Title	Parental behavior influences on motor skill development in young children with developmental disabilities: A two-year longitudinal study
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Abstract

Young children with developmental disabilities (DDs) experience motor skill deficits compared to their peers without disabilities. Even though parents play an important role in developing their children's motor skills, it has not been widely studied how parental behaviors influence motor skill development in young children with DDs. Therefore, the current study has two main purposes: a) to examine early motor skill development of preschool aged children (3-5 years) with DDs longitudinally over a two-year period and b) to longitudinally examine the relationship between parental behaviors and the motor skill development of young children with DDs. Fundamental motor skills (locomotor and object control skills) in 64 young children with DDs and their parent's behavior was measured at five time points when children were between the ages of three and five years. Multilevel modeling was used to examine motor skill progression in young children with DDs and to evaluate the longitudinal relationship between parenting behaviors and motor skill development in young children with DDs. Findings indicated that young children with DDs develop their motor skills in a non-linear fashion across two years. Young children with DDs who have parents with one standard deviation higher (+SD) in the positive parental behavior than average showed a statistically significant linear increase in the standard scores of locomotor and object-control skills with age ($b = 0.27$, $p = 0.01$; $b = 0.22$, $p < 0.01$, respectively). This study highlights the importance of positive parenting behaviors in regard to promoting motor skills in young children with DDs.

Keywords: Fundamental motor skills, Parenting, Parental behaviors, Developmental disability, Parent-child interaction

Introduction

Gross motor skills are foundational movement skills that lead to success in more complex physical activities (PA) such as sports, dance and games [1–3]. Children with lower motor skill competence have difficulty participating in many PAs compared to their well-coordinated peers [4]. In early childhood, PA engagement is known to predict later motor skill competence, but as children age, motor skill competence becomes the main predictor of PA engagement. While it is critical to acknowledge this bidirectional relationship, it is essential to target motor skill development early, in order to increase PA engagement as children age [5,6]. Given that PA participation provides individuals with many health-related benefits such as improvement of physical fitness and bone density [7], it is important for children to hone-in and develop motor skills early in childhood in order to access and engage in PA later.

Young children with developmental disabilities (DDs; a group of conditions with impairments in aspects fundamental to development including behavior, language, or learning which include impairment), experience motor skill deficits compared to their peers without disabilities [8–11]. Liu and colleagues (2014) found that children with ASD received statistically significantly lower scores in both locomotor and object control skills compared to children without ASD [10]. Additionally, a study found that among 1012 children with developmental delay, 2.2% experienced motor skill deficits [12]. In a study examining the motor skills of children with speech delay reported that 51% of children (n = 125) had motor problems [12]. Moreover, children with speech disorders have lower levels of motor skills compared to children without disabilities [13]. Thus, known motor skill delays exist in children with DDs.

Even though ample evidence supports motor skill deficits in children with DDs, it has not been widely known how motor skills develop during childhood, especially early childhood.

Lloyd et al. (2013) examined the gross motor skills of young children with ASD longitudinally (n=58) and found that motor skill delays persisted across time and that the delay became greater as young children aged [14]. Although this study provided an important finding, its results were limited to young children with ASD, and the study did not examine development by gender. Emperical studies have reported gender differences in motor skill development between boys and girls, indicating boys are more likely to develop motor skills at a faster rate compared to girls [15,16]. Better understanding the rate of motor skill development in children with DDs at a young age can confirm that delays exist and add more information about crucial developmental windows for young children with DD.

In the context of motor development, the *field of promoted action* theory [17] suggests that parents play an important role in developing their children's motor skills (a) by selecting the activities in which their children participate and (b) by providing scaffolding (i.e., the support given to a beginner by an experienced learner) to their children. This theory implies that children's movement may vary based on how parents reinforce their child's motor skill development. An empirical study examined the effectiveness of parental writing support on fine motor skill development in preschoolers without disabilities and found significant improvements in fine motor skills when parents actively engaged in their child's writing activity [18]. Although this study focused specifically on fine motor skill development, it is possible that active parent engagement could have the same effect on their child's gross motor skills. These studies provide some insight into how parents influence motor skill development in children without disabilities, yet less is known about the effects of parent behavior on motor skill development in children with DDs.

To our knowledge, there are no studies investigating a longitudinal association between parental behaviors (combined behaviors including parental encouragement, sensitivity, attachment, and support) and motor skill development in children with DDs. Therefore, the current study has two main purposes: a) to examine early motor skill development of preschool aged children (3-5 years) with DDs longitudinally over a two-year period and b) to longitudinally examine the relationship between parental behaviors and the motor skill development of young children with DDs. It was hypothesized that young children with DDs would develop their motor skills with age. It was hypothesized that there would be a positive longitudinal association between parental behaviors and motor skill development in young children with DDs.

