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Scientific/Clinical Article

Home-based movement therapy in neonatal brachial plexus palsy: A case study

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ABSTRACT

Study design: Case report.
Introduction: The value of movement-based therapy in peripheral nerve injury conditions such as neonatal brachial plexus palsy (NBPP) is unclear.
Purpose of the study: To determine the effectiveness of a home-based movement therapy program in a 17 year old female patient with a right NBPP pan-plexopathy.
Methods: Home training consisted of arm reaching and object manipulation tasks using devices which recorded performance. Training occurred for 1 h/day, 5 days/week for 6 weeks with periodic webcam supervision. Pre- and post clinical, functional and kinematic assessments were performed in a laboratory setting.
Results: Following training, shoulder flexion and elbow extension active range of motion increased by 13° and 9°, respectively, and functional ability also improved. Reach movement duration decreased significantly with a concomitant improvement in movement coordination.
Conclusions: These results demonstrate that movement therapy has the potential to improve motor function in NBPP years after the initial insult.
Level of evidence: 4

Introduction

Upper extremity paresis/paralysis results from neonatal brachial plexus palsy (NBPP) which affects approximately 1.5 of 1000 live births[1] via nerve injury from compression, traction, or inflammation of the brachial plexus, either in utero or during the perinatal period.[2] Whether infants with NBPP recover function with conservative management or require surgical treatment as is the case in up to 60% of patients,[3] occupational or physical therapy remains an essential component of treatment for all NBPP patients. Otherwise, persisting muscle weakness may lead to the development of joint contractures and joint deformities which can further impact manipulation skills and self-care activities,[4,5] impact self-esteem,[6] and significantly compromise quality of life for caregivers.[7]

Repetitive, movement-based training has been shown to improve upper limb function in congenital conditions affecting the central nervous system, most notably in children with hemiplegic cerebral palsy.[8–10] However, to what extent task-oriented, movement therapies may be effective in conditions arising from injury to peripheral nerves is not well understood since current treatment approaches for this population focus on surgical interventions or conservative treatment to maintain range of motion and increase muscle strength.[11,12] Constraint–induced therapy, which targets the affected arm while simultaneously restraining movement of the unaffected arm, was found to improve function in a two year old with NBPP using the Toddler Arm Use Test.[13] Constraint-induced therapy combined with botulinum toxin led to improved scores on the Mallet and Gilbert shoulder assessments in two children aged 6 and 7 yrs.[14] However, in two older children aged 12 yrs, observation-based functional gains were modest, ranging from 4 to 10%.[15]

In an increasingly technology-driven society, new approaches are needed which can effectively deliver rehabilitation-based health care in NBPP. For example, exercise frequency and caregiver confidence increased when following a video-based home exercise program specifically designed for children and adolescents with NBPP.[16] Using a non-constraint training regimen with bilateral reaching components,[10] the effectiveness of and high compliance with a home-based movement therapy program in central nervous system conditions such as hemiplegic cerebral palsy[17,18] and adult stroke[19] has been demonstrated.

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In this single-case study, we show that improvements in upper limb ability, revealed by both functional and kinematic assessments, is possible in older children with NBPP, well past the time when improvements are typically thought to occur.[3,20] These findings provide support for the view that movement-based training is beneficial not only in conditions characterized by central neural insult but can be of value in peripheral nerve injuries such as NBPP.

Methods

Patient

A 17 year old female with a neonatal right brachial pan-plexopathy (Narakas Group III classification) with more involvement of the upper and middle trunks was included in this single-subject research study. She used her unaffected (left) arm for most activities of daily living and had not undergone surgical nerve repair or any reconstructive procedures. Two years prior to testing, she was prescribed a home therapy program to increase range of motion and strength but found it difficult to comply with the exercise because of other commitments. At the time of testing, she was not engaged in any prescribed clinic-based or home therapy. She was motivated to participate in this study in order to participate in school athletic activities, particularly volleyball.

Pre-test assessment revealed reductions in shoulder flexion, abduction and external rotation, elbow extension, forearm supination, and wrist and finger extension. Passive range of motion was limited by approximately 90° for shoulder flexion and abduction, 20° for elbow extension, forearm supination and wrist extension, and 30° for finger extension. Active range of motion scores (Table 1) indicated a considerable reduction in the use of available joint range.

