Research Report

A Longitudinal Study of Children with Down Syndrome Who Experienced Early Intervention Programming

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Background and Purpose. *The long-term motor, cognitive, and adaptive functioning of a sample of adolescents with Down syndrome who experienced an early intervention program was examined in this descriptive study.* ***Subjects.*** *Ten children with Down syndrome (7 girls, 3 boys) who had participated in an early intervention program constituted the early intervention (EI) group. An age-matched group of children with Down syndrome (6 girls, 4 boys) who had not experienced an early intervention program served as a comparison group.* ***Methods.*** *The EI group's motor functioning was compared with that of a normative sample used in the development of the Bruininks-Oseretsky Test of Motor Proficiency. The cognitive and adaptive skills of the EI group were compared with those of the comparison group. The children were assessed using the Stanford-Binet Intelligence Scale, the Vineland Social Maturity Scale, and the Bruininks-Oseretsky Test of Motor Proficiency.* ***Results.*** *The EI group subjects fell below their chronological age levels in gross and fine motor skills; however, their mean gross motor skill levels exceeded their mean fine motor skill levels. The specific deficits in gross motor and fine motor skills, which were documented in a previous follow-up study on the same sample, continued to be areas of deficits (visual motor coordination, running speed, balance, and reaction time). The EI group subjects had significantly higher scores on measures of intellectual and adaptive functioning than did the children in the comparison group. The EI group subjects did not show the decline typically seen with age in adaptive functioning in individuals with Down syndrome.* ***Conclusion and Discussion.*** *Because of the design limitations, the differences between the groups should be interpreted with caution. [Connolly BH, Morgan SB, Russell FF, Fulliton WL. A longitudinal study of children with Down syndrome who experienced early intervention programming. Phys Ther. 1993;73:170–181.]*

Key Words: *Down syndrome; Motor skills; Tests and measurements, functional.*

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Studies on the mental and motor abilities of children with Down syndrome have been reported for many years. Initially, these studies were cross-sectional in nature, and few, if any, longitudinal studies were done. These initial reports document the development of children with Down syndrome as similar to that of typically developing children, but occurring at a much slower rate. Several

studies[1–6] have demonstrated a general decline in intelligence quotients (IQs) in children with Down syndrome from infancy to late childhood.

Motor skills in children with Down syndrome have also been studied in detail. The general rate of motor skill development has been reported to be below that of children without Down syndrome, although there is variability among children attributable to factors such as home rearing and health status.[3,7,8] Attainment of early motor milestones are thought to be delayed because of problems with ligamentous laxity in some joints, decreased strength, and hypotonia.[9–11] Additionally, postural control problems have been identified in children with Down syndrome. Shumway-Cook and Woollacott[12] found that postural responses to loss of balance were slow in young children (1–6 years of age) with Down syndrome, and they concluded that these responses were inefficient for maintaining stability. They also stated that the presence of the monosynaptic reflex during platform perturbations suggested that balance problems in children with Down syndrome do not result from hypotonia, but rather from defects within higher-level postural control mechanisms.

Motor proficiency studies in older children with Down syndrome have revealed deficits in eye-hand coordination, laterality, and visual motor control.[13–15] Connolly and Michael[16] compared the scores on the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) of children with retardation, both with and without Down syndrome, who were between the ages of 7.6 and 11 years. They found that the group with Down syndrome had significantly lower scores in running speed, balance, strength, and visual motor control than did the group without Down syndrome. Henderson et al[17] reported that children with Down syndrome who were between 7 and 14 years of age scored consistently low on agility and balance tasks when compared with matched control children. Le Blanc et al[18] also found that children with Down syndrome whose mean age was 12 years had difficulty with static balance when they were compared with children matched for chronological age and IQ. More recently, Shea[19] assessed a group of 11- to 14-year-old children with Down syndrome using the Peabody Developmental Motor Scales and found that static balance was the area in the test of greatest difficulty in gross motor skills.

