The Effects of Therapeutic Taping on Gross Motor Function in Children with Cerebral Palsy

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Purpose: Therapeutic taping to address dysfunctional sitting control in children with cerebral palsy (CP) was investigated in this study. **Methods:** Eighteen children with quadriplegic CP, Gross Motor Function Classification System for Cerebral Palsy levels IV (n = 9) and V (n = 9) participated in the 12-week program. Subjects were assigned randomly to one of two groups: therapeutic taping + physical therapy or physical therapy only. Therapeutic taping was applied for periods of up to 72 hours over the paraspinal region. The effects were assessed with the Gross Motor Function Measure (GMFM-88) at baseline, six weeks, and 12 weeks. A factorial analysis of variance was used to examine group differences over time. **Results:** No significant differences were found for the GMFM-88 scores between groups over time. **Conclusion:** Therapeutic taping does not evoke a positive functional change in the seated postural control of children with quadriplegic cerebral palsy. Subjective observation, however, suggested that one child with athetosis benefited from therapeutic taping over the paraspinal region. **(Pediatr Phys Ther 2006;18:245–252)** *Key words: activities of daily living, cerebral palsy, child, controlled clinical trial, physical therapy methods, posture, spastic diplegia, splints, treatment outcome*

INTRODUCTION

The functional skill of sitting is required for many activities that children encounter in their daily lives.[1–3] In typical development, the maturation of a child's postural control system generally ensures task-specific stability and orientation to support the primary movements required for functional activities.[3–6] Unfortunately, children with cerebral palsy (CP) often rely upon inappropriate control strategies and faulty feedback mechanisms when learning to maintain both static and dynamic sitting postures, which inevitably leads to "postural dyscontrol" and functional dependency.[3,5,7,8] In other words, the postural control system cannot effectively control the body's position and motion in space because it lacks the ability to generate appropriate muscular force and to coordinate and integrate the sensory information received from various receptors throughout the body.

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Therapeutic interventions for seated postural dyscontrol typically are directed at improving the quality of information feedback, as well as stabilizing the body for functional control.[9] This can theoretically be accomplished by improving postural alignment and gravitational forces about the body, through which optimal muscle length and normalization of recruitment and timing patterns of muscles might be accomplished. These interventions might thereby enable control to be gained over the entire vertically oriented column of segments.[10] Unfortunately, many years of therapy often are needed for children with CP to gain functional sitting control, and the time spent in therapeutic activity is minimal in relation to the amount of time the child spends in inappropriate postural movement patterns. Frequently, skills achieved in the presence of a therapist are not practiced again until the next therapy session. Under such conditions, the necessary repetition of precise performance required for the development of postural control is unlikely to be achieved. Theoretically, if a more efficient way to achieve functional sitting control could be developed, then the therapist may more effectively elicit a change and improve the capacity to function within daily environments.

The application of thermoplastic orthotic devices may allow the child to gain such control outside of the presence of the therapist. The rigidity of this type of orthotic intervention theoretically acts through biomechanical principles to reduce the degrees of freedom at which learning must simultaneously take place, to control postural alignment, to prevent deformity, and to improve function.[10,11] While thermoplastic orthotic intervention can be used for seated postural control, it is at the sacrifice of the child's ability to move freely and limits the child's sensorimotor experiences for motor learning. Dynamic bracing offers an alternative approach. Such braces are generally fabricated from Lycra material and have been referred to as dynamic Lycra pressure orthoses, Lycra splints, Lycra garment or, more specifically, as the UPsuit or the SPIO bracing system. The inherent flexibility of these orthoses allows freedom of movement while ensuring intimate skin contact with dynamic corrective forces; thus, as the user experiences more normal movement patterns, these preferred movements could be learned.[12–15]

