Digital Posturography Games Correlate with Gross Motor Function in Children with Cerebral Palsy

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Abstract

Objective: This pilot study aimed to assess whether performance on posturography games correlates with the Gross Motor Function Measure (GMFM) in children with cerebral palsy.

Materials and Methods: Simple games using static posturography technology allowed subjects to control screen events via postural sway. Game performance was compared with GMFMs using correlation analysis in a convenience sample of nine girls and six boys with cerebral palsy. Likert scales were used to obtain subjective responses to the balance games.

Results: GMFM scores correlated with game performance, especially measures emphasizing rhythmic sway. Twelve of the 15 subjects enjoyed the game and asserted an interest in playing again.

Conclusions: Digital posturography games engage children with cerebral palsy in balance tasks, provide visual feedback in a balance control task, and have the potential to increase autonomy in balance control training among pediatric patients with cerebral palsy. This approach can support the relationship between child and therapist. The potential for interactive posturography to complement the assessment and treatment of balance in cerebral palsy bears continuing study.

Introduction

POOR STANDING BALANCE INTERFERES with walking in children with cerebral palsy (CP), and standing balance is often abnormal in this group as measured by force plate posturography.¹ Biofeedback treatment of movement or posture problems have yielded some successes in children with disabilities, including CP,^{2–4} as well as children with lower limb amputations.⁵ These studies suggest that a balance biofeedback game may benefit children with CP.

Static posturography⁶ uses a platform equipped with a force plate that records the center of pressure (COP). Changes in an individual's COP over time serve as a measure of body sway and can be represented on a video screen concurrent with data storage for later analysis. Using such feedback, a subject might be asked to maintain a fixed COP by standing still or to control postural sway to track a target.

Many children arrive at therapy sessions in the midst of playing an absorbing, hand-held screen game. Our patients' persistent attention to these games suggests that there could be advantages to presenting simple balance tasks and movement strategies similar to those that are normally part of the "work" of therapy, as in digital games where the player competes against the software in a score-able task. For example, a game involving rhythmic weight shift, either along an anterior–

posterior (forward–backward) or lateral (left–right) axis, can help children learn the proprioceptive and motor-control skills required for stable walking. Posturography games could thus be well suited to help children to practice such motor learning tasks that are already entailed in physical therapy.

We therefore investigated the feasibility of posturography games for balance biofeedback in the physical therapy setting. Such an approach could add value to both the treatment and diagnosis of pediatric subjects with CP. Because most studies in this area have focused on interval change in clinical measures following exposure to posturography games, we focus here on the relationship between posturography game performance and a conventional clinical measure of capacity. We hypothesized that posturography game balance measures would correlate with the Gross Motor Function Measure (GMFM). Such a correlation could provide valuable information for further development of therapeutic posturography games.

Materials and Methods

Subjects

Informed consent was obtained from parents of 15 recruits (nine girls and six boys, 4–14 years of age), who underwent a neurological examination to confirm CP. Most subjects had

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TABLE 1. AGE, CEREBRAL PALSY DIAGNOSIS, AND GROSS MOTOR FUNCTION MEASURE SCORES OF STUDY SUBJECTS