The effects of early intervention programs (EIPs) on the developmental skills of children with Down syndrome have been of interest to researchers for a number of years. Early intervention programs usually are focused on stimulation of developmental skills in the child as well as on facilitating parent-child interactions. The beneficial effects of early intervention have been demonstrated by Brinkworth,[20] Connolly et al,[21] and Sharav and Shlomo.[22] These studies, however, did not have randomly assigned control groups. An attempt at a controlled study was made by Piper and Pless,[23] who reported that early intervention had no effect. Their study, however, was conducted for a relatively short time (ie, 6 months), and the investigators were unable to assess the degree to which the program was implemented in the home by the parents. Additionally, the infants were seen for only 1 hour every other week by the researchers. It is possible that infants in that study may have received as little as 12 hours of training during the study.[24] The choice of the Griffiths Scale for assessment of outcome in these infants may also have limited the sensitivity of the evaluation and may not have revealed important changes in the infants.[24] Few long-term follow-up studies have been undertaken to validate the effort and expenditures of early intervention services. Only two such longitudinal studies of the effectiveness of EIPs have been reported in the literature.[21,22] Investigators in both studies concluded that EIPs, along with home rearing, have improved the functioning of children with Down syndrome. Carr[6] reported a longitudinal study of individuals with Down syndrome between the ages of 6 weeks and 21 years; however, these subjects were not involved in an organized EIP.

Although the two longitudinal studies on the effectiveness of EIPs have demonstrated beneficial effects,[21,22] questions persist about positive outcomes of early intervention. Simeonsson et al,[25] in a review of 27 studies on the benefits of early intervention, concluded that (1) children with handicaps in EIPs seemed to make better progress than those children not in such programs, but statistical significance was not attained because of the small sample sizes in the studies; (2) children in the programs often made progress in areas not measured by the research instrument; and (3) improvements were noted in areas not specific to the child (eg, family or sibling adjustment). White,[26] in a recent review, concluded that insufficient information was available to be confident about the long-term impact of early intervention but felt that immediate positive effects of intervention with disadvantaged children tend to provide support for long-term benefits.

In our last follow-up of children with Down syndrome who were involved in an EIP, we found that they had significantly higher scores on measures of intellectual and adaptive functioning than did children of comparable ages with Down syndrome who did not participate in an EIP.[21] Additionally, this group of children did not show the decline typically seen over time in intellectual and adaptive functioning noted previously in children with Down syndrome.[4] As expected, the children were found to be functioning below their chronological ages in gross and fine motor skills, but, unexpectedly, their fine motor skill levels exceeded their gross motor skill levels. In particular, the children were found to perform poorly on measures of running speed, balance, strength, visual motor control, and overall gross motor and fine motor skills in comparison with children without Down syndrome but of

comparable chronological and mental ages.[16]

The purpose of this study was to examine the functioning of adolescents with Down syndrome who experienced early intervention as infants and who continued their education in classrooms appropriate to their needs. We compared the motor development of the children involved in an EIP with the normative data from a standardized motor assessment tool and with previous motor assessments using the same tool on the same children. In addition to assessment of motor functioning, we used the same measures of intellectual and adaptive functioning with these children as in our previous studies[21,27,28] in order to evaluate developmental changes in these areas. We were also interested in comparing the intellectual and adaptive functioning of these children with that of children with Down syndrome who had not experienced early intervention. A control group was not used when this longitudinal study was begun in 1973 because of the ethical concerns surrounding the withholding of services from infants assigned to control groups.[24] Shortly after the initiation of the study, state mandates that provided educational services for all children with handicaps and permissive programming for the preschool child precluded the use of children who might have served as nonintervention control subjects.

The specific questions addressed in this study were

1. Did differences in gross motor and fine motor skill levels occur over time in our sample of adolescents with Down syndrome who were involved in an EIP?

2. Have the same areas of strengths and weaknesses in gross motor and fine motor skill levels as assessed by the Bruininks-Oseretsky Test of Motor Proficiency continued over time in our sample of adolescents with Down syndrome who were involved in an EIP?

3. How do the current gross motor and fine motor skill levels compare with the intellectual levels of our sample of adolescents who were involved in an EIP? Have the motor skill levels progressed at the same rate as the intellectual levels since the last systematic study of these children?

4. Do differences in intellectual functioning exist between our sample of adolescents with Down syndrome who participated in an EIP and a comparison group that did not participate in an EIP?

5. Do differences in social and adaptive functioning exist between our sample of adolescents with Down syndrome who participated in an EIP and a comparison group that did not participate in an EIP?