The efficacy of Lycra garments for improving function in children with CP has received attention in recent years. Children with athetosis, ataxia, and/or hypotonia have been identified as the most likely candidates as evidenced by an improvement in proximal stability, reduction in involuntary movement, improved sensory awareness, and improved posture with the use of the full body Lycra garments.[13,15–17] Nicholson noted improvements in Pediatric Evaluation of Disability Inventory (PEDI) reach and grasp scores.[17] Knox[15] used the Gross Motor Function Measure (GMFM) and the Quality of Upper Extremity Skills Test (QUEST) tests. The author reported improvements in sitting balance, grasping, and self-feeding but also reported that four of eight children did not complete their trial.[15] Finally, Blair et al[13] studied 32 children with motor impairments and baseline GMFM-88 scores ranging from profound (less than 12%), severe (12% to 31%), moderate (32% to 72%), and mild (greater than 89%). The authors reported that the children classified as severely and moderately impaired at the baseline measurement demonstrated the greatest gains in stability and motor skills, as determined by descriptive analysis, rather than a repeated GMFM-88 test. It was also suggested that for optimum benefit, the wearers needed to have a capacity for purposeful intent and active participation in their daily activities.[13]

Although dynamic splinting is certainly a viable intervention option for poor postural control, each brace is (1) custom made to meet the individual needs of each child, (2) expensive, (3) perceived to be inconvenient and not user friendly, (4) hot, and (5) not accommodative to the growth of the child.[13,15] As an alternative to Lycra garments, therapeutic taping may afford similar advantages for controlling the seated posture in children with CP. It is proposed that therapeutic taping would provide the foundation for improved functional sitting abilities by (1) increasing proprioceptive and tactile facilitation; (2) controlling trunk movement in the frontal and sagittal planes; (3) restoring optimal muscle length to provide a foundation for normal firing and recruitment patterns; (4) orienting the muscle force along more normal vectors; (5) stabilizing hypermobile joints and reduce relative flexibility; (6) assisting with static and dynamic balance; and (7) optimizing gravitational forces about the column of segments by improving body alignment.[18] Currently, no quantitative evidence exists that the use of adhesive tape over the paraspinal musculature improves postural control in children with neuromotor impairments.

Purpose

Results from previous intervention studies on children with CP suggest that improvements in sitting control can be achieved through the facilitation of sensorimotor systems, enhancement of postural alignment, and with the application of dynamic splinting.[12] The goal of this project was to determine if therapeutic taping could affect functional sitting control in children with CP, as quantified by the GMFM-88. It was hypothesized that there would be a differential change in GMFM-88 scores during a 12-week period of time.

METHODS

Subjects

Eighteen children participated from four schools within the Miami-Dade County Public Schools (MDCPS) system in Florida. The inclusion criteria were as follows: (1) medical diagnosis of CP, spastic quadriparesis; (2) male or female between the ages of three and 13 years; (3) recipient of physical therapy (PT) for a minimum of one hour per month by a MDCPS physical therapist; (4) good health status, operationally defined as asymptomatic for acute treatable illness; (5) unable to sit in a conventional classroom chair without physical assistance; (6) not having participated in any previous trials with adhesive tape to the trunk musculature; and (7) classified with a maximum of Level IV on the Gross Motor Function Classification System for Cerebral Palsy (GMFCS). Children also were included despite having had surgical intervention to correct lower-extremity orthopedic abnormalities. A physician's referral for PT and written informed consent was obtained for all participants prior to their inclusion in this study.

The exclusion criteria were as follows: (1) any orthopedic or neurologic condition identified by the physician's referral that was contraindicative of positioning the child in a vertical sitting position; (2) children who could assume a functional sitting position for full participation in classroom activities; (3) children who demonstrated allergic reactions to the adhesive tape or any other materials used in this study; (4) the presence of a structural scoliosis as identified by the physician's referral form; and (5) children who had surgically implanted spinal instrumentation.

Once the children met the aforementioned inclusion criteria, they participated in an eight-day skin check to rule out rare toxic responses to adhesive tapes and other preparation products before full inclusion in this study. All 18 subjects were ultimately included in the study and were assigned randomly (coin toss) to one of two groups: (1) the experimental group (n = 9; taping intervention and school-based PT); or (2) the control group (n = 9; school-based PT only). Within the control group four children participated in educational programs for the physically impaired and five children were in programs for the profoundly mentally handicapped. Within the experimental group, three children participated in educational programs for the physically impaired and six children were in the profoundly mentally handicapped programs.