Subject number	Gender	Age (years)	Cerebral palsy diagnosis	GMFM		
				Overall score	Dimension "D" (standing)	Dimension "E" (walk, run, jump)
1	F	13.5	Athetoid cerebral palsy	92.4%	87.0%	79.0%
2	F	11	Spastic cerebral palsy	86.1%	77.0%	68.0%
3	M	6	Right hemiplegia	98.9%	97.4%	97.2%
4	F	5	Spastic diplegic cerebral palsy	97.0%	92.0%	96.0%
5	M	7	Ataxic cerebral palsy	91.8%	87.0%	83.0%
6	F	4	Left hemiplegia	98.4%	97.4%	94.4%
7	F	8	Spastic diplegic cerebral palsy	93.8%	89.7%	93.1%
8	M	5	Right hemiplegia	97.3%	94.9%	91.7%
9	F	7	Left hemiplegia	99.7%	100.0%	98.6%
10	M	11	Spastic diplegic cerebral palsy	78.7%	69.0%	39.0%
11	F	8	Ataxic cerebral palsy	99.4%	100.0%	97.2%
12	M	14	Spastic diplegic cerebral palsy	70.2%	53.8%	16.6%
13	M	10	Spastic diplegic cerebral palsy	94.3%	82.1%	91.2%
14	M	10	Spastic diplegic cerebral palsy	85.6%	74.4%	73.6%
15	F	14	Spastic diplegic cerebral palsy	95.7%	89.7%	88.8%
Summary		8.8 ± 3.2		92.0 ± 8.5%	86.1 ± 13.0%	80.5 ± 23.6%

F, female; GMFM, Gross Motor Function Measure; M, male.

spastic CP, either diparetic ($n = 8$) or hemiparetic ($n = 4$) type, and all were able to stand independently. Subjects underwent the 88-item GMFM (Table 1).⁷ Standing (dimension "D") and walking, running, jumping (dimension "E") scores were extracted, in addition to the total GMFM score, for analysis.

Posturography hardware was similar to that used in related studies in children with cerebral palsy^{8,9} (Balance Master™; NeuroCom, Inc., Clackamas, OR), and included a 2- × 2-foot metal plate with four force sensors whose signal (400 Hz sampling rate; C++ software) was represented to the player on a computer screen, so that subject sway moved a green ball image on the computer screen. The device was placed in an approximately 30- × 20-foot "therapy room" at a private, outpatient physical therapy center.

After 5 minutes to test the effect of their postural sway on the movement of the ball on screen, subjects played a sequence of three games ("Standing Still," "Test Your Limit," and "Follow That Paddle"), for a total game session of 15 minutes:

1. In "Standing Still" (three 10-second trials), the subject was instructed to keep the ball centered over a fixed target. The outcome measure was the average COP of the patient relative to the target position.
2. In "Test Your Limit" (eight 5-second trials), the subject was asked to sway so that the ball overlapped

eight circumferential targets. Each of the eight "subtests" lasted 5 seconds. The outcome measure (limit of stability) was the maximum distance to which the subject could displace his or her COP.

3. In "Follow That Paddle" (four 10-second trials), the subject was asked to keep the ball over a rhythmically moving target (leftward to rightward or forward to backward) with direction changes every 5 seconds. The outcome measure (directional control) was computed as ([intended movement – extraneous movement] divided by intended movement).

Subjects carried out three trials for each game, and the average of these trials was used for statistical analysis. Analysis (SPSS software, version 11.1; SPSS, Inc., Chicago, IL) using nonparametric correlation (Spearman's rho) compared posturography variables with GMFM subscores and with the GMFM global score.

Results

The overall GMFM scores and subscores are presented in Table 1. Overall scores and subscores correlated significantly with several posturography measures, particularly the side-to-side and the forward-backward "directional control" task

TABLE 2. CORRELATIONS (SPEARMAN'S RHO) AND *P* VALUES OF GROSS MOTOR FUNCTION MEASURE MEASURES AND MEASURES DERIVED FROM THE POSTUROGRAPHY GAMES IN 15 SUBJECTS WITH DIFFERENT FORMS OF CEREBRAL PALSY

GMFM domains	Posturography games' standing sway	Limit of stability	Directional control (left/right)	Directional control (forward/backward)
Walk, run, jump (dimension "E")	0.04 (0.87)	0.455 (0.067)	0.428 (0.112)	0.501 (0.057)
Standing (dimension "D")	0.187 (0.47)	0.487 (0.047) ^a	0.547 (0.035) ^a	0.541 (0.037) ^a
Overall GMFM score	-0.189 (0.50)	0.329 (0.232)	0.539 (0.038) ^a	0.607 (0.016) ^a

Data are Spearman's rho (*P* value).

