli A, Sciuto L, Gericke C, Vianello A. Functionel status of adults with cerebral palsy and implications for treatment of children. Dev Med Child Neurol. 2001;43:516-528.
7. Dodd KJ, Foley S. Partial body-weight-supported treadmill training can improve walking in children with cerebral palsy: a clinical controlled trial. Dev Med Child Neurol. 2007;49:101-105.
8. Borggraefe I, Meyer-Heim A, Kumar A, Schaefer JS, Berweck S, Heinen F. Improved Gait Parameters After Robotic-Assisted Locomotor Treadmill Therapy in a 6-Year-Old Child with Cerebral Palsy. Mov Disord. 2008;23(2):280-283.
9. Laforme Fiss AC, Effgen SK. Outcomes for young children with disabilities associated with the use of partial, body-weight-supported, treadmill training: An evidence-based review. Phys Ther Rev. 2006;11:179-189.
10. Raasch CC, Zajac FE. Locomotor strategy for pedaling: muscle groups and biomechanical functions. J Neurophysiol. 1999;82:515-525.
11. Brown DA, Nagpal S, Chi S. Limb-loaded Cycling Program for Locomotor Intervention Following Stroke. Phys Ther. 2005;85:159-168.
12. Sullivan KJ, Brown DA, Klassen T, Mulroy S, Ge T, Azen SP, Winstein CJ. Effects of Task-Specific Locomotor and Strength Training in Adults Who Were Ambulatory After Stroke: Results of the STEPS Randomized Clinical Trial. Phys Ther. 2007;87:1580-1602.
13. Janssen TW, Beltman JM, Elich P, Koppe PA, Konijenbelt H, de Haan A, Gerrits KH. Effects of Electric Stimulation-Assisted Cycling Training in People With Chronic Stroke. Arch Phys Med Rehabil. 2008;89:463-469.
14. Bloswick DS, Brown D, King EM, Howell G, Gooch JR. Testing and evaluation of a hip extensor tricycle for children with cerebral palsy. Disabil Rehabil. 1996;18:130-136.
15. Williams H, Pountney T. Effects of a static bicycling programme on the functional ability of young people with cerebral palsy who are non-ambulant. Dev Med Child Neurol. 2007;49:522-527.

16. Fowler EG, Knutson LM, DeMuth SK, Sugi M, Siebert K, Simms V, Azen SP, Winstein CJ. Pediatric endurance and limb strengthening for children with cerebral palsy (PEDALS) – a randomized controlled trial protocol for a stationary cycling intervention. BMC Pediatrics. 2007;7:1-9.
17. Li AM, Yin J, Yu CCW, Tsang T, So HK, Wong E, Chan D, Hon EK, Sung R. The six-minute walk test in healthy children: reliability and validity. Eur Respir J. 2005;25:1057-60.
18. Watson MJ. Refining the Ten-Metre Walking Test for Use with Neurologically Impaired People. Physiother. 2002;88:386-397.
19. Norman J, Bossman S, Gardner P, Moen C. Comparison of the Energy Expenditure Index and Oxygen Consumption Index during self-paced walking in children with spastic diplegic CP and children without physical disability. Pediatr Phys Ther. 2004;16:206-211.
20. Bohannon RW. Sit-To-Stand test for measuring performance of lower extremity muscles. Percept Mot Skills. 1995;80:163-166.
21. Russell DJ, Rosenbaum PL, Avery LM, Lane M. Gross Motor Function Measure (GMFM-66 and GMFM-88) User's Manual. London: Mac Keith Press; 2002.
22. Varni JW, Seid M, Kurtin PS. PedsQL 4.0: reliability and validity of the Pediatric Quality of Life Inventory version 4.0 generic core scales in healthy and patient populations. Med Care. 2001;39:800-812.
23. Karvonen MJ, Kentala E, Mustala O. The effects of training on heart rate; a longitudinal study. Ann Med Exp Biol Fenn. 1957;35:307-315.
24. Oeffinger D, Bagley A, Rogers S, Gorton G, Kryscio R, Abel M, Damiano D, Barnes D, Tylkowski C. Outcome tools used for ambulatory children with cerebral palsy: responsiveness and minimum clinically important differences. Dev Med Child Neurol. 2008;50:918-925.
25. Eek MN, Beckung E. Walking ability is related to muscle strength in children with cerebral palsy. Gait Posture. 2008;28:366-371.

Abstract

Background
The majority of children with CP experience difficulty in walking, and through adolescence and adulthood, the gait function decreases further. The purpose of this case report has been to examine the effects of an intensive stationary cycling intervention on walking speed, walking endurance, gross motor function and health-related quality of life.

Material and method
The participant was a 16-year-old girl with spastic triplegic CP. The following outcome measures were used: Six-Minute Walk Test (6MWT), 10-Meter Walk Test, Energy Expenditure Index (EEI), Sit-To-Stand Test (STST), Gross Motor Function Measure (GMFM) and Pediatric Quality of Life (PedsQL). The intervention was conducted in a home setting. A total of 19 sessions were completed in a 5-week period with 3-4 sessions per week. Once a week, a physiotherapist observed the training.

Results
The participant showed improvements on all outcome measures.

Discussion
The improvements yielded medium and large minimum clinically important differences in walking speed, GMFM, and PedsQL. An intensive stationary cycling programme could be a feasible and effective intervention for children and adolescents with CP. Further research is needed to verify the results from this case report.

Key words: Cerebral palsy, stationary cycling intervention, gait, motor function