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Changes in Two Children with Cerebral Palsy After Intensive Suit Therapy: A Case Report

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Purpose: The purpose of this case report was to investigate effects of intensive suit therapy on gait, functional skills, caregiver assistance, and gross motor ability in children with cerebral palsy. **Case Description:** Two children with spastic diplegia classified at level III on the Gross Motor Function Classification System participated. Outcomes were assessed using dimensions D and E of the Gross Motor Function Measure, the Pediatric Evaluation of Disability Inventory, and instrumented gait analysis. **Intervention:** Each child participated in the Therasuit Method, 4 hours a day, 5 days a week for 3 weeks. **Outcomes:** Very small improvements in function were noted in dimension D of the Gross Motor Function Measure and Pediatric Evaluation of Disability Inventory Self-care Domain with decreased function in other areas. Improved walking speed, cadence, symmetry, joint motion, and posture were found with gait analysis. **Conclusion:** Further investigation is needed of the suit itself, and intensive therapy programs in children with cerebral palsy. **(Pediatr Phys Ther 2010;22:76–85)** *Key words: activities of daily living, cerebral palsy, child, exercise intensity, exercise therapy, human movement system, motor skills, physical therapy modalities, self care, space suit, spastic gait*

INTRODUCTION

"Cerebral palsy (CP) describes a group of disorders of the development of movement and posture, causing activity limitation, that are attributed to nonprogressive disturbances that occurred in the developing fetal or infant brain."[1] Children with CP typically demonstrate problems with body functions and structures, such as decreased muscle strength, limited passive joint mobility, altered motor control, and poor alignment that limit their activity. Physical therapy (PT) interventions address these problems with the goals of improving movement patterns and optimizing the child's ability to participate in functional activities such as gross motor skills and ambulation. The benefits of task-specific training[2–4] and muscle strengthening[5–10] in children with CP are known; however, the appropriate intensity of training and strengthening, necessary to maximize the benefits, is unknown and is a topic of interest to pediatric therapists.

The typical frequency of physical therapy for children with CP in an outpatient setting is not well documented. Recently, attention has been given to the potential benefits of interventions that advocate intensive bursts of therapy. For example, strengthening programs with frequencies of up to 3 times a week demonstrate improvements in gait and function.[5–10] Protocols have been center based[5,9,10] or home/community based[6–8] and have reported changes in gross motor function,[6,7,9,10] cadence, and walking speed.[6,8,9] Other more intensive programs, with a frequency of up to 5 times a week, suggest that functional and gross motor skills of children with CP are improved when rehabilitation focuses on training-specific functional skills (FS).[3,4] One type of high-frequency intervention program, intensive suit therapy, is becoming

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available to patients and families at more locations throughout the United States and other countries.[11] One such program, the Therasuit Method, is a 3-week program that combines strengthening and FS training with a frequency of 3 to 4 hours a day, 5 days a week and claims to improve function at a faster rate than other therapy programs.[11] Proponents say that the Therasuit Method "aligns the body to as close to normal as possible," "promotes development of both fine and gross motor skills," and "normalizes (corrects) gait pattern."[12] The Therasuit Method includes using the Universal Exercise Unit (Fig. 1) and wearing a suit (Figs. 2A, B) with bungee cords attached in ways to "stabilize," "facilitate," and "load" muscle groups.[13]

Evidence indicating greater functional benefit from participation in intensive suit therapy is limited. The only published study of intensive suit therapy is a prospective randomized quasi-experimental study comparing neurodevelopmental treatment with intensive suit therapy in 24 children with CP (aged 6–12 years, Gross Motor Function Classification System [GMFCS] levels II-IV).[14] Each group participated in a therapy program of 2 hours a day, 5 days a week, for 4 weeks. Immediately after and 10 months after the intervention, the functional outcomes were measured using the Gross Motor Function Measure (GMFM)-66, and energy cost was calculated for stair climbing. Both the neurodevelopmental treatment and intensive suit therapy groups showed improvement in motor skills and energy efficiency compared with baseline, but between-group analyses showed no statistical difference. Interestingly, when each treatment group was further classified based on preintervention motor function, the suit intervention resulted in increased mechanical efficiency at 10-month follow-up for those with higher level motor function at baseline.

Fig. 1. Universal exercise unit.

Although Bar-Haim et al[14] did not find statistically significant effects of suit therapy on motor function, published abstracts of suit therapy with weaker methodology do suggest improvements in function as measured by the GMFM-88,[15,16] walking ability,[17] and performance on the 6-minute walk test.[16,17] Also, Dabrowski et al[18] published an abstract in which they reported a randomized and blinded study comparing the function of a heterogeneous group of children with CP (n = 50) who completed an intense program while wearing a suit with that of a group who completed the same program without a suit. The authors[18] suggested that those wearing the suit demonstrated greater improvements in GMFM scores during a 12-week follow-up period, but the difference was not statistically significant. However, this work by Dabrowski et al[18] suggests that gait analysis may be a useful outcome measure to determine effects of the suit in future work.

Although studies imply a trend toward improvement in function after intensive suit therapy, the effectiveness of suit therapy programs on gait and function has not been established. Therefore, the purpose of this case report was

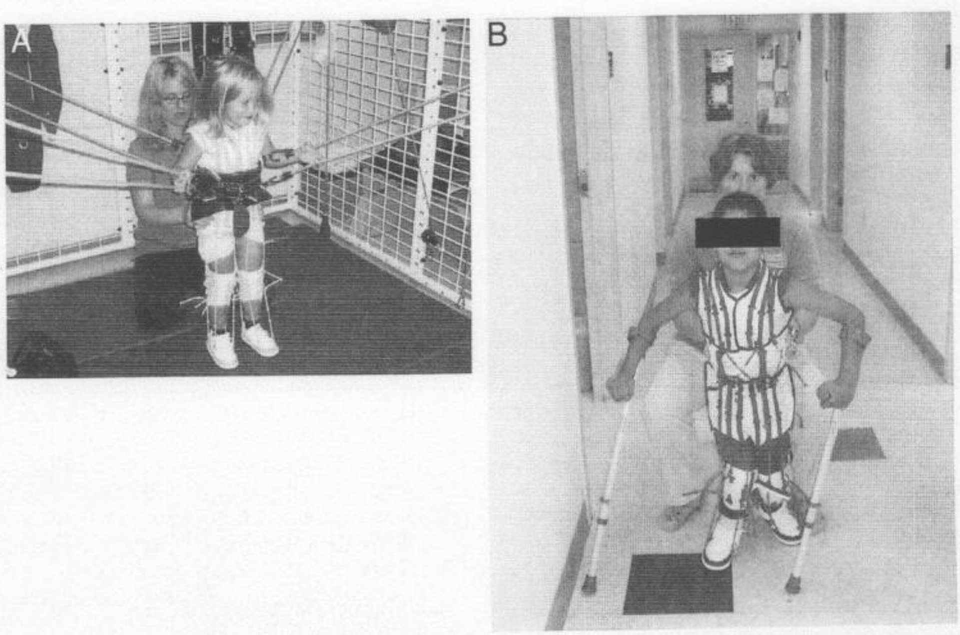

Fig. 2. A, Example of patient working in the universal exercise unit wearing the Therasuit. B, Gait training in the Therasuit.