Instrumentation

The GMFM-88 was administered to quantitatively determine the functional sitting abilities of the participants. The GMFM-88 is an observational measurement tool that incorporates 88 items that address five gross motor function domains: (1) lying and rolling, (2) sitting, (3) crawling and kneeling, (4) standing, and (5) walking, running, and jumping. This study emphasized the dimension for sitting as well as the total score for all five domains together.

Therapeutic Taping Procedure

The three school-based physical therapists that were directly involved in the participants' therapy programs were trained and deemed proficient to administer the therapeutic taping intervention proposed in this study. The materials used in this project included Beiersdorf's Leukotape® P (BSN Medical, Victoria, Australia), Beiersdorf's Cover-Roll® stretch tape (BSN Medical), Phillips'® Milk of Magnesia, 2 × 2-inch gauze pads, Smith and Nephew's (Largo, FL) Unisolve® adhesive remover wipes, and Eucerin® original moisturizing lotion.

Fig. 1. Illustration of therapeutic taping application.

The taping materials were applied as follows: (1) the subjects were positioned in a supported upright sitting position; (2) the skin was prepared by applying the milk of magnesia with a 2 × 2 gauze pad over the paraspinal musculature from thoracic vertebra-1 (T_1) to the lumbar vertebrae-3, 4 (L_{3-4}) as well as over the lower trapezius muscle from thoracic vertebra-12 (T_{12}) obliquely to the acromium process; (3) the Cover-Roll stretch tape was applied bilaterally in the following manner: Strips #1–2 were placed immediately lateral to the vertebral spinous processes in a caudal-cephalo direction from L_{3-4} to T_1; strips #3–4 were placed along the course of the lower portion of the trapezius muscle in a lateral to medial direction from the acromium process obliquely to T_{12}; and (4) the Leukotape P tape was then applied directly over the Cover-Roll stretch tape in a similar manner as the Cover-Roll® stretch tape application (Fig. 1). The tape was removed and reapplied according to the 12-week schedule presented in Table 1. After the adhesive taping materials were removed, Smith and Nephew's Uni-solve® adhesive remover wipes were used to eliminate any remaining tape residue and Eucerin® lotion was then applied to the subjects' backs.

Data Acquisition & Analysis

One week before the start of the therapeutic taping intervention, baseline data for the GMFM-88 were established for each subject. All subjects were assessed and videotaped by one physical therapist within the PT department at their schools. The videotaped assessments were then blindly reviewed and scored by two pediatric physical therapists who were trained in the use of the GMFM-88, but who were not directly involved in the any of the

TABLE 1

Twelve Week Therapeutic Taping Schedule

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week 1	ON-AM*	OFF-PM†	OFF	ON-AM	OFF-PM	OFF	OFF
Week 2	ON-AM	OFF-PM	OFF	ON-AM	OFF-PM	OFF	OFF
Week 3	ON-AM	OFF-PM	OFF	ON-AM	OFF-PM	OFF	OFF
Week 4	ON-AM	ON	ON	OFF-PM	ON-AM	ON	ON
Week 5	OFF-AM	ON-AM	ON	OFF-PM	ON-AM	ON	ON
Week 6	OFF-AM	ON-AM	ON	OFF-PM	ON-AM	ON	ON
Week 7	OFF-AM	ON-AM	ON	OFF-PM	ON-AM	ON	ON
Week 8	OFF-AM	ON-AM	ON	OFF-PM	ON-AM	ON	ON
Week 9	OFF-AM	ON-AM	ON	OFF-PM	ON-AM	ON	ON
Week 10	OFF-AM	ON-AM	ON	OFF-PM	ON-AM	ON	ON
Week 11	OFF-AM	ON-AM	ON	OFF-PM	ON-AM	ON	ON
Week 12	OFF-AM	ON-AM	ON	OFF-PM	ON-AM	ON	ON

* Therapeutic taping was applied in the morning by the physical therapist.
† Therapeutic taping was removed in the evening by the parent.

subjects' intervention. Two different scores were obtained for each subject, (1) the target goal score for sitting domain and (2) the total outcome score for all five domains combined. The effects of the experimental treatment were assessed after six weeks of intervention and then again at the conclusion of the 12-week program. The scores were subsequently averaged for the two therapists and analyzed using a factorial analysis of variance to compare the GMFM-88 scores at the three measurement times: baseline, six weeks, and 12 weeks.

