Are the cognitive functions of children with Down syndrome related to their participation?

TANYA RIHTMAN | ESTI TEKUZENER | SHULA PARUSH | ALEX TENENBAUM | STEVEN J BACHRACH | ASHER ORNOY

1 School of Occupational Therapy, Hebrew University Hadassah Medical School, Jerusalem, Israel. 2 Jerusalem Institute of Child Development, Israeli Ministry of Health, Jerusalem, Israel. 3 Alfred I DuPont Hospital for Children, Wilmington, DE, USA. 4 Hebrew University Hadassah Medical School, Jerusalem, Israel. 5 Department of Child Development and Rehabilitation, Israeli Ministry of Health, Jerusalem, Israel.

Correspondence to Prof Asher Ornoy at the Laboratory of Teratology, Hebrew University Hadassah Medical School, PO Box 12272, Jerusalem 91120, Israel. E-mail: ornoy@bgu.ac.il

PUBLICATION DATA
Accepted for publication 10th March 2009.
Published online 16th September 2009.

LIST OF ABBREVIATIONS
Beery Beery-Buktenica Developmental Test of Visual-Motor Integration, 5th Edition
SBIS Stanford-Binet Intelligence Scale, 4th Edition
VABS Vineland Adaptive Behaviour Scales, Interview Edition
VMI Visual-Motor Integration subscale of Beery test

AIM There is a lack of investigation into the functional developmental profile of children with Down syndrome. On the basis of current international health paradigms, the purpose of this study was to assess the developmental profile of these children.

METHOD Sixty children (33 males, 27 females) with Down syndrome (age range 6–16y; mean age 9y 3mo, SD 28.8mo), who had received standard, holistic, early intervention, were assessed. Of these, 42 (70%) had congenital anomalies, 12 had severe congenital heart defects. Participants were assessed on measures of cognitive function (Beery-Buktenica Developmental Test of Visual-Motor Integration; Stanford-Binet Intelligence Scale) and participation (Vineland Adaptive Behaviour Scales).

RESULTS No difference was found on any measure on the basis of severity of congenital anomaly. Results showed improvements in age-related body function and correlations between specific body functions and participation. No decline in IQ was found with age, and significant correlations between IQ and all other measures were noted. Although sex differences were found in the body functions of short-term memory and motor function, no difference in measures of activity performance and participation was found.

INTERPRETATION Our findings emphasize the need for paediatric Down syndrome intervention to encourage improved body functions while emphasizing the acquisition of functional skills that enable enhanced participation in age-appropriate activities.

Down syndrome is the most common autosomal anomaly occurring in live births, and has been described as a syndrome-complex of genetic origin with protein neurobiological consequences, and several characteristic neurodevelopmental and neuropsychological manifestations. Resulting from trisomy of chromosome 21, Down syndrome is the most common single cause of mild, moderate and severe learning disability, with between 70% and 75% of individuals with Down syndrome attaining an IQ of between 25 and 50 by the end of the first decade of life.

A wide variety of frequencies is reported, but most report a range of 1 in 650 to 1000 live births. When compared with the general population, individuals with Down syndrome experience a reduced life expectancy, but within the Down syndrome population, life expectancy is increasing. There is a statistically significant difference between the survival of males and females with Down syndrome, in favour of males.

Clinically, individuals with Down syndrome present with a wide range of physical and anatomical characteristics, congenital malformations and a tendency towards specific medical conditions. Medical paradigms have undergone major changes in recent years, and international measures of health now reflect the importance of participation and function on the health of individuals, communities and society. The World Health Organization has adopted the International Classification of Functioning, Disability and Health (ICF), a biopsychosocial model that no longer measures the repercussions of disease but emphasizes components of health. A holistic approach is now vital when assessing the individual, from body functions (such as IQ, which is incorporated within the 'body function' category of the ICF) to activities and participation, defined by the ICF as 'the execution of a task or action' and 'involvement in a life situation' respectively. Despite these shifts, there has been limited investigation into the activity performance and participation of children with Down syndrome, as measured by their adaptive functioning.