6. Did our sample of adolescents with Down syndrome who participated in an EIP and subsequent appropriate educational programming show the typical deceleration in intellectual and adaptive functioning reported in the literature with children with Down syndrome?

Method

Subjects

Ten of the children with Down syndrome who participated in previous studies reported by Connolly and colleagues[21,27,28] constituted the early intervention (EI) group in this study. Forty children with Down syndrome who were participating in an ongoing EIP were the subjects in the original study.[27] By the time of the first follow-up study,[28] however, only 20 of the children could be located. Sixteen of the children had moved from the area, 3 children failed to continue in their educational programs, and 1 child did not consent to participate. Fourteen of the 20 children in the second study also participated in the next follow-up study.[21] Only 10 of those children, however, were available for follow-up evaluation in the current study. Three of the 14 children had moved from the area, and 1 child's parents did not respond to requests for participation. All of these children had completed the EIP at the University of Tennessee Child Development Center by 3 years of age, had remained in their homes, and had been placed in educational settings appropriate to their level of functioning. For the current study, the age range of the EI group subjects for the psychological testing was 13.9 to 17.8 years ($\bar{X}$=15.7, SD=1.3). Their age range for gross and fine motor testing was 13.9 to 17.9 years ($\bar{X}$=16.3, SD=1.1). The EI group consisted of 7 female and 3 male subjects. Four of the children had attended private special education schools, and 6 of the children had attended public special education schools. A signed informed consent statement was obtained from each parent before testing.

An attempt was made to compare the intellectual and adaptive skills of the EI group with those of children with Down syndrome who had been evaluated at the same center but who had not experienced early intervention. Our 1984 study[21] used, as a comparison group, children with Down syndrome of comparable ages from a normative study.[3] The normative data, however, did not include mean IQs or social quotients (SQs) for children over 10 years of age. For the current study, the comparison data were drawn from the records of children who had been evaluated at the center during the previous 12-year period and who fell within the same age range at the time of testing as the EI group subjects. From a pool of 20 children, 10 children were selected on the basis of three criteria: (1) availability of scores on the Stanford-Binet Intelligence Scale, Form L-M,[29] and the Vineland Social Maturity Scale[30]; (2) closeness in age to the EI group subjects at the time of testing; and (3) gender. Age at time of testing was used as the primary matching variable because previous studies have consistently shown a deceleration in the rate of development in intellectual and adaptive skills with increased chronological age in children with Down syndrome.[3,4]

Table 1. *Composite Scores for Fine Motor Skills and Gross Motor Skills of Early Intervention Group (N=10)*

Category	Second Follow-up Study[21]	Present Study
Gross motor composite age (y)		
$\bar{X}$	4.85	6.05[a]
SD	0.72	1.38
Range	3.5–5.9	3.5–7.7
Fine motor composite age (y)		
$\bar{X}$	4.50	5.64[b]
SD	0.82	1.01
Range	3.0–5.7	3.0–7.5

[a]Significant at $t=2.69$, $df=18$, and $P=.0249$.

[b]Significant at $t=4.02$, $df=18$, and $P=.0003$.

The age range (at time of testing) of the children in the comparison group was 12.1 to 18.6 years ($\bar{X}=14.8$, SD=1.8). A *t* test indicated no significant differences in age at testing between the EI group and the comparison group. The gender distribution of the comparison group was 6 females and 4 males. A chi-square test revealed no significant differences in gender distribution between the EI and comparison groups.

Although the comparison group was from the same geographic region as the EI group and both groups appeared to be representative of a broad socioeconomic range, lack of precise records on such variables as parental income and educational level precluded control of socioeconomic level, which could be a confounding variable. Another problem concerned the possible cohort effect because the children in the comparison group were, on the average, 8 years older than the children in the EI group (although their chronological age at the time of testing was comparable) and may not have had, for example, the same educational opportunities. The implications of these limitations in comparative data are discussed later.