to investigate the effects of intensive suit therapy on gait, FS, caregiver assistance, and gross motor ability in 2 children with spastic diplegia.

DESCRIPTION OF CASES

Two children with spastic diplegia participated in intensive suit therapy per the Therasuit Method.[19] This study was approved by our institution's Internal Review Board, child assent was not required, and consent was obtained from each caregiver/guardian before the initiation of the study. A description of each child's history is summarized in Table 1. Both children had a medical diagnosis of spastic diplegia, were classified as level III on the GMFCS, had previously participated in the Therasuit Method, could follow instructions, and were not taking oral antispasticity medication. Exclusion criteria were as follows: hip subluxation >35%, severe scoliosis, intrathecal baclofen pump, autism, attention deficit disorder, progressive encephalopathy, any psychiatric or behavior disorders, or uncontrolled seizures. Each child was cleared by a physician before participation in the intervention.

MEASUREMENT TOOLS

Performance on the Pediatric Evaluation of Disability Inventory (PEDI), dimensions D and E of the GMFM, and 3-dimensional gait analysis were measured before and after the intervention. The preassessment was completed 3 days and 10 days before the intervention for participant 1 and 2, respectively. For both participants, the postassessments were completed 4 days after the intervention. The same physical therapists administered the PEDI and dimensions D and E of the GMFM (A.F.B.) and the gait analysis (L.C.S.) before and after the intervention.

PEDI

The PEDI is a parental-report questionnaire that assesses the functional abilities of infants and children aged 6 months to 7½ years old. However, the PEDI can be used with older children if their abilities are less than expected for a 7½-year old child without disabilities.[20] The PEDI has 2 scales, FS and Caregiver Assistance (CA). Within each scale, there are 3 domains: self-care, mobility, and social function. In this study, the self-care and mobility domains within each scale were used, as it was expected the intervention might change scores in these areas. For the FS Scale, each item on the PEDI is scored as 0 (unable to perform) or 1 (able to perform), and a total score is obtained by adding the items.[20] For the CA Scale, the items are scored from 0 to 5 (0, total assistance to 5, completely independent). Scaled scores were used to evaluate changes over time. The PEDI has established reliability,[20] validity,[21,22] and has been shown to be sensitive to change in children with CP.[23,24]

Dimensions D and E of the GMFM

The GMFM is an assessment of motor skills developed for children with CP that was originally developed as an 88-item instrument, and after Rasch analysis was reduced to 66 items to improve interpretability.[25] It has been shown to be reliable, valid, and responsive to change in gross motor function for children with CP.[25] Item scores range from 0 to 3 (0, does not initiate to 3, completes). The items on dimension D (standing) and E (walking, running, and jumping) are the same for both the 88- and 66-item versions. However, dimension percentage scores, as described in the manual for the GMFM-88, rather than a total test score from the GMFM-66 or -88, can be used when detecting change over time in a specific area of interest.[25] Higher level skills were of most interest in this case report; therefore, percentage scores on dimensions D and E were evaluated, as has been done previously.[26]

Three-Dimensional Gait Analysis

Trunk, pelvis, and lower extremity joint motion during walking was tracked using a digital 10-camera motion analysis system (Eagle cameras, Motion Analysis Corporation, Santa Rosa, Calif) at 240 Hertz (Hz). The cameras were set-up to detect the motion of reflective markers (10 mm) secured bilaterally over the acromion process, anterior superior iliac spine, anterior aspects of the mid-thigh and tibial tubercle, medial and lateral femoral condyles, medial and lateral ankle malleoli, the dorsal aspect of the foot between the second and third metatarsals, base of the calcaneous and over the sacrum and left scapula.

Participants walked barefoot along a 10-meter walkway at their self-selected walking speed and were encouraged to walk as independently as possible. Participant 1

TABLE 1
Participant History

Participant Gender	Age*	Diagnosis	Preferred Method of Community Ambulation	Muscle Groups and Age When Botox Was Injected	Procedure and Age When Surgery Was Performed
F	8 yr, 3 mo	CP, spastic diplegia	Using 1 Lofstrand crutch	B Gastrocnemius: 33 mo, 60 mo; B Hamstrings: 36 mo, 41 mo, 44 mo	Selective dorsal rhizotomy, 47 mo; percutaneous selective myofascial lengthenings of B hamstrings, Achilles tendons, and adductors, 82 mo
M	7 yr, 11 mo	CP, spastic diplegia	Using 2 single-point canes	B Gastrocnemius: 29 mo, 36 mo; B Hamstrings: 33 mo	Selective dorsal rhizotomy, 36 mo; percutaneous selective myofascial lengthenings of B hamstrings, Achilles tendons, and adductors, 72 mo

*At start of intervention.
B indicates bilateral; CP, cerebral palsy.

completed both gait analyses without assistance and participant 2 used single-point canes bilaterally during both gait analysis sessions. During walking, marker trajectories were recorded (EvaRT software, Motion Analysis Corporation, Santa Rosa, Calif), and data collection continued until at least 4 usable trials were collected for each lower extremity. A usable trial was operationally defined as one in which all markers were visible throughout the entire trial and consecutive steps were taken by the participant along the recording length of the walkway. Data were collected in the same fashion during the pre-testing and post-testing.

The data were processed using Visual 3D software (C-Motion, Inc. Rockville, Md). Marker data were filtered with a fourth-order Butterworth filter at a cut-off frequency of 6 Hz, and joint angles were calculated with Cardan angles. Initial contact and toe-off were defined using the heel marker and target pattern recognition. Lower extremity joint angles were normalized to 100 data points across the gait cycle (initial contact to ipsilateral initial contact) and trunk and pelvis motion were normalized to 100 data points across stance phase (initial contact to ipsilateral toe off).

