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Rhythmic Motor Behavior of Preambulatory Motor Impaired, Down Syndrome and Nondisabled Children: A Comparative Analysis

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The developmental course of rhythmic motor behavior was followed longitudinally for three groups of preambulatory children—normally developing, Down syndrome, and those with profound motor impairment. The groups differed in chronological age but were comparable with respect to motor age. The motor impaired subjects displayed significantly less rhythmic motor behavior than the nondisabled and Down syndrome groups. In comparing particular subtypes of rhythmic motor behavior, differences were found in both the average number of bouts and duration of subtypes among the groups. Longitudinal analyses of the data over the entire observation period revealed that the rhythmic motor behavior of the children with Down syndrome was more similar to that exhibited by the nondisabled children than was the rhythmic motor behavior of the children with motor impairment. However, there was considerable variability among the groups in several particular subtypes.

Children engage in a variety of quantifiable rhythmic and topographically invariant motor behaviors during the early developmental period. These behaviors include body rocking, head rolling, head banging, and com-

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plex hand movements (Kravitz & Boehm, 1971; Kravitz, Rosenthal, Teplitz, Murphy, & Lesser, 1960; deLissovoy, 1961; Lourie, 1949; Sallustro & Atwell, 1978). Some have termed such behavior as self-stimulatory (Lovass, Newsom, & Hickman, 1987) while others have emphasized its role in communication (Wolff, 1967) and motor development (Sallustro & Atwell, 1978; Thelen 1979; 1981).

The performance of rhythmic motor behavior, at least among normally developing children, closely parallels the predictable sequence of motor development. Wolff (1967) was among the first to articulate this relationship although Piaget and others have postulated a similar correspondence. The relationship was supported by Thelen (1979) who established that rhythmic motor behavior is an essential element of early motor development. Her longitudinal study of nondisabled infants reported a developmental course for each topography of rhythmic motor behavior and revealed that particular topographies occur most frequently at transition points in early motor development. These observations suggest that developmental level, not necessarily chronological age, predicts the form and amount of rhythmical motor behavior observed at a particular point in time.

Comparative data on the age of onset of rhythmic motor behaviors (including hand sucking, foot kicking, lip biting, body rocking, toe sucking, head rocking, head banging, and tooth grinding) among children with Down syndrome, infants with a diagnosis of cerebral palsy, and nondisabled infants have been reported by Kravitz and Boehm (1971). With the exception of head rolling and head banging, the motor impaired children had significantly delayed onset of rhythmic motor behavior as compared with the nondisabled infants. It is our contention, however, that had data collection continued beyond 12 months of age significant differences would also have been evident for head rolling and head banging. Although comparisons were not made with respect to developmental level, these findings suggest that developmental rate may have been responsible for the observed differences.

Such a conclusion is supported by a study conducted by Field, Ting and Shuman (1979). They reported that while preterm infants were significantly delayed in their onsets of foot kicking, lip sucking, body rocking, toe sucking, and teeth grinding, as compared with normal infants and postterm infants, the ages of onset among these groups were not significantly different when comparisons were based on gestational age. These data support the view that rhythmic motor behavior evolves in a predictable sequence and is integrally associated with preambulatory motor development (Thelen, 1981).

The developmental course of rhythmic motor behavior was described for three groups of preambulatory children. While the chronological ages of the nondisabled, Down syndrome, and motor impaired children varied considerably, their developmental motor ages at the beginning of the study were comparable. These observations provide the first longitudinal data of this type for preambulatory children with Down syndrome and motor impairments and permit comparison with a nondisabled group.

METHOD

Subjects

Seven children with Down syndrome and eleven children with significant motor impairments were recruited from the Kennedy Center Susan Gray School for Children to participate in the study. In addition to a diagnosis of Down syndrome, confirmed by karyotype, several children had undergone surgical correction of congenital heart defects. The motor impaired subjects exhibited diverse medical diagnoses. Five had abnormally high muscle tone and hyperreflexia consistent with a diagnosis of spastic cerebral palsy. This condition was typically associated with premature birth and a history of intraventricular hemorrhage. Four displayed markedly low muscle tone presumably owing to cerebral atrophy or hydrocephalus. The motor impairments of the remaining two subjects were related to global retardation secondary to a rare chromosomal disorder, or porencephaly. Seizure disorders had been diagnosed for one Down syndrome subject and four motor impaired subjects.