Tests

The BOTMP (long form) was individually administered to each of the children who had been involved in the EIP by a physical therapist experienced in the administration of the test.[31] Validity of the BOTMP scores has been established through consideration of (1) the relationship of test content to significant aspects of motor development as cited in research studies, (2) the relevant statistical properties of the test, and (3) the functioning of the test with contrasting groups of handicapped and nonhandicapped children.[31] Reliability for test scores has been established through studies on interrater reliability ($r=.90$-$.98$) and test-retest reliability ($r=.86$-$.89$).[31] The BOTMP consists of subtests in running speed, balance, bilateral coordination of the arms and legs, strength, upper-limb coordination, response time, visual motor control, and speed and dexterity of the upper extremities. The BOTMP, a standardized test, yields two ages for each of the individual subtests: a gross motor skills composite age and a fine motor skills composite age. If a child scores below the basal age of the test (ie, 4 years 2 months), he or she is assigned a score of below 4 years 2 months. The test is standardized for children between the ages of 4 years 2 months and 16 years. Although most of the children in this study were chronologically beyond 16 years of age, the test was felt to be appropriate because their mental and motor ages were below 16 years. Motor ages on the eight subtests of the BOTMP as well as a gross motor and a fine motor composite age were determined for each child. Data on the BOTMP were not available on the comparison group because of the lack of availability of the BOTMP prior to 1978. The test scores of the children involved in the EIP were compared against the normative data presented on the BOTMP and against their own previous scores.

Both the Stanford-Binet Intelligence Scale, Form L-M, and the Vineland Social Maturity Scale were individually administered to the children by a trained psychological examiner. The Stanford-Binet Scale served as a measure of general intellectual functioning, and the Vineland Scale served as a measure of general adaptive functioning including socialization, communication, and self-help skills. Both scales have been demonstrated to be psychometrically sound instruments with acceptable reliability and validity.[29,30] For the Vineland Scale, each child's mother or father provided the information from which the SQ was derived. Although more recent editions of each of these scales are now available, the editions used in our past follow-up studies were used to allow for more valid comparisons from study to study.

Procedures

Data collection took place at the Boling Center for Developmental Disabilities at The University of Tennessee, Memphis, or at the Department of Psychology at Memphis State University. One child was seen at Vanderbilt University, but by the same examiners who evaluated the other children in the study. The order of testing of the children was random and not according to their individual developmental or chronological ages. To obtain the data, a total of 4 hours on two separate occasions was spent with each child and parent. The administration

Table 2. *Bruininks-Oseretsky Test of Motor Proficiency Mean Component Scores for Fine Motor Skills and Gross Motor Skills of Early Intervention Group (N=10)*

Component	Second Follow-up Study[21]	Present Study
Running speed	>4.17	5.42[b]
Balance	4.00	4.92[b]
Bilateral coordination	5.17	5.92
Strength	5.92	7.42[a]
Upper-limb coordination	5.92	6.67
Response speed	>4.17	4.92
Visual motor coordination	4.42	5.92[c]
Upper-limb speed and dexterity	5.42	6.42[b]

[a]Significant at $P=.05$.

[b]Significant at $P=.01$.

[c]Significant at $P=.005$.

of the cognitive, adaptive, and academic tests at times different (with one exception) from that of the administration of the motor tests should not have influenced the results of the study.

Data Analysis

Descriptive and inferential statistics were used to describe and analyze fine motor and gross motor skills of the EI group subjects as well as their intellectual and adaptive functioning. Means, ranges, and paired *t*-test values were used for analysis of the first two research questions. The Pearson Product-Moment Correlation Coefficient was used to determine the relationships between changes in mental ages and motor ages for research question 3. Means, ranges, and independent *t*-test values were also used to analyze the data pertaining to research questions 4 and 5. Descriptive statistics of means, ranges, and percentages were used to analyze information related to research question 6. When inferential statistical analysis was performed, a .05 level of significance was used. Caution should be used in interpreting statistical significance from multiple *t* tests, because at least 1 of every 20 tests undertaken will achieve statistical significance by chance alone. Use of a smaller alpha-risk or level of significance, however, allows one to be more certain about accepting or rejecting a hypothesis.

Table 3. *Motor Skills of Early Intervention Group[a] (N=10)*

Second Follow-up Study[21]	Present Study
Upper-limb coordination	Strength
Strength	Upper-limb coordination
Bilateral coordination	Upper-limb speed and dexterity
Upper-limb speed and dexterity	Bilateral coordination
Balance	Visual motor coordination
Visual motor coordination	Running speed
Running speed	Balance
Response time	Response time

[a]Ranked highest to lowest.