DESCRIPTION OF INTERVENTION

The Therasuit Method of intensive suit therapy was administered for 4 hours a day, 5 days a week for 3 consecutive weeks by physical and occupational therapists specifically trained in the intervention protocol. All of the activities of the Therasuit Method were administered in the same sequence each day (see Table 2 for details). The Therasuit was fit based on each child's size and was only worn during the treatment intervention beginning with 30 minutes of wear time on day 1 of the intervention. Each child then progressed to wearing the Therasuit an additional 30 minutes each day to a maximum wear time of 2.5 hours by day 5 of the intervention and for the remainder of the program. During treatment, both children wore the suit with bungee cords placed over the abdominals, trunk extensors, obliques, gluteals, and the scapular region. Bungee cords were used to connect the vest to shorts, shorts to kneepads, and kneepads to shoes. Each participant's specific program was individualized with the goal of advancing the patient to the next level of function. Both participants completed the program, and each family was instructed in a home program to maintain functional gains at the end of the program.

The program for participant 1 focused on achieving 2 functional goals: ambulating without Lofstrand crutches for community distances and greater independence in self-care skills. Additional bungee cords were added during weeks 2 and 3 for hip stabilization and to facilitate knee flexion and ankle plantar flexion. This child worked on single limb stance activities, ambulation without an assistive device on level and uneven surfaces, stairs, curbs, jumping jacks, dynamic balance skills, using utensils, and dressing skills (shoes, socks, orthoses, pants, and fastening small buttons on shirts) throughout the 3 weeks.

The program for participant 2 focused on achieving 2 functional goals: getting up from the floor and ambulating without single-point canes for short distances. Additional bungee cords were added for the duration of the program for bilateral hip stabilization. This child worked on knee walking, floor to stand transitions, stair climbing, dynamic balance, ambulation with and without an assistive device, hamstring stretching, and typing throughout the 3 weeks. He presented with knee pain before beginning the program, but he was able to complete the full program.

Data Analysis

Score changes on the PEDI self-care and mobility domains and dimensions D and E of the GMFM were compared between pretesting and posttesting sessions. Walking speed, cadence, limb support time, step length, and joint motion of the hip, knee, ankle, trunk, and pelvis were compared between pretesting and posttesting sessions.

TABLE 2

Sequence and Description of Therasuit Method Activities

Activity	Description	Duration
Hot pack and massage	Upper and lower limbs	30 min (hot packs placed for 12- to 15-min periods; 3–6 min for each lower limb massage; 3 min for each upper limb massage)
Pulleys	Using universal exercise unit for lower limb strengthening and range of motion/stretching	30–45 min; approximately 2–4 exercises for 30 repetitions each
Rest break + Toileting 5–10 min		
Donning suit	Therasuit and bungees donned	15–20 min
Therapeutic exercises	Trunk and lower limb strengthening using Swiss balls, bolsters, plinths, benches	30–40 min; 3–6 exercises for 30 repetitions each
Rest break 5 min		
Pulleys	Using universal exercise unit for upper limb strengthening	20 min; approximately 2 exercises for 30 repetitions each
Sensorimotor activities	Using universal exercise unit for jumping or swinging	5 min
Fine motor skills	Activities of daily living and progression of fine motor tasks	30 min
Rest break 5 min		
Balance and coordination activities	Using universal exercise unit	20–30 min; 1–3 exercises completed
Gross motor functional skills	Standing, transitions, and progression of ambulation skills	20–30 min

DESCRIPTION OF OUTCOMES

Dimensions D and E of the GMFM and PEDI

Tables 3 and 4 show pre and post scores of dimensions D and E of the GMFM and PEDI scores. Minor changes were seen on dimensions D and E of the GMFM and the PEDI with the largest increase documented for participant 1 on the PEDI FS self-care domain. Other smaller increases in FS and CA self-care were documented for participant 2. In addition, both participants demonstrated small decreases on some domains of the PEDI.

TABLE 3

Participant 1, Preintervention and Postintervention Performance on GMFM (Raw Scores [%]) and PEDI (Raw Scores [Scaled Scores])

Participant 1	Pre	Post
GMFM dimension D	29/39 (74%)	30/39 (77%)
Single-limb support (Item 57)	0	1
Single-limb support (Item 58)	0	1
Stands, picks up object from floor (Item 64)	3	2
GMFM dimension E	41/72 (57%)	40/72 (56%)
Walks forward between parallel lines (Item 73)	2	1
Steps over stick (Item 75)	1	0
Kicks ball (Item 78)	3	2
Walks backward (Item 71)	2	3
Jumps forward (Item 81)	0	1
PEDI functional skills self-care	58 (67.6)	64 (72.6)
Uses a knife (Item 9)	0	1
Brushes hair (Item 22)	0	1
Puts on shirt, not including fasteners (Item 42)	0	1
Buttons and unbuttons (Item 47)	0	1
Zips and unzips (Item 48)	0	1
Ties shoe lace (Item 58)	0	1
PEDI functional skills mobility	55 (82.5)	55 (82.5)
PEDI caregiver assistance self-care	26 (62.2)	24 (60.1)
Dressing upper body (Item D)	3	1
PEDI caregiver assistance mobility	30 (72.7)	29 (70.5)
Chair/toilet transfers (Item A)	5	4
Stairs (Item G)	5	4

Scores on items that changed are reported.

TABLE 4

Participant 2, Preintervention and Postintervention Performance on GMFM (Raw Scores [%]) and PEDI (Raw Scores [Scaled Scores])

Participant 2	Pre	Post
GMFM dimension D	23/39 (59%)	25/39 (64%)
Single-limb support holding large bench (Item 54)	2	3
Single-limb support holding large bench (Item 55)	2	3
GMFM dimension E	19/72 (26%)	19/72 (26%)
PEDI functional skills self-care	65 (73.6)	66 (74.7)
Puts on unfastened shoes (Item 55)	0	1
PEDI functional skills mobility	56 (85.2)	55 (82.5)
Walks down stairs: no difficulty (Item 59)	1	0
PEDI caregiver assistance self-care	28 (64.5)	31 (68.1)
Dressing upper body (Item D)	1	5
PEDI caregiver assistance mobility	35 (100)	33 (82.5)
Car transfers (Item B)	5	3

Scores on items that changed are reported.