RESULTS

The mean ages for the experimental group (6.5 ± 2.7 years) and control group (5.5 ± 1.9 years) were not significantly different ($t_{[16.0]} = -1.0594$, $p = 0.4078$; Table 2). In addition, the difference in absentee rate between the experimental group (5.4 ± 5.3 days) and control group (8.9 ± 8.2 days) was not statistically significant ($t_{[16.0]} = 0.8502$, $p = 0.3051$).

Pearson product-moment correlation coefficients (r) for the total GMFM-88 scores at baseline, six weeks, and 12 weeks were 0.9262, 0.8708, and 0.9132, respectively (Table 3). The Pearson product-moment correlation coefficients for the target goal score for sitting at baseline, six weeks, and 12 weeks were 0.7944, 0.8994, and 0.9422, respectively. Intraclass correlation coefficients (ICC [3,1]) also were calculated to assess inter-rater reliability. The baseline, six week, and 12-week ICC (3,1) values for the total GMFM-88 scores were 0.9190, 0.8623, and 0.9081, respectively. Similarly, the ICC (3,1) values for the target goal score for sitting at baseline, six weeks, and 12 weeks were 0.7876, 0.8630, and 0.8211, respectively.

The mean GMFM-88 total and sitting domain individual scores are presented in Figures 2 and 3. The mean GMFM-88 total and sitting domain group scores for the experimental and control groups are presented in Table 4. A 2 × 3 mixed factorial analysis of variance was performed to determine differences between the two experimental conditions and within the three time periods. Parallel analyses were performed on two different dependent variables: (1) total GMFM-88 score, and (2) target goal score for sitting (Tables 5 and 6). The analysis of variance results revealed (1) no significant main effect in GMFM-88 scores for the experimental condition in either dependent variable ($p > 0.05$), (2) no significant main effect in GMFM-88 scores for time period for either dependent variable ($p > 0.05$), and (3) the interaction comparison for the GMFM-88 scores between the experimental conditions over the three

TABLE 2
Subject Demographics

	Subject ID	Age (yr-mo)	Gender	Type of CP	GMFCS Level	Educational Program
Control	1	7-8	M	Spastic Quadriparesis	IV	PI*
	2	8-0	F	Athetiod	IV	PMH†
	3	5-4	M	Spastic Quadriparesis	V	PMH
	4	5-0	M	Spastic Quadriparesis	IV	PI
	5	7-6	F	Athetoid	V	PI
	6	3-4	M	Spastic Quadriparesis	V	PMH
	7	4-8	F	Athetoid	IV	PI
	8	6-0	M	Spastic Quadriparesis	V	PMH
	9	3-4	F	Spastic Quadriparesis	V	PMH
Experimental	10	9-7	M	Spastic Quadriparesis	IV	PMH
	11	5-0	F	Spastic Quadriparesis	V	PMH
	12	8-4	F	Spastic Quadriparesis	IV	PI
	13	11-7	M	Spastic Quadriparesis	IV	PI
	14	4-4	M	Spastic Quadriparesis	V	PMH
	15	3-6	F	Spastic Quadriparesis	V	PMH
	16	5-11	F	Spastic Quadriparesis	V	PMH
	17	5-0	M	Athetoid	IV	PMH
	18	4-7	M	Spastic Quadriparesis	IV	PI

* Educational program for children with physical impairments (PI).
† Educational program for children with profound mental handicaps (PMH).