Down syndrome is associated with a distinct profile of developmental outcomes regarding body functions and activity performance, with evidence for great variation in the range and level of deficits resulting from biological and environmental...
tal factors. In comparison with normally developing children, children with Down syndrome show developmental delays in most areas. Relatively preserved visual–spatial and visual–motor skills are often noted, yet the influence of these skills on the activity performance of the child with Down syndrome is unclear.

The cognitive limitations of individuals with Down syndrome have an important influence on the level of functioning attained, and a significant correlation has been noted between IQ and all areas of function. There is a common perception that the IQ scores of individuals with Down syndrome change over time, and a progressive decline has been reported. This decrease seems most significant in the first decade; in adolescent years, cognitive function has been reported to reach a plateau that continues into adulthood.

Studies investigating the physical and neurodevelopmental profile of this syndrome often incorporate mixed-sex study groups, resulting in inconclusive evidence about sex differences in areas vital to participation. Of the few studies comparing males with females, some have not found differences but others have found that males perform less well than females in specific functional areas of activity performance and participation.

The few existing studies investigating the holistic functional profile of children with Down syndrome have tended to be qualitative and investigated adult populations, even though all these children will display some form of intellectual disability resulting in the need of functional intervention. Few studies have measured specific skills appropriate to the wide range of abilities presented by children with Down syndrome or reported attainment levels for children in different age groups. There remains, therefore, a dearth of investigation into the functioning and participation of children with Down syndrome based on age-appropriate, socially acceptable activities.

Up-to-date information is needed to guide parents and professionals with regard to reasonable expectations. On the basis of current international health paradigms, the purpose of this study was to assess the developmental profile of 60 children with Down syndrome between the ages of 6 and 16 years who had received a holistic early intervention from birth until their entry into an appropriate educational framework. A focus was placed on investigating the developmental continuum on measures of body functions (specifically IQ and visual–motor integration), academic activities and participation and assessing whether this continuum differs between sexes. The relationship between body function variables and participation as well as the performance of specific school-related activities was also studied.

**METHOD**

**Participants**

This study included 60 Hebrew-speaking children (33 males, 27 females) with Down syndrome, all of whom were treated at the Jerusalem Institute for Child and Family Development of the Israel Ministry of Health from birth until their entry into an appropriate educational framework between the ages of 3 and 4 years. The children were aged between 5 years and 10 months and 15 years 8 months (mean 9y 3mo, SD 28.8mo) at the time of testing. No child was receiving treatment at the Institute at the time of the study. The children were divided into the following three similarly sized age groups: youngest (n=20; 12 males, eight females; mean age 6y 11mo, SD 7.05mo; range 5y 10mo–7y 8mo); middle (n=21; nine males, 12 females; mean age 9y, SD 9.8mo; range 7y 9mo–10y) and oldest (n=19; 12 males seven females; mean age 12y 2mo, SD 20.3mo; range 10y 2mo–15y 8mo). These age groups were selected because it seemed feasible to expect greater differences in groups of children between the ages of 6 to 8 years (younger preteens) and 8 to 10 years (older preteens) than in adolescents.

**Instruments**

**Medical examination**

A complete physical and neurological evaluation was performed by a developmental paediatrician, paying special attention to the presence of major congenital anomalies.

**Stanford–Binet Intelligence Scale, 4th Edition (SBIS)**

The SBIS is a normative, reliable, and valid measure developed to test cognitive ability in individuals from 2 to 23 years of age, which provides an IQ score.

**Vineland Adaptive Behaviour Scales, Interview Edition (VABS)**

The VABS is a standardized and norm-referenced measure of personal and social skills for use in populations from birth to 18 years 11 months old. The interview edition includes 577 items, divided into four domains (communication, daily living skills, socialization skills, and motor skills). In the present study, the scale was completed by parent report. This measure enables the assessment of the construct of participation through its assessment of adaptive behaviour, which is defined as the age-related performance of the daily activities required for personal and social sufficiency.

**Beery–Buktenica Developmental Test of Visual–Motor Integration (VMI), 5th Edition (Beery)**

The Beery is a standardized, reliable, and valid assessment of visual–motor skills for individuals between the ages of 2 and 18 years. Participants were tested with the full format of the VMI, and completed the supplemental developmental tests of visual perception and motor coordination.