Gait Analysis

Tables 5 and 6 show changes in gait characteristics for both participants. Participant 1 demonstrated improved walking speed (0.26 m/s increase), decreased double limb support time (6% decrease), and no appreciable change in stride length (0.04 m increase). Increased cadence was also noted, with small or no changes observed in single limb support time and step length. Joint motion during walking before and after intervention are shown in Figures 3–5. Most notable, Figure 3 shows improved hip extension at terminal stance changing from 3.3° of hip flexion on the right to 10.9° of hip extension after the intervention, and on the left changing from 2.6° of hip flexion to 12.3° of hip extension after the intervention. Also, improved symmetry was noted with pelvic rotation (Fig. 4) and lateral tilt (Fig. 5).

Participant 2 demonstrated improved walking speed (0.14 m/s increase), no change in double-limb support time, and no appreciable change in stride length (0.01 m increase). Cadence and single-limb support time both increased with small or no changes observed in step length. Joint motion during walking before and after intervention are shown in Figures 6 to 8. Notable improvements included reduced knee hyperextension motion during midstance, on the right reducing from 7.4° of extension to 0.5° of extension, and on the left reducing from 11.3° of extension to 2.7° of extension (Fig. 6). Lateral trunk motion (Fig. 8) showed greater symmetry with little change noted

TABLE 5

Participant 1, Temporal-Spatial Gait Characteristics

Participant 1	Pre	Post
Walking speed, m/s	1.16	1.36
Double-limb support, % gait cycle	17	11
Stride length, m	0.97	1.1
Cadence; [M (SD)], steps/min		
Right	142 (9)	146 (12)
Left	144 (10)	159 (10)
Single-limb support time, % gait cycle		
Right	41	42
Left	43	47
Step length; [M (SD)], m		
Right	0.46 (0.06)	0.49 (0.03)
Left	0.50 (0.03)	0.59 (0.03)

TABLE 6

Participant 2, Temporal-Spatial Gait Characteristics

Participant 2	Pre	Post
Walking speed, m/s	0.82	0.96
Double limb support, % gait cycle	17	17
Stride length, m	0.99	1.0
Cadence; [M (SD)], steps/min		
Right	103.7 (8.07)	106.7 (9.18)
Left	103.6 (8.5)	110.6 (17.6)
Single limb support time, % gait cycle		
Right	42	45
Left	35	40
Step length; [M (SD)], m		
Right	0.51 (0.02)	0.52 (0.06)
Left	0.49 (0.04)	0.54 (0.05)

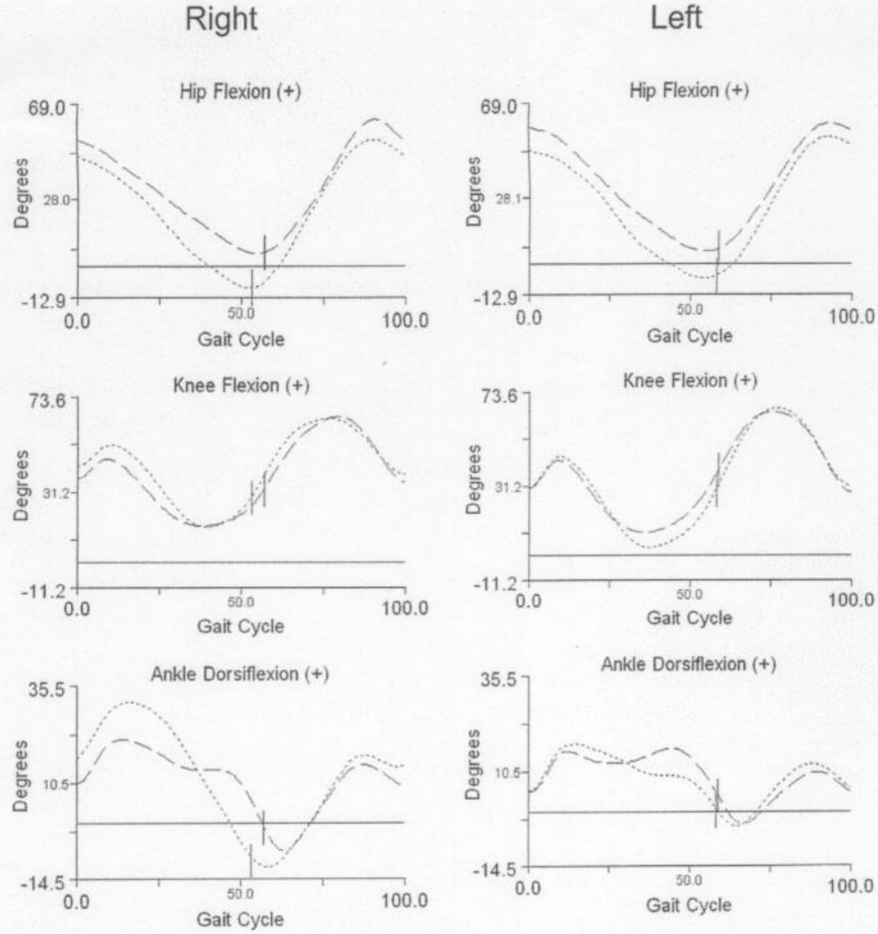

Fig. 3. Participant 1: Hip, knee and ankle flexion, and extension motion across the gait cycle. Dashes indicate pretesting session, dots indicate posttesting session. Hash marks indicate toe-off.