TABLE 3
Inter-Rater Reliability Coefficients

	Baseline		Six Weeks		12 Weeks	
	r	ICC (3,1)	r	ICC (3,1)	r	ICC (3,1)
Total GMFM	0.9262	0.9190	0.8708	0.8623	0.9132	0.9081
Score	$p < 0.0001$		$p < 0.0001$		$p < 0.0001$	
Target goal	0.7944	0.7876	0.8994	0.8630	0.9422	0.8211
Score for sitting	$p < 0.0001$		$p < 0.0001$		$p < 0.0001$	

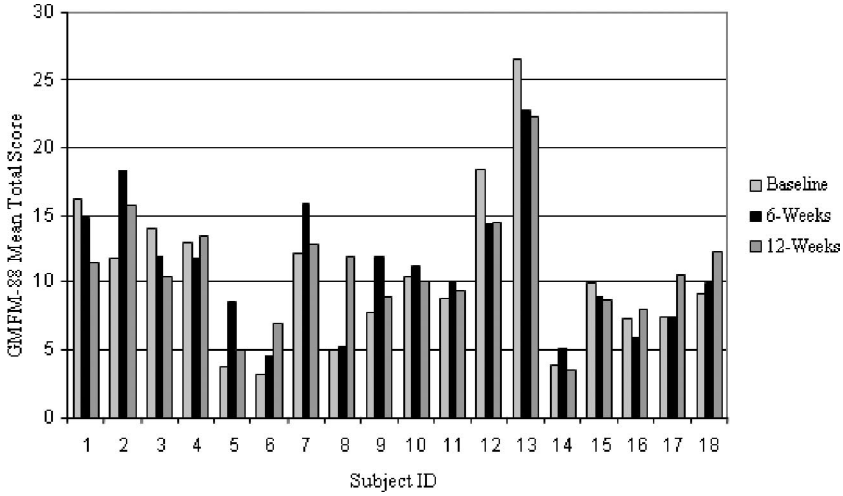

Fig. 2. Individual GMFM-88 mean total scores.

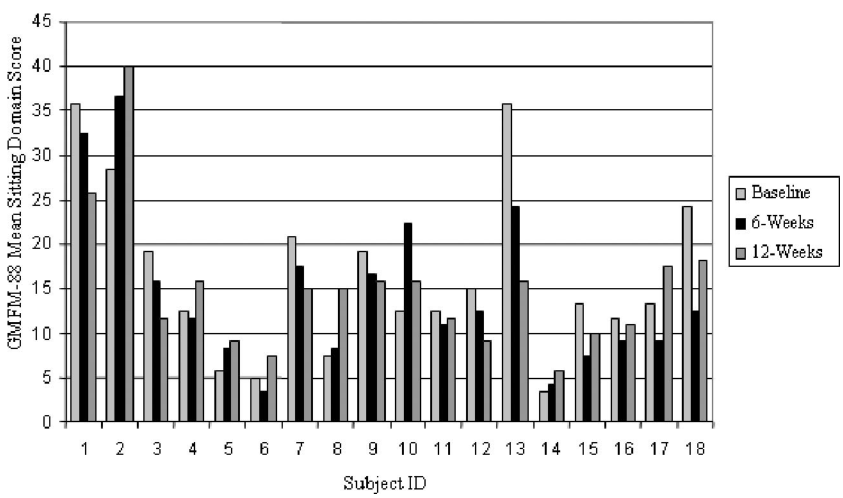

Fig. 3. Individual GMFM-88 mean sitting domain scores.

TABLE 4

Mean (±SD) GMFM-88 Total and Sitting Dimension Scores for Each Group Over Time

	GMFM-88 Total Score			GMFM-88 Target Goal Score for Sitting		
	Baseline	Six Weeks	12 Weeks	Baseline	Six Weeks	12 Weeks
Experimental group	11.27 (±6.91)	10.61 (±5.31)	11.01 (±5.15)	15.74 (±9.21)	12.50 (±6.67)	12.78 (±4.27)
Control group	9.62 (±4.80)	11.36 (±4.53)	11.00 (±2.81)	17.13 (±10.52)	16.75 (±11.15)	17.31 (±9.98)

time periods was not statistically significant for either dependent variable ($p > 0.05$).