Ten normally developing children were recruited from local daycare centers or from families with motor impaired children participating in the Susan Gray School for Children. A summary of subject characteristics is presented in Table I. Although they differed in chronological age at the beginning of the study, their motor age equivalents, as determined by the Bayley Scales of Infant Development (Bayley, 1969), were not significantly different (F (2, 25) = 1.48, $p > .05$). We considered this control as essential in making comparisons among the groups regarding their rhythmic motor behavior.

Procedure

Subjects were observed every two weeks throughout their participation in this longitudinal study of early motor development. Length of par-

Table I. Demographic Characteristics of Participants at Study Entry

Group	Chronological age[a]			Bayley Motor Age Equivalent[a]		Bayley Mental Development Index (MDI)		Bayley Psychomotor Development Index (PDI)	
	Mean	*SD*	Range	Mean	*SD*	Mean	*SD*	Mean	*SD*
Nondisabled (n = 10)	5.8	(2.1)[b]	2.8–9.3	5.6	(1.4)	119.6	(23.0)	109.7	(18.6)
Down syndrome (n = 7)	14.5	(7.7)	4.9–22.3	7.5	(4.4)	63.7	(24.6)	51.7	(15.9)
Motor impaired (n = 11)	23.4	(7.3)	15.0–38.3	5.2	(2.3)	<50		<50	

[a]In months.
[b]Values in parentheses are standard deviations.

ticipation in the project ranged from 9 to 14 months. For each child there were at least 12 biweekly observation sessions with an average number of 19 sessions. The number of observation sessions did not differ significantly among the groups. Each observation lasted for one hour and occurred in the subject's home or daycare setting. Parents and siblings, if present, were told to "Do as you would normally do." No limit or direction was placed on the conditions of the observation. For many sessions the parents, siblings, or caregivers were present and either watched or interacted with the child.

An observational coding system was adapted from that originally developed by Thelen (1979). The code set reflected the body part or parts involved in a rhythmic motor act (head, mouth, arm, legs, hands, feet, and torso). A rhythmic act was defined as any body movement repeated at least three times at a rate of at least one movement per second. Observers recorded the onset of a bout of rhythmic motor behavior by entering a specific code into an OS-3 electronic data recorder. At the completion of the bout an offset code was entered thus permitting analysis of both the number and duration of bouts.

RESULTS

Interobserver Agreement

Interobserver agreement was determined for 25% of the observation sessions. During these sessions the primary observer and a second observer recorded the child's rhythmic behavior from opposite sides of the room.

Table II. Percentage of Sessions in Which Seven Subtypes of Rhythmic Motor Activity Were Observed by Groups

Subtype	Nondisabled	Down syndrome	Motor impaired
Mouth	97%	97%	88%[a,b]
Arm	94%	97%	71%[a,c]
Leg	62%	58%	42%[a,b]
Hand	52%	65%	34%[a,b]
Torso	50%	51%	24%[a,b]
Head	17%	13%	25%
Foot	6%	25%	9%

[a]Motor impaired group differs significantly from the other groups.
[b]$p < .05$.
[c]$p < .01$.

Interobserver agreement was assessed with Cohen's Kappa, thus adjusting for chance agreement (Cohen, 1960) using computer software adapted from MacLean, Tapp, and Johnson (1985). For the rhythmic motor behavior observed in this study, the average interobserver agreement was Kappa = .60, with 86% of the Kappas being .40 or above. Although such values are typical of studies employing complex multidimensional code sets and live observation (Hartmann, 1982; Jones, Reid, & Patterson, 1975), there remains the possibility that the observed patterns may not be fully reproducible across samples.

Overall Rhythmic Activity

An initial comparison of the average amount of total rhythmic motor activity exhibited by each subject group over the course of the study revealed that the Motor impaired group exhibited significantly less rhythmic motor behavior than the Nondisabled or Down syndrome groups ($F(2, 561) = 6.30$, $p = .002$). The average amount of total rhythmic motor activity observed per session was not significantly different between the Nondisabled and Down syndrome groups.