**Procedure**

Between 1970 and the middle of the 1990s, the Jerusalem Institute for Child and Family Development of the Israel Ministry of Health was the major provider of services for all children born with Down syndrome in the Jerusalem area. During this period, the parents of these children were contacted immediately after delivery and the child was referred to the Institute for treatment and follow-up.

The intervention protocol was standard throughout this period. During their first year, all children received weekly home-based interventions from an occupational or physical
therapist on the basis of a holistic approach, according to sensory, motor, and cognitive developmental milestones. From the age of 1 year until their enrolment into an appropriate educational program, the children were individually treated weekly at the Institute by occupational, physical, and speech therapists and underwent regular medical evaluations.

The study was approved by the ethics committee of the School of Occupational Therapy of the Hebrew University Hadassah Medical School, Jerusalem. Letters were sent to the parents of all children born with Down syndrome in the Jerusalem vicinity between 1988 and 1998 who had been treated at the Institute (n=119). Eight children had died, 30 children were not traced and 21 declined to participate in the study, leaving the study group with 60 children. Parents signed a consent form, and all participants were invited to the Institute for one or two testing sessions (between 4 and 6 h).

**Statistical analysis**

A type I error rate of 0.05 was used for all analyses. Statistical Package for Social Sciences for Windows (version 13; SPSS Inc., Chicago, IL, USA) was used for all calculations. Standard scores were used for all calculations incorporating the VABS and the SBIS. Raw scores were used for analyses incorporating the Beery subtests because the rating scale is narrow and the use of raw scores for this scale enabled a more sensitive performance of comparisons across Down syndrome age and sex groups for this test. Pearson's coefficient correlations were performed to assess relationships between interval variables, and Spearman's correlations were performed to assess relationships between ordinal variables. Age was investigated as a continuous variable for some procedures, whereas for others the children were divided into three similarly sized age groups.

Multiple (2 x 3) analyses of variance (MANOVAS) were performed to assess the effects of age group, sex, and age-group x sex interaction effects for the subtests of each instrument (Beery, VABS, and SBIS). Two-way analyses of variance (ANOVAS) were conducted on the VABS and SBIS test composite scores. Scheffé multiple comparison tests were selected for post-hoc analyses. A Kruskal–Wallis analysis was performed when a nonparametric ANOVA was required. The pairwise deletion method was used to deal with missing data; although this method creates unequal group sizes, it was selected because it enables the maintenance of sufficient group sizes for analyses. Effect sizes were ascertained by means of $\eta^2$, which reflects the proportion of the total variance attributed to or accounted for by an effect, with 0.01 reflecting a small effect size, 0.06 reflecting a medium effect size, and 0.14 reflecting a large effect size.

**RESULTS**

Of the total study sample (n=60), 18 children (30%) had no congenital anomalies, 26 (43%) had cardiac anomalies, six (10%) had noncardiac anomalies, and 10 had both cardiac and noncardiac anomalies (17%). Of the 16 children with noncardiac anomalies (27%), 14 had one noncardiac anomaly (23%), one had two noncardiac anomalies (2%), and one had three noncardiac anomalies (2%). Two children had respiratory/upper-airway anomalies (cleft palate, pulmonary hypertension; 3%) and two children had genitourinary anomalies (hypospadias, cryptorchidism; 3%). Five children (8%) had one gastrointestinal anomaly, and one child (2%) had two gastrointestinal anomalies (diagnoses: duodenal atresia/stenosis, colostomy, omphalocele). Two children (3%) had musculoskeletal anomalies (congenital talipes equinovarus). Endocrine anomalies (hypothyroidism, elevated thyroid-stimulating hormone) were also considered to be among the noncardiac congenital anomalies, and six children (10%) had conditions of this type.

Of those children with cardiac anomalies (n=36), 24 (67%) had minor cardiac anomalies (patent ductus arteriosus, small atrial septal defects, and patent foramen ovale) and 12 (33%) had severe cardiac anomalies (ventricular septal defect not closed spontaneously, atrioventricular canal, and tetralogy of Fallot). No significant difference was noted on the scores of any measure on ANOVAs calculated to investigate between-group differences between children without cardiac anomalies, those with minor cardiac anomalies, and those with major cardiac anomalies (Table SI, supporting information published online), suggesting that none of these anomalies was so severe as to interfere with the function of the child.