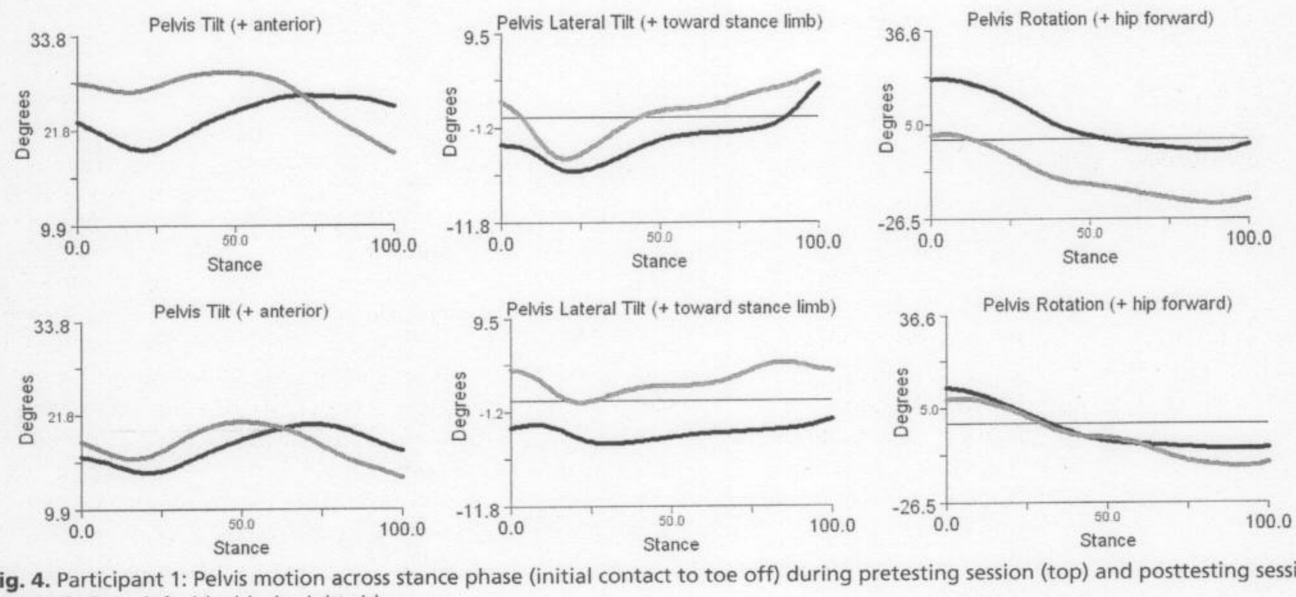

Fig. 4. Participant 1: Pelvis motion across stance phase (initial contact to toe off) during pretesting session (top) and posttesting session (bottom). Gray, left side; black, right side.

at the pelvis (Fig. 7). The use of single-point canes during the testing sessions likely influenced trunk and pelvic motion.

DISCUSSION

The purpose of this case report was to investigate the effects of intensive suit therapy on gait, FS, CA, and gross motor ability in 2 children with spastic diplegia. Both participants showed minimal gains in some areas and decline in other areas of functional performance after the Therasuit Method of intensive suit therapy as measured by dimensions D and E of the GMFM and the PEDI. Our findings indicate that intensive suit therapy may contribute to some

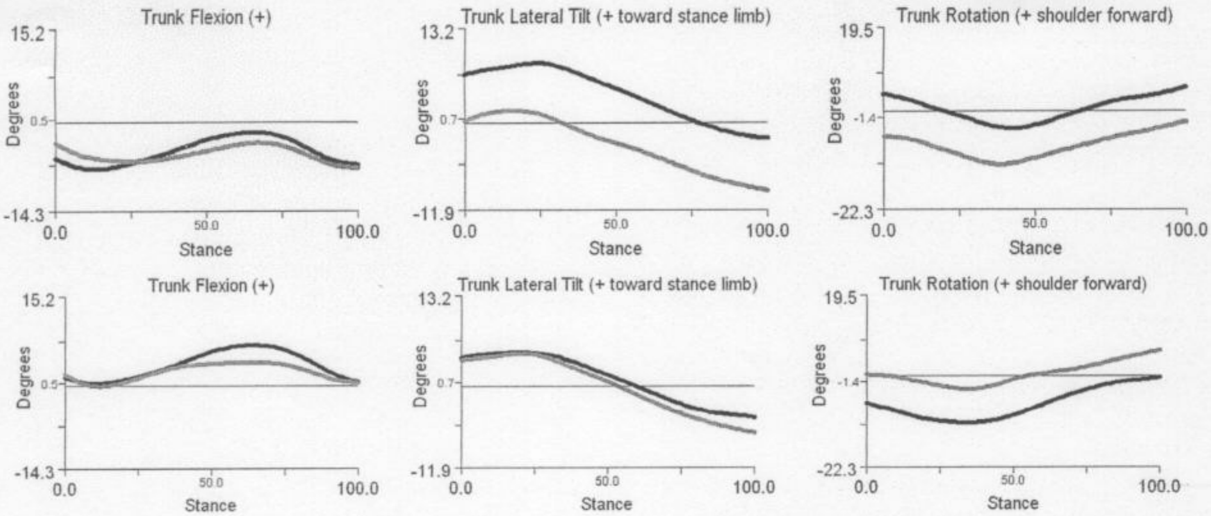

Fig. 5. Participant 1: Trunk motion across stance phase (initial contact to toe off) during pretesting session (top) and posttesting session (bottom). Gray, left side; black, right side.