Table II presents the percentage of observation sessions in which each of seven subtypes of rhythmic motor behavior was observed for each of the subject groups. The subtypes were formed by combining the observations of distinct topographies involving the same body part. There was considerable variability in the obtained percentages among the subtypes. Mouth and Arm movements were exhibited in many more sessions than Head and Foot movements. Analyses of variance with preplanned comparisons were used to contrast the Down syndrome and Motor impaired subjects with the remainder of the groups. Across the groups, the number

Table III. Average Number of Bouts and Duration of Rhythmic Motor Activity per Observation Session

Subtype	Nondisabled		Down syndrome		Motor impaired	
	Mean	SD	Mean	SD	Mean	SD
Mouth						
Number of bouts	24.63	13.29	52.07[a,b]	43.74	14.96[c,d]	15.46
Duration	383.42	177.89	604.10[a,d]	441.01	240.83[c,d]	175.61
Arm						
Number of bouts	15.14	4.01	18.92	8.27	10.31[c,d]	10.74
Duration	119.86	77.49	141.40	92.22	89.09	93.66
Leg						
Number of bouts	4.63	5.63	3.95	4.20	2.53	2.15
Duration	43.76	71.64	23.45	26.42	25.88	23.49
Hand						
Number of bouts	2.04	1.27	4.01	4.32	1.96	3.51
Duration	30.88	51.78	30.78	41.42	19.10	32.27
Torso						
Number of bouts	2.52	1.90	3.27	4.57	1.12	2.16
Duration	34.81	47.07	29.45	35.08	17.73	33.77
Head						
Number of bouts	0.35	0.36	0.20	0.20	1.35[c,d]	2.02
Duration	2.51	2.75	1.16	0.98	7.36	13.81
Foot						
Number of bouts	0.14	0.21	3.04[a,d]	4.42	0.83	2.39
Duration	0.90	1.41	33.88[a,b]	47.33	4.55	17.89

[a]Down syndrome group differs significantly from the other groups.
[b]$p < .01$.
[c]Motor impaired group differs significantly from the other groups.
[d]$p < .05$.

of observation sessions in which the Motor impaired group engaged in Arm, Mouth, Leg, Hand, and Torso movements was significantly less than the Nondisabled and Down syndrome groups. All other comparisons yielded nonsignificant results.

A summary of means and standard deviations for the average number of bouts and duration of rhythmic motor behavior per observation session is presented in Table III. These values were also analyzed with preplanned comparisons that contrasted the Down syndrome and Motor impaired groups with the remainder of the subjects. The Motor impaired subjects had significantly lower mean number of bouts of Arm and Mouth movements, a significantly lower duration of Mouth movements and a significantly greater average number of bouts of Head movements as compared to the Nondisabled and Down syndrome subjects. The Down syndrome subjects displayed significantly greater average number of bouts and duration of Foot and Mouth movements than the other subjects.

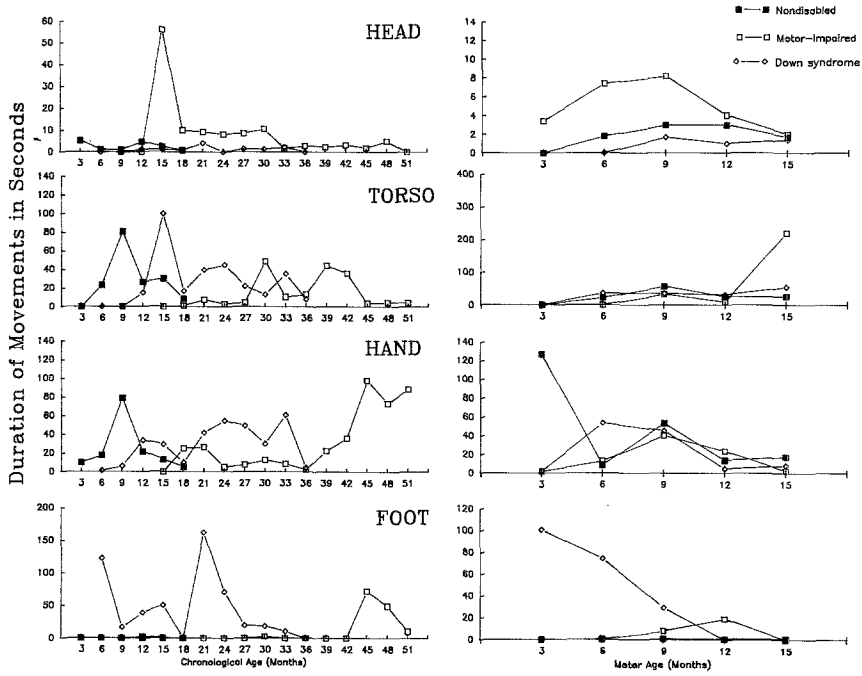

Fig. 1. Duration of Head, Torso, Hand, and Foot subtypes displayed by the three subject groups. Left-hand graphs represent duration of movement by the groups at each three-month chronological age interval while right-hand graphs represent durations of movement at each three-month motor age equivalent interval.