Pearson's coefficient correlations between age and the subtests of the VABS and the SBIS respectively, for the study group as a whole, revealed a moderately significant negative correlation between age and the short-term memory subtest of the SBIS ($r=-0.35$; confidence interval [CI] $r=-0.56$ to $-0.10$). Pearson's coefficient correlations between age and the subtests of the Beery revealed significant correlations for all three scales (VMI: $r=0.48$; CI ($r=0.23$–0.67); visual: $r=0.39$; CI ($r=0.12$–0.60); motor: $r=0.46$; CI ($r=0.21$–0.66)).

A 2 x 3 MANOVA was performed to assess the effects of age group (three levels) and sex (two levels) on the three Beery subtests (VMI, motor, and visual). The mean scores and standard deviations on the three subtests according to age and sex are presented in Table SI (supporting information published online). The results showed significant main effects for both age (Wilks' $\Lambda=0.63$, F[6,82]=3.56, $p=0.003$, $\eta^2=0.21$) and sex (Wilks' $\Lambda=0.82$, F[3,41]=3.07, $p=0.038$, $\eta^2=0.18$) with large effect sizes, yet no significant age x sex interaction effect was found (Wilks' $\Lambda=0.95$, F[6,82]=0.33, $p=0.92$).

To investigate the main effect of sex further, the between-participant effects of the MANOVA model were analyzed. Significant sex difference, with a large effect size, were found only for the motor subtest ($F[1,47]=8.81$, $p=0.005$, $\eta^2=0.17$) with females (mean 12.63, SD 3.30) performing better than males (mean 9.30, SD 4.88). No sex difference for the VMI ($F[1,47]=3.26$, $p=0.078$) or visual ($F[1,47]=0.96$, $p=0.33$) subtests was found.

To further investigate the main effect of age, the between-participant effects of the MANOVA model were analyzed. Significant age group differences were found, with large effect sizes, for each subtest (VMI: $F[2,47]=10.01$, $p<0.001$, $\eta^2=0.32$; visual: $F[2,47]=4.33$, $p=0.019$, $\eta^2=0.17$; motor: $F[2,47]=7.92$, $p=0.001$, $\eta^2=0.27$). Scheffé post-hoc analyses performed for
each dependent variable revealed that on the VMI subtest, the oldest group (mean 12.94, SD 3.50) differed significantly from both the middle (mean 9.13, SD 3.82, p=0.013) and youngest (mean 7.00, SD 3.30, p=0.001) groups, but no significant difference between the youngest and middle groups was found (p=0.24). For the visual subtest, the oldest group (mean 15.71, SD 5.17) differed significantly from the youngest group (mean 9.50, SD 5.42, p=0.013) but not from the middle group (mean 13.43, SD 4.91, p=0.64). The difference between the middle and youngest groups was not significant (p=0.12). Similarly, for the motor subtest, the oldest group (mean 13.47, SD 4.22) differed significantly from the youngest group (mean 7.50, SD 4.35, p=0.001) but not from the middle group (mean 10.62, SD 3.20, p=0.10). Again, the difference between the middle and youngest groups was not significant (p=0.07).

To assess the effects of age group (three levels) and sex (two levels) on the three subtests of the VABS (daily living skills, socialization, and communication) a separate 2 x 3 MANOVA was performed. The mean scores and standard deviations on the three subtests according to age and sex are presented in Table SII. The results revealed no effect of age (Wilks’ $\Lambda=0.82$, $F(6,92)=1.60$, $p=0.16$) or sex (Wilks’ $\Lambda=0.94$, $F(3,46)=0.97$, $p=0.41$) and no age $\times$ sex interaction effect (Wilks’ $\Lambda=0.94$, $F(6,92)=0.47$, $p=0.83$) for the subtests of this measure.

To analyze the effects of age group (three levels) and sex (two levels) on the test composite score of the VABS, a two-way ANOVA was performed. No significant main effect was found for either age group ($F(2,54)=2.90$, $p=0.064$), or sex ($F(1,54)=0.00$, $p=0.993$), and no significant age $\times$ sex interaction was found ($F(2,54)=0.04$, $p=0.964$).