Results

Motor Skills

On the average, the children in the EI group had a mean gross motor composite age of 6.05 years (SD=1.38) compared with a fine motor composite age of 5.64 years (SD=1.01), as determined by the motor assessment tools. The range of individual scores was from 3.5 to 7.7 years in gross motor skills and from 3.0 to 7.5 years in fine motor skills. Table 1 compares the scores obtained for the EI group in the previous follow-up study[21] and in this study.

Changes for the EI group on specific subtests of the BOTMP are shown in Table 2. Significant differences were noted in running speed, balance, strength, visual motor coordination, and upper-limb speed and dexterity. A further comparison of the subtest scores of the children revealed that strength, upper-limb coordination, bilateral coordination, and upper-limb speed and dexterity continued to be areas of strength and that balance, visual motor coordination, running speed, and response time continued to be areas of weakness (Tab. 3). Five of the children had fine motor skill scores that exceeded their gross motor skill scores; the other five children had gross motor skill scores that exceeded their fine motor skill scores. Interestingly, those children who had attended a private school that emphasized participation of the children in Special Olympics programs had gross motor skill scores that surpassed their fine motor skill scores.

Table 4 illustrates the changes in the rate of development that occurred since the last assessment of the EI group subjects in the areas of gross motor, fine motor, and cognitive functioning. As noted, the ratio of gross motor skill development to mental age improved in 8 of the 10 children. The ratio of fine motor skill development to mental age im-

Table 4. *Ratios of Gross Motor Age and Fine Motor Age to Mental Age for the Early Intervention Group (N=10)*

Child	Gross Motor Age/Mental Age	Fine Motor Age/Mental Age
1		
1984	1.46	1.17
1989	1.38	1.44
2		
1984	0.89	0.81
1989	0.54	0.65
3[a]		
1984	0.96	0.89
1989	1.17	1.00
4		
1984	1.08	0.92
1989	1.56	1.78
5[a]		
1984	0.89	0.89
1989	1.08	0.85
6[a]		
1984	1.00	1.00
1989	1.27	1.03
7[a]		
1984	1.04	1.17
1989	1.15	0.85
8		
1984	1.11	0.94
1989	1.18	1.06
9[a]		
1984	0.84	1.02
1989	1.03	1.24
10		
1984	0.72	0.76
1989	0.89	1.00

[a]Involved in organized physical education program.

proved in 7 of the 10 children. Additionally, using the Pearson correlation coefficient, no significant correlations were found between changes in motor skill levels and changes in cognitive functioning of the children using the mean gross motor composite, fine motor composite, and mental age data (r=.04-.43).

Intellectual and Adaptive Skills

Table 5 shows the comparison between the EI group and the comparison group in terms of chronological age, IQ, and SQ. Although the two groups were comparable in age at the time of testing for this study, the differences in scores should be used only for rough comparative purposes because of the previously noted uncontrolled variables. As in each of our previous studies,[21,27,28] the EI group showed significantly higher IQs and SQs than did the comparison group. The mean IQ for the EI group was about 10 points higher than that for the comparison group, a difference that is statistically significant (t=2.18, df=18, P<.05). Further, the mean SQ for the EI group was 24.5 points higher than that for the comparison group, which represents a highly significant difference (t=3.55, df=18, P<.01).

Table 6 compares the EI and comparison groups with regard to percentage of children at each level of mental retardation as defined by IQ range. The majority (70%) of the EI group subjects were at the mild and moderate levels, whereas the majority (60%) of the comparison group subjects were at the severe and profound levels. Moreover, none of the EI group subjects were at the profound level, whereas 20% of the comparison group subjects were at this level.

Table 7 compares IQ and SQ means and ranges for the 10 children in the EI group at the time of the first two follow-up studies[21,28] and in this study. Although the mean SQ has remained relatively stable for the three studies (1980–1989), the mean IQ showed a statistically significant decrease (t=7.82, df=9, P<.001) from 53.5 to 40.1 during the 6.8 years between the time of data collection of the second follow-up study[21] and this study.