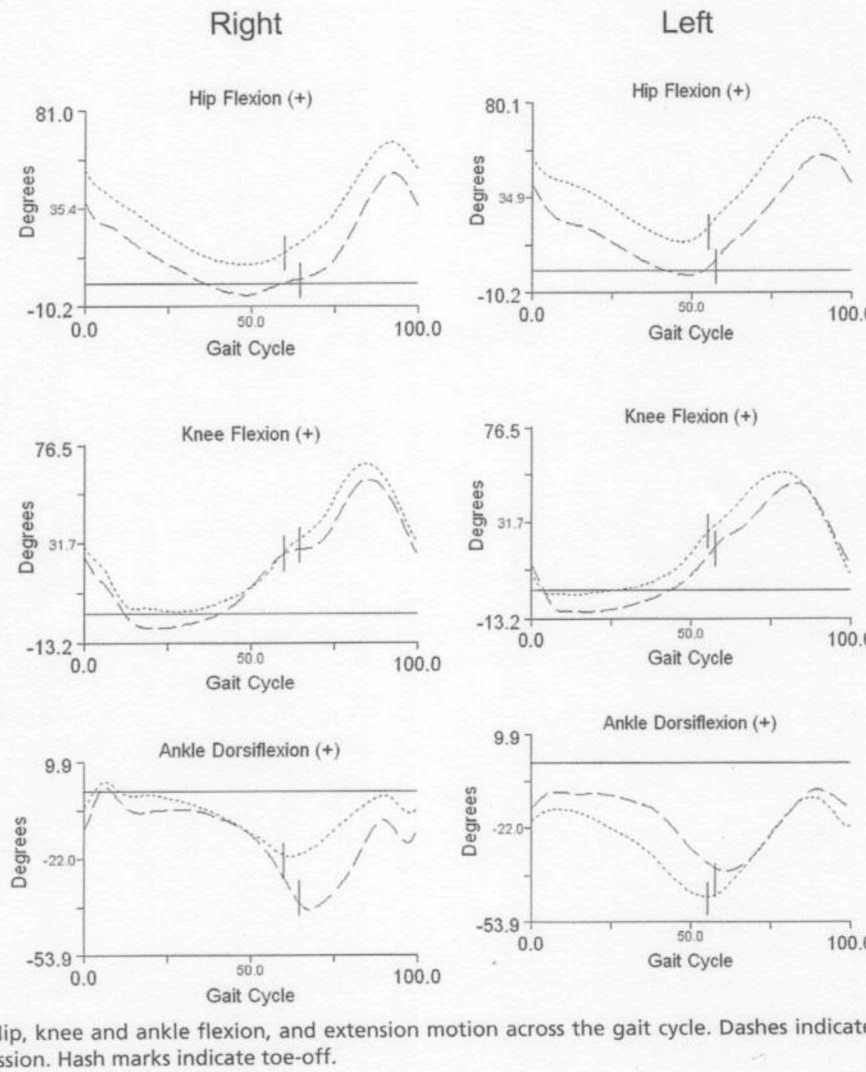

Fig. 6. Participant 2: Hip, knee and ankle flexion, and extension motion across the gait cycle. Dashes indicate pretesting session, dots indicate posttesting session. Hash marks indicate toe-off.

improvements in gait, but further investigation is necessary before recommending this program.

The change scores on dimensions D and E of the GMFM were not as large as expected. Motor development curves, based on the GMFM-66, suggest that the motor development of the participants in this case report may have previously reached the expected limit of their potential.[27] As such, dimensions D and E of the GMFM may not

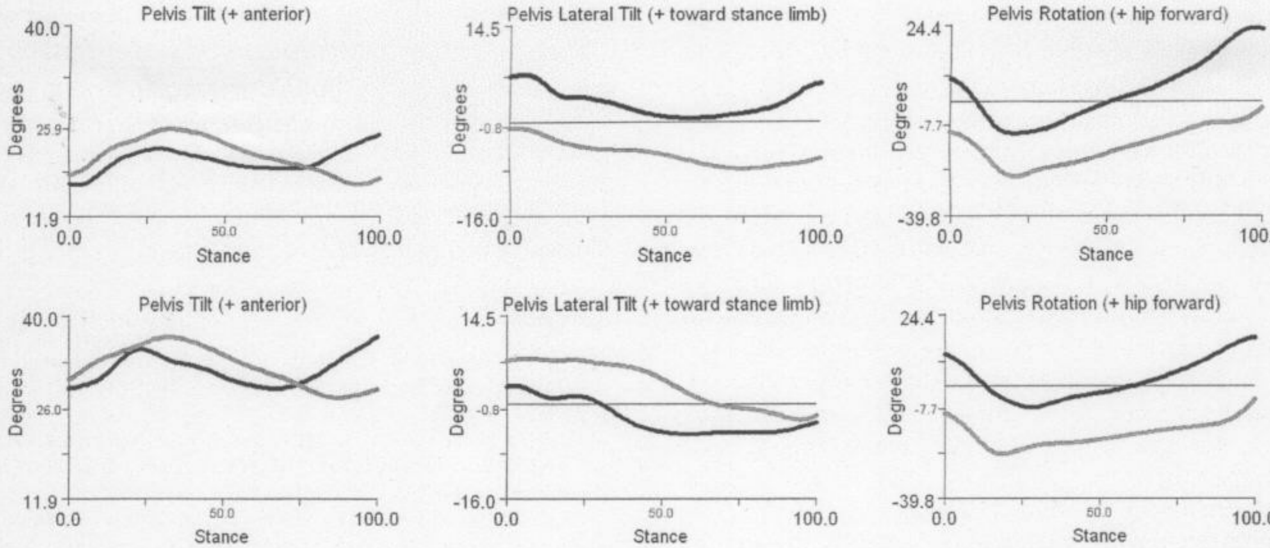

Fig. 7. Participant 2: Pelvis motion across stance phase (initial contact to toe off) during pretesting session (top) and posttesting session (bottom). Gray, left side; black, right side.

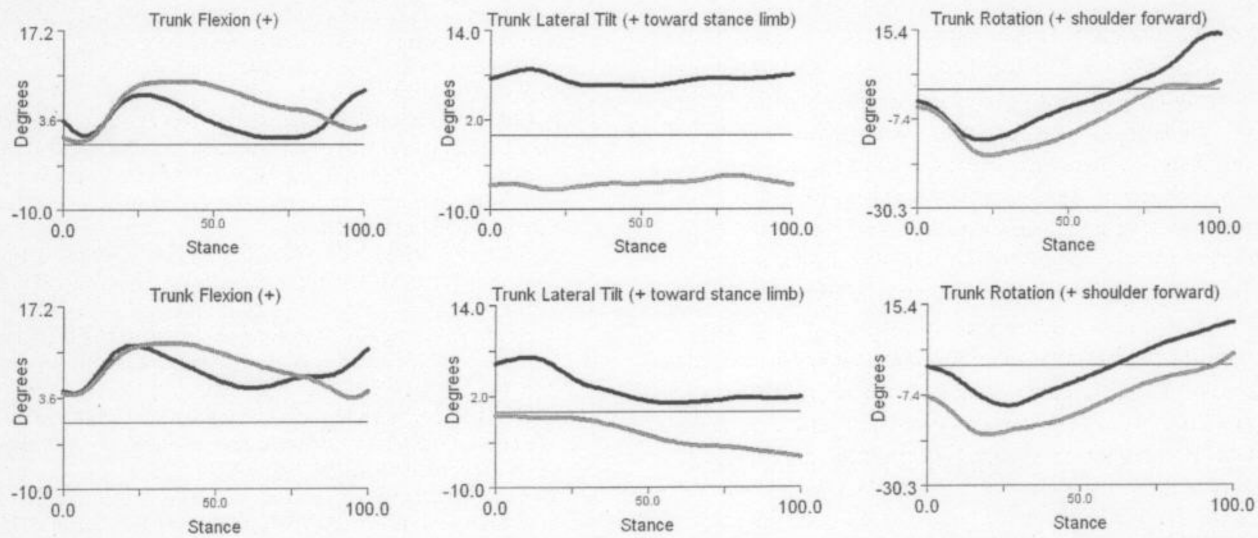

Fig. 8. Participant 2: Trunk motion across stance phase (initial contact to toe off) during pretesting session (top) and posttesting session (bottom). Gray, left side; black, right side.

have been the most sensitive measure by which to detect changes in the gross motor abilities of our participants after the intervention. Additionally, our study obtained scores on only dimensions D and E, which makes it difficult to compare our results with previous work reporting improvements based on total scores.[14–16] Only one other published abstract has reported improvements in GMFM dimension scores after an intensive suit therapy program[17]; however, the description of the subjects suggests that they were not GMFCS level III as in this case report.