To assess the effects of age group (three levels) and sex (two levels) on the four subtests of the SBIS (verbal, abstract/visual, quantitative reasoning, and short-term memory) a final 2 x 3 MANOVA was performed. The mean scores and standard deviations on the four subtests according to age and sex are presented in Table SII. The results showed a significant main effect for sex (Wilks’ $\Lambda=0.78$, $F(4,47)=3.29$, $p=0.019$, $\eta^2=0.22$) with a large effect size, yet no significant age effect (Wilks’ $\Lambda=0.90$, $F(8,94)=0.63$, $p=0.748$) or age $\times$ sex interaction effect (Wilks’ $\Lambda=0.83$, $F(8,94)=1.15$, $p=0.338$) was found.

To investigate the main sex effect further, the between-participant effects of the MANOVA model were analyzed. A significant sex effect with a large effect size was found only for the short-term memory subtest ($F(1,54)=5.34$, $p=0.025$, $\eta^2=0.10$); females (mean 50.11, SD 9.19) performed better than males (mean 44.41, SD 7.43).

A two-way ANOVA was performed to analyze the effects of age group (three levels) and sex (two levels) on the test composite score of the SBIS. No main effect was found for either age group ($F(2,51)=1.35$, $p=0.267$) or sex ($F(1,51)=2.08$, $p=0.156$), and no interaction effect was found ($F(2,51)=0.61$, $p=0.546$).

A Kruskal–Wallis analysis performed to assess differences in sex performance on the VABS scores of copying, free writing, and handwriting for those children for whom the data were available (n=33; 16 males, 17 females) yielded no significant difference.

For the whole study group, significant Pearson’s coefficient correlations were found between IQ and all the Beery subtests as well as IQ and all subtests and composite scores of the VABS (Table I).

Pearson’s coefficient correlations between the Beery and the VABS composite scores yielded significant moderate correlations between the scores of the children on the Beery VMI and motor subtests but not on the visual subtest (Table II). Significant Spearman’s coefficient correlations were found between all subtests of the Beery and the VABS scores for copying, free writing, and handwriting for the children who completed these sections of the assessment (Table II).

**DISCUSSION**

The purpose of this study was to assess the functional profile of 60 children with Down syndrome aged between 6 and 16 years. No participant had congenital anomalies severe enough to interfere with their function, implying that all functional deficits noted were primary and due to the trisomy itself. Our finding of sex differences on the short-term memory subtest of the SBIS, with females performing better than males, is particularly noteworthy. It is not clear whether the developmental continuum differs between males and females, and our findings begin to shed light on such differences. The finding that females showed superior motor function to that of males is also significant, particularly in view of the fact that functional sex differences on the specific VABS measures of copying, handwriting and free writing were not found.

Also noteworthy is our finding of notable group differences on the raw scores of the Beery, which seems to negate the idea of a plateau in VMI skills. This is reinforced by the lack of significant differences based on standard scores, implying that the performance of the children was not poorer when compared with typically developing peers. Alternatively, this finding may be due to improved maturity in these skills, an interpretation that would explain the finding of group differences between the oldest and youngest groups on the motor

<table>
<thead>
<tr>
<th>Measure</th>
<th>Subtest</th>
<th>Stanford-Binet test composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beery</td>
<td>VMI</td>
<td>0.48</td>
</tr>
<tr>
<td></td>
<td>Motor</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td>Visual</td>
<td>0.40</td>
</tr>
<tr>
<td>Vineland</td>
<td>Communication domain</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td>Daily living skills domain</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td>Socialization domain</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>Adaptive behaviour composite</td>
<td>0.63</td>
</tr>
</tbody>
</table>

CI, confidence interval; VMI, Visual–Motor Integration.
Table II: Pearson's correlations between subtests of the Beery-Buktenica Test of Visual Motor Integration and Vineland Adaptive Behaviour Scales composite score and Spearman's correlations between copying, free writing, and handwriting

<table>
<thead>
<tr>
<th>Beery subtest</th>
<th>Vineland composite</th>
<th>Copying (n=36)</th>
<th>Free writing (n=35)</th>
<th>Handwriting (n=34)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>CI (r)</td>
<td>r</td>
<td>CI (r)</td>
</tr>
<tr>
<td>VMI</td>
<td>0.38</td>
<td>0.11–0.80</td>
<td>0.64</td>
<td>0.39–0.80</td>
</tr>
<tr>
<td>Motor</td>
<td>0.40</td>
<td>0.14–0.61</td>
<td>0.61</td>
<td>0.36–0.78</td>
</tr>
<tr>
<td>Visual</td>
<td>0.24</td>
<td>ns</td>
<td>0.46</td>
<td>0.14–0.68</td>
</tr>
</tbody>
</table>