DISCUSSION

The intervention used in this study was designed to be used throughout the day and, thus, could be incorporated into the many functional activities that the child encountered in every day life. Specifically, the intent was to quantitatively determine the functional effects of therapeutic taping on seated postural control in children with CP. Unfortunately, the GMFM-88 measure failed to detect any significant changes that could be attributed to the taping protocol. The following discussion will review the findings, limitations and conclusions of this investigation.

Previous research has demonstrated the usefulness of the GMFM-88 tool for assessing functional outcomes of intervention studies, including PT, selective dorsal root rhizotomies, and therapeutic electrical stimulation.[19–22] For example, Trahan and Malouin (1999) studied 24 children with CP, spastic quadriplegia during an eight-month period of PT intervention.[23] They reported change in the magnitude of 3.9, 2.3, and 6.2 percentage points for three comparisons, across the first four months, four to eight months, and across the full eight months, respectively. They also reported that those with worse levels of impairment

TABLE 5

ANOVA Summary Table: Analysis of GMFM-88 Target Goal Score for Sitting

Source	df	SS	MS	F	*p* Value
Group	1	155.50	155.50	0.76	0.3970
Id (group)	16	3284.21	205.26		
Time	2	32.17	16.08	0.90	0.4172
Time × group	2	27.37	13.68	0.76	0.4739
Error (time)	32	572.90	17.90		
Total	53	4072.15			

TABLE 6

Analysis of Variance Summary Table: Analysis of GMFM-88 Total Score

Source	df	SS	MS	F	*p* Value
Group	1	1.25	1.25	0.02	0.8948
Id (group)	16	1104.23	69.01		
Time	2	3.61	1.80	0.45	0.6423
Time × group	2	13.49	6.75	1.68	0.2026
Error (time)	32	128.58	4.01		
Total	53	1251.16			

also had lower total scores on the GMFM-88 instrument. In another project, Russell et al[24] studied 111 children with CP over a four- to six-month period. Total GMFM-88 scores were reported to change in the magnitude of 1.3 to 6.2 percentage points, with the lower change scores obtained by children who were more severely involved, both physically and mentally. The magnitude of change over time reported in the present investigation was smaller than those reported by other authors. In this study, the magnitude of GMFM-88 total score change for the experimental and control groups ranged from −0.26 to 0.66 percentage points and from −0.36 to 1.74 percentage points, respectively.

The children in the present study obtained baseline GMFM-88 total scores in the profound range of motor impairment (<12%). In addition, 12 of 18 children were classified as profoundly mentally handicapped by a school psychologist, and most of these children were functionally dependent upon others, both physically and cognitively, for all daily activities within the educational environment. Thus, the lack of change may have been related to the severity of the motor involvement of the children studied. In other words, as a group, these children may not have been the appropriate candidates for therapeutic taping because of their level of cognitive and physical functioning. This finding is consistent with that reported by Knox[15] who studied children classified at lower functional levels on the GMFCS, for example, Levels IV and V, and reported smaller change scores on the GMFM. Likewise, Blair et al[13] reported that the Lycra garment enhanced stability and motor skill acquisition in children with moderate-to-severe motor impairments, i.e., 32% to 72% and 12% to 31% GMFM-88 baseline total score, respectively, but failed to elicit a change in children with profound motor impairment, i.e., baseline GMFM-88 total score of less than 12%. In contrast, children capable of purposeful action and active participation in their daily lives are reported to be the ideal candidate for Lycra garments as indicated by the degree of functional change.[13,16,17,25] Rennie et al[25] and Nicholson et al[17] reported functional, although not significant, change when using the PEDI in studies of children that were ambulatory or who were capable of purposeful movement.