Longitudinal Comparisons

Figures 1 and 2 present longitudinal comparisons of the durations of rhythmic motor behavior subtypes for each subject group. These plots contain data accumulated from all observations. Rhythmic motor behaviors are graphed according to both chronological age and motor age equivalents to permit a comparative analysis. For each subject group, the observations corresponding to a particular three month chronological or motor age equivalent interval are combined and a mean value serves as the summary data point. The left hand plots of each figure are expressed in chronological age. Differences in the concentration of observations at particular chronological ages are due primarily to the varying rates of motor development manifested by the three subject groups. With the exception of the Foot

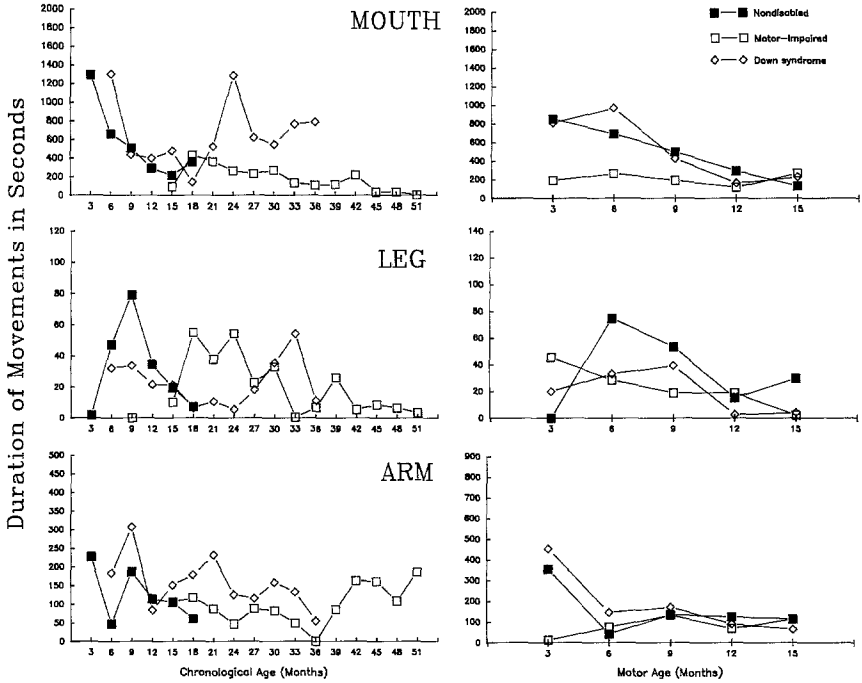

Fig. 2. Duration of Mouth, Arm, and Leg subtypes displayed by the three subject groups. Left-hand graphs represent duration of movement by the groups at each three-month chronological age interval while right-hand graphs represent durations of movement at each three-month motor age equivalent interval.

subtype, the relative ordering of the subject groups across chronological age follows closely developmental rate. The Nondisabled children exhibited these rhythmical motor behaviors between the chronological ages of 3 and 18 months, the Down syndrome subjects between 6 and 36 months, and the Motor impaired children between 12 and 51 months.