Discussion

Motor Skills

The outcome of the motor assessment revealed that the children in the EI group, on the average, had gross motor skill levels that exceeded their fine motor skill levels. Additionally, the children's overall gross motor age (6.05 years) more closely approximated their average mental age (6.1 years) than did their fine motor age (5.64 years).

Previous studies have demonstrated that children with Down syndrome generally have deficits in eye-hand coordination, balance, laterality, visual motor activities, and reaction time.[12–19] Our previous data on the EI group using the BOTMP in 1984 revealed that eye-hand coordination, bilateral coordination, and upper-limb speed and dexterity were found to be among the most advanced motor skills for the children.[21] These skills were also found to be high in this

Table 5. *Chronological Age, Intelligence Quotient (IQ), and Social Quotient (SQ) of Early Intervention (EI) Group and Comparison Group*

	EI Group (n=10)	Comparison Group (n=10)
Chronological age (y)		
$\bar{X}$	15.7	14.8
SD	1.3	1.8
Range	13.9–17.8	12.1–18.6
IQ[a]		
$\bar{X}$	40.1[b]	30.5
SD	9.6	10.1
Range	25–53	17–45
SQ[c]		
$\bar{X}$	60.2[d]	35.7
SD	18.6	11.4
Range	34–96	21–61

[a]Assessed by Stanford-Binet Intelligence Scale (Form L-M).

[b]Significant at $t=2.18$, $df=18$, $P<.05$.

[c]Assessed by Vineland Social Maturity Scale.

[d]Significant at $t=3.55$, $df=18$, $P<.01$.

study. Areas of deficit continued to be running speed, balance, and reaction times.

As previously stated, running speed and balance continued to be problematic for these children.[16] Our results are consistent with previous reports of balance problems in other studies of children with Down syndrome.[18,19] The neuropathology associated with children with Down syndrome included delayed cerebellar maturation and a relatively small cerebellum and brain stem.[32] We hypothesize that the problems noted in balance, running speed (as related to motor planning), and coordination (as measured by reaction times) in the children with Down syndrome may be related to neuropathological causes.

Although we did not perform specific sensory evaluations on the EI group subjects during this study, we suspected problems in the somatosensory and vestibular systems because of the deficits identified. Previous research supports our suppositions about improper integration of sensory information in children with Down syndrome. Anwar and Hermelin[33] reported that children with Down syndrome had more difficulty than control groups in making directional judgments after participation in asymmetrical pointing. These authors suggested that the children with Down syndrome experienced a disruption of their spatial frame of reference because of the kinesthetic aftereffects of the asymmetrical pointing and that the use of proprioceptive reafferent feedback might be beneficial in children with Down syndrome.

Henderson et al[15] found that tasks requiring the use of both proprioceptive and visual reference systems (ie, drawing and copying) were deficient in children with Down syndrome. They speculated that children with Down syndrome have difficulty with integration of information across modalities. In support of the results reported by Henderson et al, we found that the EI group subjects had deficits in visual motor coordination and response time tasks on the BOTMP that could have resulted because they experienced difficulty in integrating visual and proprioceptive information.

Butterworth and Cicchetti[34] reported that young children with Down syndrome needed longer periods of visual cuing than did children without Down syndrome when they were placed in a situation in which the walls moved and the floor on which they were sitting remained stable. They suggested that infants with Down syndrome may require a higher level of vestibular input in order to respond to information from the environment. In view of these reported somatosensory deficits noted in children with Down syndrome, the need for increased somatosensory input may become clinically important.

As a group, the children involved in the EIP continued to make gains in their gross and fine motor skills between the time of second follow-up study and this study. When comparisons were made of the ratios between

Table 6. *Percentage of Children at Each Mental Retardation Level in Early Intervention (EI) and Comparison Groups*

Mental Retardation Level[a]	EI Group (n=10)	Comparison Group (n=10)
Mild (IQ=52–67)	10	0
Moderate (IQ=36–51)	60	40
Severe (IQ=20–35)	30	40
Profound (IQ<20)	0	20

[a]According to American Association on Mental Retardation classification.