CI, confidence interval; ns, not significant; VMI, Visual–Motor Integration.

and visual subtests, with no findings of group differences between the middle and youngest groups. The suggestion of improved body function with age is further supported by the relationship found for the whole sample between age and scores on all subtests of the Beery. This trend of a linear improvement in performance on VMI, visual and motor tasks implies that, as they get older, children with Down syndrome between the ages of 6 and 16 years show better graphomotor control and are better able to imitate and visually discriminate between figures with increasingly challenging properties. This may also imply that functional maturation of the brain continues in these children, but at a slower pace than that of typically developing children.

Our findings begin to shed light on the contribution of copying shapes to successful participation in writing activities in children with Down syndrome. The association found between all the scores on the Beery and the scores of the child on parent-reported measures of copying, free writing, and handwriting reinforce the existence of a connection between body functions and activity performance. Taken together, these findings have functional implications for the acquisition of writing skills, an area that has been under-researched in this population.17

In comparison with typically functioning populations, the visual–spatial, short-term memory function of individuals with Down syndrome has been reported to be impaired.19 Our finding of decreased short-term memory with age supports this claim. However, the lack of finding of correlations in any other area may be explained by the use of standard scores for analyses with these measures. The findings of correlations between age and raw scores of the Beery, and the lack of finding of correlations between age and standard scores of the VABS and SBIS (with the exception of short-term memory), imply that within the age groups and measures investigated, the children did not reach a plateau.

Our finding of an association between IQ and all other measures (visual–motor integration and adaptive behaviour) supports previous findings19 implying that the IQ of children with Down syndrome is related to their success at implementing functional components and participating in specific activities. This result is also important when considering reports that functional attainments earned in childhood seem to be maintained into adulthood in this population.30 Adults with Down syndrome who are the most accomplished in terms of independence in daily living and maintaining paid employ-

and visual subtests, with no findings of group differences between the middle and youngest groups. The suggestion of improved body function with age is further supported by the relationship found for the whole sample between age and scores on all subtests of the Beery. This trend of a linear improvement in performance on VMI, visual and motor tasks implies that, as they get older, children with Down syndrome between the ages of 6 and 16 years show better graphomotor control and are better able to imitate and visually discriminate between figures with increasingly challenging properties. This may also imply that functional maturation of the brain continues in these children, but at a slower pace than that of typically developing children.

Our findings begin to shed light on the contribution of copying shapes to successful participation in writing activities in children with Down syndrome. The association found between all the scores on the Beery and the scores of the child on parent-reported measures of copying, free writing, and handwriting reinforce the existence of a connection between body functions and activity performance. Taken together, these findings have functional implications for the acquisition of writing skills, an area that has been under-researched in this population.17

In comparison with typically functioning populations, the visual–spatial, short-term memory function of individuals with Down syndrome has been reported to be impaired.19 Our finding of decreased short-term memory with age supports this claim. However, the lack of finding of correlations in any other area may be explained by the use of standard scores for analyses with these measures. The findings of correlations between age and raw scores of the Beery, and the lack of finding of correlations between age and standard scores of the VABS and SBIS (with the exception of short-term memory), imply that within the age groups and measures investigated, the children did not reach a plateau.

Our finding of an association between IQ and all other measures (visual–motor integration and adaptive behaviour) supports previous findings19 implying that the IQ of children with Down syndrome is related to their success at implementing functional components and participating in specific activities. This result is also important when considering reports that functional attainments earned in childhood seem to be maintained into adulthood in this population.30 Adults with Down syndrome who are the most accomplished in terms of independence in daily living and maintaining paid employ-

ment are those who participated in structured school experiences aimed at teaching them specific skills,31 yet reports of an IQ plateau or decrease beginning in early adulthood are common.31 If the attainment of functional skills and abilities (which are maintained into adulthood) are dependent on IQ (which may decline with age)31,12,17,20 or develop more slowly than in typically developing individuals,15 it is essential to providing functionally focused interventions from the earliest possible age in children with Down syndrome. This need for early intervention focusing on function is further supported by the finding that the functional profile of children with Down syndrome does indeed improve with age.