We expected to observe improvements on both the self-care and mobility domains of the PEDI, and only observed small positive changes in the self-care domain. Our results are consistent with the work of Stiller[3] following an intensive therapy program that did not involve a suit. Although the PEDI provides useful information regarding translation of motor skills to functional ability the outcome relies on caregiver response, which may be influenced by their expectations and beliefs regarding the tested intervention. As such, Stiller[3] suggests that families report on more noticeable differences but do not comment on the smaller changes. Caregiver expectations or the previous participation of the participants in the program may have influenced the small changes that we noted.

A unique aspect of this case report was the use of 3-dimensional gait analysis to quantify changes in gait performance and movement patterns during walking after an intensive training program. Significant associations between muscle strengthening programs and improved gait performance, specifically faster gait velocity (up to 0.18 m/sec change[28]) and increased cadence (6 and 8 step/min increase[6,28]) have been reported in children with CP.[6,28] Both children in this case report demonstrated increased self-selected gait velocity after the intervention program with magnitudes of improvements that are similar to those previously reported.[6,28] Also consistent with previous studies, increased cadence seems to be the mechanism responsible for faster walking speed.[6,29] Of the few studies[5,9] that have examined gait kinematic data after strengthening interventions, increases of 2° to 8° of joint motion have been documented for programs that specifically focus on muscles of the knee[5] and ankle.[9] The intervention program used in this case report did not only focus on strengthening and was comparatively broad in nature. The Therasuit Method emphasizes not only selective muscle activation but also transition and functional activities that require the coordination of several body segments and joints. The notable changes in hip and knee motion for participants 1 and 2, respectively, may represent meaningful improvement. However, the functional significance (such as improved energy efficiency) of our measured changes requires analysis beyond the methodology of this case series.

Although we expected to see greater improvements in function and gait patterns after the intervention, the findings of this case report suggest several areas related to intensive suit therapy that warrant further investigation. The observed changes in hip and knee motion, and pelvis and trunk symmetry have the potential to translate into more energy efficient walking patterns. We speculate that improved energy expenditure during walking and other functional activities may be one of the most beneficial outcomes of intensive therapy programs; however, we did not include measures of metabolic cost in this study, and it remains an important area for future work. Further delineation of the benefits of intensive therapy with or without a suit would be beneficial. Finally, all intensive therapy programs require commitment and compliance of the patients and families. The 2 children and families in this case report showed high compliance with the program, and anecdotal comments from previous work[14] suggests parent satisfaction with intense therapy programs. However, further research is needed to determine whether there are certain characteristics of children and families that choose intensive programs over other modes of service delivery.

We acknowledge the case report design used in this study limits the applicability of the results. Further, families that have participated in intensive suit programs have reported that functional changes are not observed immediately after the intervention, suggesting that a longitudinal follow-up would be useful. Both participants in this case report completed the training program, although participant 2 reported knee pain before and throughout the intervention, which could have been a confounding factor in functional gains. The use of more sensitive measures of motor function and quality of movement may have provided useful information regarding the benefits of intensive suit therapy.

CONCLUSION

Both participants in this case report showed minimal gains in some areas and decline in other areas of functional performance after the Therasuit Method of intensive suit therapy as measured by dimensions D and E of the GMFM and the PEDI. We noted small but potentially important changes in gait movement patterns after participation in this intensive program. Further investigation with larger sample sizes is needed to examine the different components of the Therasuit Method before conclusions can be drawn as to the effectiveness of the program. Finally, this program is available at a substantial cost, and the benefits obtained may not be worth the investment.

REFERENCES

1. Bax M, Goldstein M, Rosenbaum P, et al. Proposed definition and classification of cerebral palsy, April 2005. *Dev Med Child Neurol.* 2005;47:571–576.
2. Ketelaar M, Vermeer A, Hart H, et al. Effects of a functional therapy program on motor abilities of children with cerebral palsy. *Phys Ther.* 2001;81:1534–1545.
3. Stiller C, Marcoux BC, Olson RE. The effect of conductive education, intensive therapy, and special education services on motor skills in children with cerebral palsy. *Phys Occup Ther Pediatr.* 2003;23:31–50.
4. Odman P, Oberg B. Effectiveness of intensive training for children with cerebral palsy—a comparison between child and youth rehabilitation and conductive education. *J Rehabil Med.* 2005;37:263–270.
5. Damiano DL, Vaughan CL, Abel MF. Muscle response to heavy resistance exercise in children with spastic cerebral palsy. *Dev Med Child Neurol.* 1995;37:731–739.
6. Damiano DL, Abel MF. Functional outcomes of strength training in spastic cerebral palsy. *Arch Phys Med Rehabil.* 1998;79:119–125.
7. Dodd KJ, Taylor NF, Graham HK. A randomized clinical trial of strength training in young people with cerebral palsy. *Dev Med Child Neurol.* 2003;45:652–657.
8. Eagleton MIA, McDowell J, Morrison R, et al. The effects of strength training on gait in adolescents with cerebral palsy. *Pediatr Phys Ther.* 2004;16:22–30.
9. Engsbert JRS, Collins D. Increasing ankle strength to improve gait and function in children with cerebral palsy: a pilot study. *Pediatr Phys Ther.* 2006;18:266–275.
10. MacPhail HE, Kramer JF. Effect of isokinetic strength-training on functional ability and walking efficiency in adolescents with cerebral palsy. *Dev Med Child Neurol.* 1995;37:763–775.
11. Burman G. Suiting up: a look inside the pediatric fitness center and its suit therapy for kids with CP. *Cerebral Palsy Mag.* Vol June;2006: 28–32.
12. Therasuit LLC. TheraSuit Method. Available at www.suittherapy.com/therasuitinfo.htm. Accessed May 26, 2009.
13. Koscielny I. KR. *TheraSuit™ Manual.* Keego Harbor, MI: TheraSuit LLC; 2002.
14. Bar-Haim S, Harries N, Belokopytov M, et al. Comparison of efficacy of Adeli suit and neurodevelopmental treatments in children with cerebral palsy. *Dev Med Child Neurol.* 2006;48:325–330.
15. Carr P, Kolobe TA, O'Connell L, Williams S. Effects of an intensive therapy protocol on children with cerebral palsy. *Pediatr Phys Ther.* 2006;18:73.
16. Braswell J. The effect of intensive physical therapy for children with cerebral palsy. *Pediatr Phys Ther.* 2008;20:100–101.
17. Braswell J, Benedict A, Chapman C, et al. Intensive physical therapy for two children with cerebral palsy. *Pediatr Phys Ther.* 2006; 18:84.
18. Dabrowski E. Efficacy of axial loading with therapy in cerebral palsy: a preliminary report. *Develop Med Child Neurol.* 2004; 46(suppl 99):45–46.
19. Koscielny I. *TheraSuit™ Method Training Course Manual.* Keego Harbor, Michigan: TheraSuit LLC; 2002–2004.
20. Haley SM CW, Ludlow LH, Haltiwanger JT, et al., eds. *Pediatric Evaluation of Disability Inventory Version 1 Development, Standardization and Administration Manual.* Boston, MA: New England Medical Center Hospitals and PEDI Research Group; 1992.
21. Feldman AB, Haley SM, Coryell J. Concurrent and construct validity of the Pediatric Evaluation of Disability Inventory. *Phys Ther.* 1990;70:602–610.