Table 7. *Chronological Age, Intelligence Quotient (IQ), and Social Quotient (SQ) of Early Intervention Group (N=10)*

	First Follow-up Study[28]	Second Follow-up Study[21]	Present Study
Chronological age (y)			
$\bar{X}$	4.5	8.9	15.7
SD	0.8	1.0	1.3
IQ			
$\bar{X}$	55.3	53.5	40.1
SD	12.2	11.9	9.6
Range	38–78	35–69	25–53
SQ[a]			
$\bar{X}$	59.8	63.3	60.3
SD	15.7	11.7	18.6
Range[a]	41–81	43–78	34–96

[a]n=8.

their mental ages and their gross and fine motor skill ages, 8 of the 10 children had motor ages that increased at a faster rate than their mental ages. When individual comparisons were made, only 2 of the 10 children did not show this increase in gross motor skills. Both of these children were overweight, although 2 of the other 8 children were also overweight. Additionally, 1 child who did not show an increase in the ratio of gross motor skills to mental age had received a cardiac pacemaker at 6 months of age. This particular child has had several "demand" type pacemakers implanted since the time of the original pacemaker and has been restricted in her physical activities since her early teens.

On the average, the children who demonstrated the greatest increases in their gross motor skill levels were children who were involved in organized physical education programs that culminated in their participation in Special Olympics events. Participation of adolescents with mental retardation in structured physical training programs has been shown to be beneficial in several studies. Wright and Cowden[35] reported that adolescents with mental retardation who participated in a Special Olympics swimming program had a significant improvement in self-concept and cardiovascular endurance after only a 10-week period. Skrobak-Kaczynkie and Vavik[36] reported that male subjects with Down syndrome (ages 11–31 years) responded well to circuit-training programs that were aimed at increasing aerobic capacity and muscular strength. Additionally, they stated that those subjects who participated in the circuit-training programs had significant weight loss and subcutaneous fat loss as well as having a marked increase in muscle strength.

Observations during the administration of the subtests of the BOTMP in this study revealed that the children, as a group, were slow in their fine motor movements during the administration of the tests. Overall, the children were attuned to accuracy and had increased error correction during the testing. For example, when a bead was dropped during the stringing of beads, most of the children opted to pick up the dropped bead (even from the floor) and string it next rather than taking another bead from the container. During pencil tracing inside a pathway, the children self-corrected and returned to the point at which they had exited the pathway in error with the pencil rather than continuing to the end of the pathway. This increased attention to accuracy "cost" the children valuable seconds during the testing and thus lowered their scores on the subtest.

Intellectual and Adaptive Skills

In view of uncontrolled variables between the two groups, the differences in intellectual and adaptive scores should be interpreted with great caution within the context of this descriptive study. Table 5 reveals the mean IQ for the EI group to be about 10 points higher than that for the comparison group and the mean SQ to be almost 25 points higher. Furthermore, as shown in Table 6, 70% of the EI group subjects were at the mild or moderate level of retardation, with none at the profound level. In contrast, 80% of the comparison group subjects were at the moderate or severe level, and 20% were at the profound level.

Our findings are consistent with the hypothesis that early intervention has a beneficial effect on intellectual and adaptive skills that extends well into the adolescent years; however, the limitations of the design allow for alternative explanations. We cannot conclude that the higher scores of the EI group were unequivocally due to early intervention. Because the EIP was open to any family and participation was voluntary, we were unable to randomly assign children to either a treatment group or a control group. In the absence of a randomized groups design or a matched groups design, certain uncontrolled variables could well have contributed to differences between the two groups.

Foremost among these variables is that of the cohort effect. Because the children in the comparison group were, on the average, 8 years older than the children in the EI group, there is the strong likelihood that they did not have comparable educational opportunities and experiences as their younger counterparts. Another confounding variable that could conceivably have contributed to the dif-

ferences in scores is the possible differences in socioeconomic levels between the two groups. Another significant variable that must be considered is the substantial attrition that occurred in the EI group from the time of the original study. It is likely that this group represents a select group in terms of health as well as intellectual and adaptive functioning. Moreover, their parents probably constitute a select group in terms of motivation and interest, as reflected both in their pursuit of appropriate educational programs and in their participation in a series of follow-up studies.