Usually, Down syndrome intervention programmes emphasize body structures and functions, and finding a way to create a bridge with participation is essential. The finding of significant (albeit moderate) correlations between body functions (of VMI and motor function) and the VABS (adaptive functioning) may be explained by the distinct personality motivational profile16 of individuals with Down syndrome; although this was not directly assessed in this study, it is plausible that poor performance on developmental tests may be due to a deficit in motivation and not to functional delay as such.32 Thus, children with Down syndrome who show improved performance on structured tests may be those with greater motivational levels and are, therefore, predisposed to greater adaptive functioning by virtue of having a greater tendency toward experience and learning. Alternatively, more successful adaptive functioning may occur in children with the physical foundation of better functional components. Perhaps those children who performed well on the Beery are those who also had more intact functional components in other areas. It is possible that these children are then the ones who are better able to participate successfully in functional activities. If this is true, it would lend empirical support for intervention that is directed at improving functional components while using these functions to create a bridge with actual participation in age-appropriate activities.

A number of limitations are evident in the present study. Foremost, there was a lack of demographic data characterising the identified population. The lack of assessment results from when the children were younger (for example age 2 or 3y) resulted in the lack of possibility of using baseline measures to assess whether the functional outcomes of children with Down syndrome are dependent on initial developmental levels. The lack of infancy baseline scores also prevented the use of pre-
and posttests for the comparison of intervention effects. However, it should be noted that (despite findings of correlations between body functions and adaptive behaviour at the time of testing) assessments of infant psychomotor skills have been found to be poor prognosticators of later adaptive functioning in children with Down syndrome. The lack of baseline scores for the participants in the study may, therefore, not be critical. Although more successful adaptive functioning may occur in children with the physical foundation of better functional components, it seems that psychomotor skills can be acquired. However, the lack of prognosticative ability of infant psychomotor skills does not negate findings of the maintenance of functional skills acquired in early childhood, nor does it negate our claim of the need to provide early, functionally focused interventions.

An additional limitation of the study is the wide age range of the oldest group, as a result of the attempt to include all teenagers within the same group and to examine differences between younger (6–8y) and older (8–10y) preadolescent school-aged children. Future studies should ensure improved homogeneity of age groups and should also attempt to attain objective measures of handwriting performance. Finally, this study used a cross-sectional study design that limits the interpretation of the developmental continuum of the child with Down syndrome. Further research should seek to apply longitudinal study designs.

CONCLUSION
Changing international health measures and paradigms have led to a need for a shift in intervention focuses in treating children with Down syndrome, with increased emphasis being placed on participation and on the acquisition of specific, functional skills. Because a large proportion of individuals with Down syndrome remain at home and are living for longer, functional independence is a vital element of their quality of life.

Our findings of continuous improvement in function with age, if such intervention has been provided, is further evidence supporting the need for paediatric Down syndrome intervention to encourage improved body functions while emphasizing the acquisition of functional skills that enable enhanced participation in age-appropriate activities. In addition, this study raises doubts as to whether or not children with Down syndrome do indeed reach a functional plateau and offers the possibility of changing our perception with regard to the functional and educational potential of children with trisomy 21.

ACKNOWLEDGEMENTS
The authors thank Dr Hagit Magen for her statistical advice during the preparation of the manuscript.

SUPPORTING INFORMATION
Additional Supporting Information may be found in the online version of this article:
Table S1: Group comparisons between children without cardiac anomalies, minor cardiac anomalies, and major cardiac anomalies Table S2: Means (SD) on the three subtests of the Beery, the three subtests of the Vineland Adaptive Behavior Scales, and the four subtests of the Stanford–Binet Intelligence Scale, according to age and sex.

Please note: Wiley-Blackwell are not responsible for the content or functionality of any supporting materials supplied by the authors. Any queries (other than missing material) should be directed to the corresponding author for the article.

REFERENCES

Participation of Children with Down Syndrome. Tanja Ruhm et al. 77