Using the modified Mallet classification of shoulder function (I indicates no shoulder function, V indicates normal movement symmetric with the contralateral, unaffected side), grades were primarily III with a grade of IV for the hand to mouth test. Shoulder muscle strength (grade 3−) was sufficient to partially move the affected arm against gravity. Muscle weakness was also observed for elbow extension (triceps strength: 2+, wrist and finger extensors: 3−). This study was approved and followed patient rights and confidentiality procedures established by the University of Michigan Medical School Institutional Review Board.

Procedures

Pre- and post-study assessments

Clinical and kinematic assessments were performed prior to and immediately following completion of home training. Primary clinical measures included: active range of motion using clinical goniometry, grip strength using hand-held (Jamar) dynamometry, hand dexterity using the Nine-Hole Peg Test (NHPT), and tactile spatial acuity using a gratings orientation task.[21] Since there is no validated instrument to assess upper limb coordination for older children with NBPP,[22] the Streamlined Wolf Motor Function Test (WMFT),[23] was employed.

Kinematic analysis of reaching movements, shown to reflect changes in the ability of the central nervous system to produce efficient and coordinated multi-joint movements,[24] was performed using a 3D electromagnetic motion capture system (MotionMonitor, Innsport) with a sampling rate of 100 Hz.[19] Sensors were attached to the dorsal surface of the hand to record reach movement trajectories. The patient was seated with shoulders adducted and the elbows flexed at 90°. Based on active shoulder and elbow ROM, forward reaching movements were made to two targets located at waist (mid) and hip (low) height on a target board placed in front of the patient. Movements were made as quickly and as accurately as possible for a total of 5 trials per task. Movement kinematics (duration, hand path deviation from an ideal straight-line path) were calculated for each reach movement using custom designed software (LabVIEW 8.5).

Home-training program

A computer-controlled target reaching board and several hand manipulation/discrimination devices were placed in the patient's home. Training duration was 1 hour/day, 5 days/week for 6 weeks for a total of 30 h of training during the intervention period. Most sessions took place after school or during the early evening. Webcam monitoring by trained personnel occurred 3–4 times a week. Task progression varied by task and was based on the patient's performance during the three preceding training sessions, and the patient's willingness to perform more challenging tasks.

The tasks included a variety of multijoint reaching movements and object manipulation/identification activities. *Repetitive reaching movements* were made to computer-determined illuminated targets located on a vertical board in front of the patient. Based on passive ROM for shoulder flexion at pre-assessment, the higher target required approximately 50° of shoulder flexion and the patient was allowed to use her unaffected arm as needed to assist reaching this target during the first two weeks of training. Movements were made unilaterally during week 1 with simultaneous and sequential bilateral movements in weeks 2 and 3. During weeks 4 through 6, only bilateral simultaneous and sequential reaching movements were performed. The number of reach repetitions increased from 25 for week 1 to 40 during weeks 4 through 6. *Hand tapping* involving repetitive forearm supination and pronation movements between two horizontal targets were performed unilaterally (weeks 1–2) and bilaterally (weeks 3–6). Seven to 9 cycles were performed in each session. *Card turning* (weeks 1–6) required grasping a card from a card holder and then supinating the forearm sufficiently to drop the card face up. This task was performed unilaterally throughout week 1 followed by the addition of bilateral sequential card turning during weeks 2 and 3. During weeks 4 through 6, card turning was performed unilaterally and using both hands simultaneously. Across all sessions, the number of cards removed from the holder in 30 s was recorded. The *object identification (stereognosis)* task required fine hand control in order to manipulate and identify computer-determined wooden letters (weeks 1–2) or raised dot domino patterns (weeks 3–6) in the absence of vision. During each session, 4 different letters or 4 different domino patterns were used. For the *tactile discrimination* task, the patient inserted her hand through an opening in a box containing a series of raised pin patterns. The task required identification of the correct pin pattern from three possible computer-

Table 1
Pre- and post-assessment active range of motion (ROM), grip strength, hand dexterity (Nine-Hole Peg Test) scores and percentage change scores for the affected arm. Normative ROM values are provided in the left hand column

	Pre	Post	% change
AROM shoulder flexion (0–180°)	0–32	0–45	+40.6%
AROM shoulder abduction (0–180°)	0–43	0–41	−4.6%
AROM elbow extension − flexion (0–150°)	52–142	43–143	+17.3% extension
AROM forearm supination (0–90°)	0–35	0–38	+8%
AROM wrist flexion − extension (90-0-70°)	74–19	73–18	−5.2% extension
AROM finger extension (0–45°)	20	20	0%
Grip strength (lb)	11.0	10.4	−6%
Nine-Hole Peg Test (s)	29	29	0%