In interpreting differences between groups from one follow-up study to another, it should be kept in mind that the same comparison group could not be used for the three studies. Examiner bias may have been present because only the EI group was evaluated for gross motor and fine motor skills across the 16-year longitudinal study and the physical therapist was therefore not blinded to the status of the children. The scores obtained were either compared with normative data from standardized tests or from the children's own previous scores on the evaluative tool. Less chance of examiner bias was present in the IQ and SQ testing, as the psychological examinations were performed by psychologists who had not been involved in the EIP or in previous psychological testing with the EI group subjects. All of these design problems necessitate cautious interpretations of our findings and consideration of alternative explanations for the differences between the groups.

In this study, we also did a longitudinal comparison of IQs and SQs for the 10 EI group subjects, who participated in all three of the follow-up studies. Although this group showed similar mean IQs from the first follow-up study[28] (IQ=55.3) to the second follow-up study[21] (IQ=53.5), the group's mean IQ dropped to 40.1 during the 6.8 years from the second follow-up study to this study. Nevertheless, the mean IQ in this study was significantly higher than the mean IQ of 30.5 in the comparison group. These results suggest that the rate of deceleration in intellectual development shown in most children with Down syndrome was not as pronounced in the EI group subjects.[4] An encouraging finding was that the mean SQ, which serves as a measure of adaptive functioning, demonstrated no corresponding decrease and remained fairly stable for the first (SQ=59.8), second (SQ=63.3), and third (SQ=60.2) follow-up studies. This finding indicates that the EI group subjects' adaptive skills were maintained at a relatively high level (mild retardation) and were less affected by increasing age than were their intellectual abilities.

Clinical Implications

The developmental therapist working with children with Down syndrome needs to be aware of gross motor and fine motor skill deficits that are seen in children with Down syndrome during the adolescent years. Balance and visual motor tasks continue to be problem areas[12,18,19,34] for children with Down syndrome, and we believe EIPs should emphasize therapeutic interventions in these areas as a means of decreasing functional deficits.[33,37–39] Functionally, balance may be a problem for the older child with Down syndrome who must be able to perform in situations in which his or her center of gravity is routinely perturbed (eg, crowded school hallways, shopping malls, city streets, playgrounds, and other recreational areas). We concur with others who suggest that techniques that involve proprioceptive, vestibular, and visual input may be beneficial to children with Down syndrome.[33,37–39]

Based on the findings of the 10 EI group subjects, participation in an organized physical education program even during the adolescent years may be important in order for the children to continue to make optimal progress in their gross motor skill development. Physical therapists should play a consultant role to physical educators in offering suggestions for activities that improve gross motor and fine motor functioning as well as physical fitness.

In the area of fine motor development, perhaps less emphasis should be placed on accuracy with adolescents with Down syndrome and more emphasis placed on speed if speed is needed in the motor tasks that are asked of them. This would be of particular functional importance if the adolescent is being prepared for a vocation that requires speed but not necessarily precision.

Conclusions

The overall results indicated that our sample of adolescents with Down syndrome continued to show deficits in similar areas of gross motor and fine motor skills that were identified during their late childhood. As a group, however, their gross motor and fine motor skills improved over time. The EI group subjects' intellectual and adaptive functional levels were found to be higher than expected at 13 to 17 years of age in comparison with other children of comparable age with Down syndrome. Although there are threats to the validity of these findings and we cannot clearly attribute the subjects' levels of functioning to the EIP, we continue to believe that early intervention with the child and the family is a critical first step in the long-range educational program of children with Down syndrome. We also believe that the EIP served as a motivator for parents in securing appropriate programs and services for their children.

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Commentary

The last two decades have witnessed extraordinary changes in the lives of individuals with Down syndrome, beginning with the deinstitutionalization movement and continuing with the current effort toward inclusion in the mainstream of society. Connolly and colleagues have conducted an interdisciplinary study of the motor, mental, and social attainments of a group of children with Down syndrome who had participated in an early intervention program in the 1970s. The current report is the fourth in their series.[1–3] They are to be commended for their perseverance in this difficult, but very worthwhile, task.

In designing the study, the authors also identified a group of children with Down syndrome who had not experienced early intervention for comparison of mental and social abilities with the study group. They acknowledge several factors that limit comparison of the two groups. Another issue that may be relevant is that samples drawn from clinic populations, such as the comparison group in this study, frequently include children who are having problems of some sort, which is the reason for