^aCorrelations were significant at the $P < 0.05$ level.

GMFM, Gross Motor Function Measure.

(Table 2). Comparison of the “walk, run, jump” GMFM subscore with the limit of stability and with forward–backward directional control approached statistical significance.

Deviations of the COP paths from target suggest that the games did pose a balance challenge to these subjects. In some cases, subjects found it difficult to shift movement strategies (e.g., from forward oscillating movement to a side-to-side oscillating movement).

Likert scale results (Table 3) indicated that over half (8/15) enjoyed playing the games; four were neutral, and three didn’t enjoy the games. Subjects scattered widely in their assessment of the balance games’ difficulty, but most (8/15) found them not too difficult (score of 1–3). About half of the subjects (7/15) were enthusiastic about playing the games in future (score of 4 or 5), whereas five were noncommittal (score of 3), and three were averse to playing again.

Discussion

We developed and tested posturography games for children with CP that could facilitate balance therapy and identified a correlation between a widely used clinical measure of balance and movement in the setting of pediatric CP (the GMFM) and posturography game measures. Small uncontrolled studies^{2,3,10} have focused on performance improvements attributable to posturography games. Accuracy in rhythmic game movement correlated with the GMFM, suggesting that posturography games measure some of the same movement skills as those assessed by the GMFM. This finding supports the relevance of movement tasks evoked in posturography games to those that have long been emphasized by physical therapists. Moreover, in the context of physical therapy evaluation, this finding opens a pathway toward use of posturography game-based assessment of movement skills to incite pediatric patients, who prioritize digital games, to render their best effort.

We used Likert scales to assess subjects’ impressions and found interest, as well as some disaffection, with the experience of the posturography games. The perceived level of difficulty did not uniformly correspond among subjects with level of enjoyment or inclination to play posturography games in the future, consistent with varying tolerance for challenge among individuals and with the notion that other factors besides difficulty determine affective response to games.¹¹ The wide dispersion of “level of difficulty” Likert scores suggests that, although further modifications and individualization of the games may be helpful to suit individual players’ needs for challenge, the games’ level of difficulty was on average appropriate for this clinical group.

Limitations of the study include the consideration that the generalizability of the correlations we found could have been improved if we had randomized the game order. It is recognized that posturography games cannot identify the specific postural or biomechanical factors underlying balance problems. The games we used for this initial study were relatively unsophisticated compared with commercial games. The enthusiasm of subjects and parents¹² for posturography games as therapy adjuncts supports efforts to develop more interesting posturography games for children of varying ages. Future studies should also address reliability of game performance statistics over a longer time period.

Research regarding the feasibility and utility of game-based technology for neurorehabilitation is just beginning. The technology necessary for posturography games appears safe in the setting of CP and is already widely distributed in children’s homes. In principle, multimodal, automated therapies that simultaneously engage sensory, perceptual, attentional, and planning skills may prove helpful in the physical therapy of children with CP. In addition to identifying key motivating elements of posturography games, future studies should address the comparative efficacy of posturography games to usual care for this population.¹³

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Author Disclosure Statement

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TABLE 3. LIKERT SCALE RESULTS OF SUBJECTS’ IMPRESSIONS OF THE BALANCE GAMES

Subject number	Did you enjoy playing the computer games? ^a	Were the games hard to play? ^b	Would you like to play the games again? ^c
1	1	3	3
2	3	3	1
3	3	2	3
4	3	1	1
5	5	1	5
6	1	5	1
7	5	1	5
8	5	3	3
9	2	4	3
10	3	4	4
11	5	4	3
12	5	3	5
13	5	4	5
14	5	5	5
15	4	5	5
Median	4	3	3

^aOn a scale from 5 = very much to 3 = neutral to 1 = not at all.

^bOn a scale from 5 = very hard to 1 = very easy.

^cOn a scale from 5 = very much to 3 = neutral to 1 = not at all.

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