In addition to consideration of the child's functional ability, the 12-week taping timeframe in this study may have influenced the outcomes.[17,25] Blair et al[13] intervened for a 16-week period with reported functional change. The four-week time differential between the present study and the study reported by Blair et al[13] have might also affected the long-term functional outcomes of this investigation. In other words, the children were simply unable to demonstrate a functional change in such a short period of time. This finding is consistent with Knox, who studied a similar population, but for a four-week period of time.[15]

Subjective improvements in trunk stability and immediate reduction of involuntary movements was observed in a child with athetosis who was capable of purposeful action, which suggests that this child may have been the more ideal candidate for therapeutic taping. This finding is consistent with the evidence for Lycra garments that suggested that children with athetosis, ataxia, or hypotonia were the most ideal candidates.[13,16,17,25] In contrast, the motor impairments of children with exaggerated extensor tone worsened with therapeutic taping, as determined by subjective observation.

Russell et al[24] investigated the relationship between change on the GMFM-88 test and the judgment of clinical importance. It was concluded that a conservative estimate of clinically meaningful change as determined by parents for children with diplegic or quadriplegic CP was 1.825 percentage points. In the present study, although statistical significance was not found between or within the groups, some subjects demonstrated clinically meaningful responses to the intervention. It was expected that children with lower scores should demonstrate the greatest gain upon re-testing. Indeed, six of the eight children that achieved scores in the lower 33rd percentile of the scores obtained in this study (two from the experimental group and four from the control group) demonstrated at least a 1.825 percentage point increase in total GMFM-88 performance. Likewise, four of four children that achieved scores at or below the 33rd percentile in the GMFM-88 sitting scores obtained in this study demonstrated the greatest improvement in sitting performance. Based on this evidence, it was presumed that maturation or a combination of school-based PT and maturation, rather than therapeutic taping alone, had a greater impact on motor function in the children studied.

Four children that achieved baseline GMFM-88 totals at or greater than the 66th percentile of the scores obtained in this study demonstrated a negative change in overall gross motor function during the course of the study. Notably, three of these four children were considered to have only minimal cognitive involvement and were, thus, able to make discernable choices. Similar findings were demonstrated for the target goal score for sitting. The nine children (four with minimal cognitive impairment) that failed to demonstrate any improvement in sitting abilities over time achieved baseline-sitting scores between the 66th and 100th percentile of the scores obtained in this study. In general, it can be speculated that because these children began the study at a higher level of overall gross motor function and sitting abilities, their performance regressed to the mean and did not increase as much as those who had lower baseline scores.

CONCLUSIONS

Results from previous intervention studies on children with CP suggested that improvements in sitting control could be achieved through the facilitation of sensorimotor systems, enhancement of postural alignment, and with the application of dynamic splinting.[1,8,9,13,26] The predominance of statistical evidence presented in this study suggested that therapeutic taping was an ineffective means for addressing seated postural control in the children studied. Notwithstanding, one particular child with athetosis and capable of purposeful movement did, indeed, demonstrate subjective improvements in response to therapeutic taping. In particular, this child exhibited an immediate decrease in involuntary movement and increase in trunk stability when the tape was applied. Therefore, although the results suggested that therapeutic taping was not an effective strategy for children with CP, quadriplegia, it may behoove the clinical researcher to utilize a multiple case study design with children with athetosis to discriminate the population of children that may actually benefit from therapeutic taping.

Recommendations for Future Research

Future studies may be warranted to determine the effect of therapeutic taping on gross motor function while the tape is applied. Because the GMFM-88 was administered to all children when the tape was not applied, the present study did not address whether functional changes would occur while the tape was applied. It may be relevant to examine the direct functional implications of the taping protocol by administering the GMFM-88 instrument under the taped condition to determine the direct effects of therapeutic taping on motor performance in children with quadriplegic CP.

Recommendations for Clinicians

Subjective clinical assessment indicated that therapeutic taping might be appropriate for children with athetosis who are capable of purposeful action. In contrast, therapeutic taping seemed to be ineffective for children with exaggerated extensor tone and/or limited cognitive function. Therefore, it is recommended that clinicians assess the child's classification of CP, postural tone, and cognitive status when considering therapeutic taping as an option for addressing seated postural control in children with quadriplegic CP.

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