The right hand plots in each figure are expressed in motor age equivalents. Comparisons are limited to those motor age equivalent intervals in which each subject group had representation (3-15 months). Visual analysis of the plots revealed some similarity in distribution for the Head and Torso subtypes indicating that the groups shared the same distribution of behavior across the motor age profile. With regard to the Mouth, Leg and Arm subtypes, the similarity between the developmental profiles of the Nondisabled and Down syndrome groups was considerably greater than the

Table IV. Pairwise Spearman Rank Order Correlation Values Contrasting the Rhythmic Motor Behavior of the Down Syndrome and Motor Impaired Groups with the Nondisabled Group

	Contrast	
Subtype	Nondisabled–Down syndrome	Nondisabled–Motor impaired
Head	.55[a]	.72[a]
Torso	.50[a]	.90[b]
Mouth	.80[a]	–.10
Arm	.70[a]	–.30
Leg	.60[a]	–.30
Hand	–.60[a]	–.30
Foot	–.78[a]	.12

[a] $p < .10$.
[b] $p < .05$.

similarity between the Nondisabled and Motor impaired groups. There was little correspondence in the Hand and Foot subtypes.

As a supplement to the data graphically reported in Figures 1 and 2 the rhythmic motor behavior of the Down syndrome and Motor impaired groups was compared with the Nondisabled group using Spearman Rank Order correlations. Table IV presents the Spearman correlation values for each pairwise comparison. The correlations between durations of rhythmic motor behavior at each motor age equivalent for the Down syndrome and Nondisabled groups were marginally significant ($p < .10$) and positive for 5 of the 7 subtypes. Only the Torso ($p < .05$) and Head ($p <. 10$) subtypes for the Nondisabled and Motor impaired groups were positively related.

Although this study was not designed to examine ages of onset or ages associated with peak frequencies of rhythmical motor behavior, some developmental ordering of the subtypes was evident. At 3 months motor age equivalent there was already considerable Arm, Hand, and Foot movement. The Leg and Head subtypes became more prevalent over time, followed by the Torso subtype.

DISCUSSION

The goal of this study was to describe the rhythmic motor behavior of three groups of preambulatory children. Children with Down syndrome and children with motor impairment were compared to children without disability. The three groups were equivalent with regard to motor ability at the beginning of the longitudinal period but were developing at markedly different rates. Despite differences in chronological age and developmental

rate among the groups, each group exhibited rhythmic motor behavior of the sort reported in previous studies of preambulatory children (cf. Thelen, 1979). The Motor impaired children evidenced significantly less rhythmic motor behavior over the course of the study than the other groups. Further examination of the data by specific subtype of rhythmic motor behavior revealed that the Motor impaired children engaged in Arm, Leg, Hand, and Torso subtypes in significantly fewer observation sessions than the other groups.

We then compared the average number of bouts and duration of each subtype of rhythmic motor behavior across the groups and found that the Motor impaired children engaged in significantly less Mouth and Arm subtypes and significantly greater Head movements than the other groups and that the Down syndrome children engaged in significantly greater Mouth and Foot subtypes per observation session. There were no significant differences in average number of bouts or duration per session among the groups for the Leg, Hand, and Torso subtypes.

Visual analyses of the longitudinal data when expressed in terms of chronological ages of the subjects revealed that the groups were engaging in rhythmic motor behavior over different age ranges. These differences were a function of the developmental rate of the subjects. We then compared the longitudinal data among the groups on the basis of motor age equivalents to examine the similarity in distribution of behavior over time. We found that the data for the Head and Torso subtypes obtained from children with Down syndrome and children with significant motor impairment were similar to data obtained from a group of nondisabled children. Furthermore, the Nondisabled and Down syndrome groups had developmental profiles for the Mouth, Arm, and Leg subtypes that were more similar than comparisons made between the Nondisabled and Motor impaired groups.

Given the descriptive nature of this study, it is not possible to determine the basis for the observed differences among the groups. However, it is likely that the Motor impaired children had underlying neurological damage that manifested itself in disturbances of voluntary activity (Melyn & Grossman, 1976). The observation that the Motor impaired group engaged in a greater average number of bouts of Head movements is consistent with such an interpretation in that children with an abnormal distribution of muscle tone tend to acquire some degree of head control long before they achieve coordinated motor activity of the limbs (Denhoff, 1976).

In summary, the results of this study provide further support for the conclusion that rhythmic motor behavior is an important aspect of preambulatory motor development. Although the three groups of children, each

developing at different rates, exhibited such behavior during comparable developmental periods, group differences were apparent between the developmentally disabled groups and the Nondisabled group that likely reflect clinical differences among the children. For example, it is likely that the rhythmic motor behavior of the motor impaired children was affected by central nervous system insult. Future research should be directed toward determining how these differences may be relevant to the development of aberrant behavior among developmentally disabled children and adults.

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