22. Nichols DS. Reliability and validity of the Pediatric Evaluation of Disability Inventory. *Pediatr Phys Ther.* 1996;8:15–24.
23. Dudgeon BJ, Libby AK, McLaughlin JF, et al. Prospective measurement of functional changes after selective dorsal rhizotomy. *Arch Phys Med Rehabil.* 1994;75:46–53.
24. Vos-Vromans DC, Ketelaar M, Gorter JW. Responsiveness of evaluative measures for children with cerebral palsy: the Gross Motor Function Measure and the Pediatric Evaluation of Disability Inventory. *Disabil Rehabil.* 2005;27:1245–1252.
25. Russell DJ, ed. *Gross Motor Function Measure GMFM-66 and GMFM-88 User's Manual.* Ontario: Mac Keith Press; 2002. Clinics in Developmental Medicine No. 159.
26. Sullivan E, Barnes D, Linton JL, et al. Relationships among functional outcome measures used for assessing children with ambulatory CP. *Dev Med Child Neurol.* 2007;49:338–344.
27. Rosenbaum PL, Walter SD, Hanna SE, et al. Prognosis for gross motor function in cerebral palsy: creation of motor development curves. *JAMA.* 2002;288:1357–1363.
28. Blundell SW, Shepherd RB, Dean CM, et al. Functional strength training in cerebral palsy: a pilot study of a group circuit training class for children aged 4–8 years. *Clin Rehabil.* 2003;17: 48–57.
29. Abel MF, Damiano DL. Strategies for increasing walking speed in diplegic cerebral palsy. *J Pediatr Orthop.* 1996;16:753–758.

ERRATUM

Effects of Music on Crying Behavior of Infants and Toddlers During Physical Therapy Intervention: Erratum

In the article cited above, on page 329 of the Winter 2009 issue of *Pediatric Physical Therapy*, the caption of Fig. 1 included a grammatical error; the words "those in" should have been deleted. The figure with the corrected caption appears below.

Reference:

Rahlin M, Stefani J. Effects of music on crying behavior of infants and toddlers during physical therapy intervention. *Pediatr Phys Ther.* 2009;21(4):325–335.

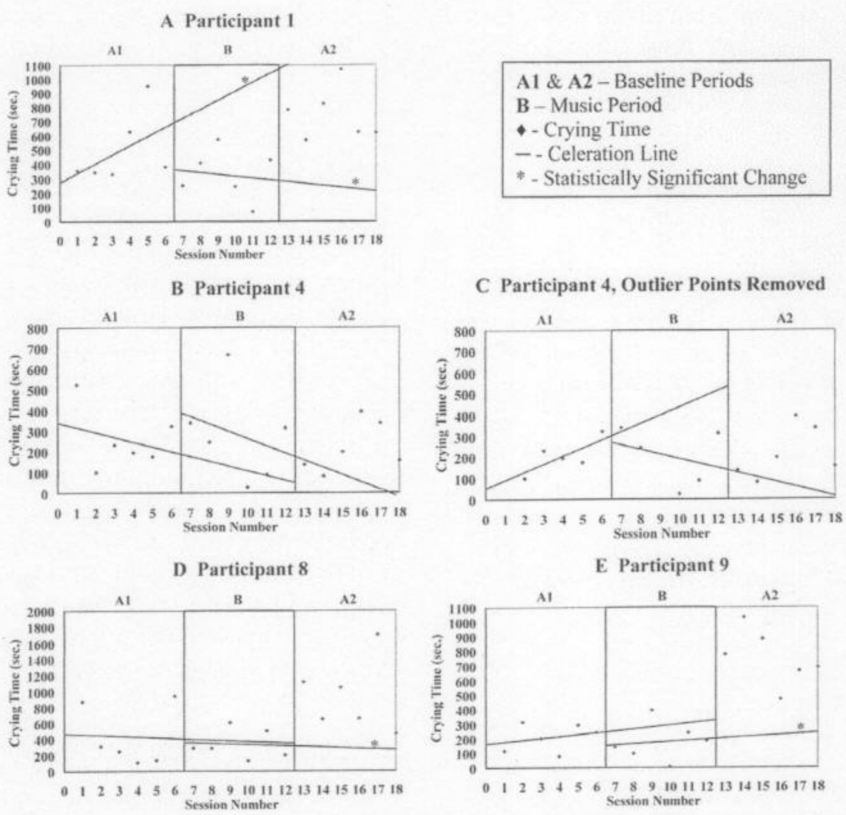

Fig. 1. Celeration lines for crying times across 3 periods of the study constructed for participant 1 (A), participant 2 (B and C), participant 8 (D), and participant 9 (E), who cried less in the music period compared with the first baseline period and subsequently cried more in the second baseline period.