Method

This study is a part of a larger longitudinal investigation of family-based interventions for caregivers with young children with DDs in the Pacific Northwest region of the United States [redacted]. Data was collected at five time points when children were between the ages of three and five years. The average interval between each assessment for each participant was approximately six months. 64 young children with DDs met the predetermined inclusion criteria: a) between the ages of two to four years at time of entrance into the study, b) had a documented developmental delay or disability, c) received services through an Individualized Family Service Plan (IFSP), d) were ambulatory, e) were living with their primary caregiver for at least 1 year and f) children's motor skills were evaluated at least three times. Children who were deaf or blind were excluded from participation in this study. Assessments included in this study were primarily collected in the child's home.

Measures

Demographic questionnaire

Demographic information about the children and parents/caregivers were collected through a questionnaire via in-home interviews that were administered by a team of research assistants. The demographic variables included the child's age, gender, race/ethnicity, disability status (e.g., disability type), special education and related service utilization, as well as the parent/caregiver age, education and household income. The child's disability status was identified by parent report.

Gross motor skills

Children's motor skills were assessed with the Test of Gross Motor Development-2 (TGMD-2; Ulrich, 2000) by a trained research assistant in the child's home at each time point, every six months for two years (i.e., five time points). The TGMD-2 is a valid and reliable assessment of motor skills for children and has successfully measured motor skills of children with developmental disabilities [10,19,20]. Even though this assessment has been validated for children aged three to ten, it has been implemented in children as young as two years of age [21]. The TGMD-2 measures the performance of 12 gross motor skills and consists of two subtests, the locomotor subtest (run, gallop, hop, leap, jump, and slide) and the object-control subtest (strike, dribble, catch, kick, throw, and roll). The performance of each item on the subtest is measured for major movement patterns, each of which are dichotomously scored (1 = present, 0 = not present). The scores of all gross motor skills are then added up to yield the total raw score. This raw score can be converted into standard scores using the standardized norms. In the current study, the standard scores of the two subtests (locomotor and object control) were used for the analysis.

Parental behavior

115 During the home visits, each parent and child dyad were asked to interact together as they
116 usually do, and this play session was video recorded. The observation consisted of a free play
117 task (10 min), a clean-up task (2 min), and a structured activity task (3 min). The free play task
118 consisted of common toys used in social-play and lasted for ten minutes. After the free play, the
119 clean-up task was followed (i.e., putting toys back into a bin). Lastly, the parent-child dyad was
120 asked to participate in a structured activity (e.g., puzzles, shape sorter, or ring stacker) for three
121 minutes. The total observation lasted for 15 minutes.

122 Trained coders (who were trained and achieved more than 80% agreement) examined the
123 video recorded parent-child interaction, using the Coder Impression Inventory [22]. Parental
124 behaviors were derived from a comprehensive observation system, which included observations
125 on parenting behaviors as well as child behaviors. The Coder Impression Inventory examines
126 parenting behaviors, specifically how parents interact with their child, by using coder
127 impression. It includes 33 questions with a 9-point Likert scale (i.e., 1 = not at all, 5 = somewhat,
128 and 9 = very much). Example questions include, but are not limited to, “Does the parent
129 encourage positive child behavior with praise and/or incentives?”, “Does the parent use
130 directives that seem specific and clear to the child?”, and “Does the parent follow through with
131 requests or directives to assure compliance and/or cooperation?”. Using this inventory, two
132 trained coders coded videos. The inter-rater reliability of the entire observation system was 88%.
133 This was calculated by taking the total number of agreements between raters and dividing by the
134 total number of items on the scale and multiplying by 100 to calculate a percentage.

135 Based on the inventory instructions, 13 positive parenting-related questions were
136 averaged and named *positive parenting*. Thus, *positive parenting* is a combination of parental
137 encouragement, sensitivity, attachment, and support. Positive parenting was used as the variable

for the analysis in the current study. To calculate internal consistency of the variable, Cronbach alpha was used, the internal consistency of the variable was $\alpha = .77$. It is important to note that there was no significant difference in positive parenting between mothers and fathers $t(62) = -1.65$, $p = .102$, so the current study did not separate positive parenting by parent gender.

Statistical Analysis

Because of the nesting inherent in repeated assessments of children's motor skills, multilevel modeling was used to examine motor skill progression in young children with DDs and to evaluate the longitudinal relationship between positive parenting and motor skill development in young children with DDs. Based on this observed trajectory, SAS PROC MIXED with the maximum-likelihood estimation method was used to evaluate fixed and random effects for linear and quadratic term by accounting for missing data in all growth models. This procedure minimizes the effect of missing data on results by including all available data to develop estimates of effects [23]. Participants who were assessed at least three times among five times were included in the final analysis. Four multilevel growth models were fitted. Models 1and 2 addressed the effects of time on object control and locomotor skill development in boys and girls, respectively. Models 3 and 4 addressed the effects of parenting behaviors on object-control and locomotor skill development, respectively (i.e., main analysis). To find a best fit model among unconditional model, linear growth model, and quadratic curve model, maximum likelihood technique was used for all models. For models 3 and 4, the positive parenting variable was treated as a time-invariant variable. Given a large body of literature indicated that young boys have higher levels of motor skills compared to young girls [15,16], child sex was selected as a covariate (i.e., 0 = boy, 1 = girl). Furthermore, parental income was also selected as a covariate based on literature, which indicates that families with a higher income are more likely

to offer their child PA opportunities that allow their child to learn motor skills in comparison to families with a lower income [24]. Thus, these two covariates were included in all models. For models 3 and 4, each individual parenting behavior scores were centered by the sample average score of parenting behaviors. The multilevel modeling equation for each model is as follows:

Model 1) $y_{ti}(object-control\ skills) = [\beta_{00} + \beta_{01}(Child\ Sex\ \text{i}) + \beta_{10}(Month36_{ti}) + \beta_{11}(Month36_{ti} * Child\ Sex_{\text{i}}) + \beta_{20}(Month36_{ti} * Month36_{ti}) + \beta_{21}(Month36_{ti} * Month36_{ti} * Child\ Sex_{\text{i}}) + \beta_{30}(parent\ income)] + [U_{0i} + U_{1i}(month36)_{ti} + e_{ti}]$,

Model 2) $y_{ti}(locomotor\ skills) = [\beta_{00} + \beta_{01}(Sex\ \text{i}) + \beta_{10}(Month36_{ti}) + \beta_{11}(Month36_{ti} * Child\ Sex_{\text{i}}) + \beta_{20}(Month36_{ti} * Month36_{ti}) + \beta_{21}(Month36_{ti} * Month36_{ti} * Child\ Sex_{\text{i}}) + \beta_{30}(parent\ income)] + [U_{0i} + U_{1i}(month36)_{ti} + e_{ti}]$,

Model 3) $y_{ti}(object-control\ skills) = [\beta_{00} + \beta_{01}(parenitng\ \text{i}) + \beta_{10}(Month36_{ti}) + \beta_{11}(Month36_{ti} * Parenting_{\text{i}}) + \beta_{20}(Month36_{ti} * Month36_{ti}) + \beta_{21}(Month36_{ti} * Month36_{ti} * Parenting_{\text{i}}) + \beta_{30}(parent\ income) + \beta_{40}(child\ sex)] + [U_{0i} + U_{1i}(month36)_{ti} + e_{ti}]$, and

Model 4) $y_{ti}(Locomotor\ skills) = [\beta_{00} + \beta_{01}(parenitng\ \text{i}) + \beta_{10}(Month36_{ti}) + \beta_{11}(Month36_{ti} * Parenting_{\text{i}}) + \beta_{20}(Month36_{ti} * Month36_{ti}) + \beta_{21}(Month36_{ti} * Month36_{ti} * Parenting_{\text{i}}) + \beta_{30}(parent\ income) + \beta_{40}(child\ sex)] + [U_{0i} + U_{1i}(month36)_{ti} + e_{ti}]$

Results

There were a total of 64 participants included in the final analysis. The average age of participants was 36.5 months (*SD*: 4.7) and the average age of parents/caregivers was 32.5 years

(*SD*: 7.5). Of the sample, there were 50 males and 14 females with DDs, reflecting a common trend in developmental disability prevalence (i.e., males are more often diagnosed with a DD). Majority of parent/caregiver participants were female (male = 6). Demographic information can be found in table 1. Descriptive statistics of positive parental behaviors can be found in table 2. The average scores of object-control and locomotor scores of young children with DDs in each time point across the two-year duration of the study can be found in table 3. The quadratic curve model for object-control skill and locomotor skills resulted in the best fit model and were included in the final analysis. In addition, the quadratic curve model was the best fit model for the association between positive parenting, object-control and locomotor skills. The results of these analyses can be found in the supplemental material 1.

Insert table 1 about here

Insert table 2 about here

Object-control skill progression

Fixed effects of model 1 indicated that both boys and girls showed a significant linear increase in the standard scores of object-control skills with age (boys: $b = 0.14$, $p = 0.02$, Girls: b=0.22, $p = 0.04$). However, quadratic decrease was only found in boys ($b = -0.007$, $p = 0.0001$). Random effects of model 1 indicated that there was a statistically significant individual object-control difference, but no statistically significant individual difference in rate of linear change. The intraclass correlation of this model was 0.31. There were no statistical differences between child sex in the intercept, linear and quadratic slope. For more details, see table 3.

Insert table 3 about here

Locomotor skill progression

Fixed effects of model 2 indicated that boys showed a statistically significant linear increase in the standard scores of locomotor skills with age (b = 0.22, p = 0.005) and a statistically significant quadratic decrease with age (b= -0.008, p = 0.008). However, girls showed both non-statistically significant linear increase and quadratic decrease. Random effects of model 2 indicated that there was no statistically significant individual locomotor skill difference and individual difference in rate of linear change. The intraclass correlation of this model was 0.18. There was no statistical differences between child sex in the intercept, linear and quadratic slope. For more details, see table 4.

Insert table 4 about here

The effects of positive parenting behaviors on object-control skill development

Fixed effects of model 3 indicated that young children with DDs who have parents with one standard deviation higher (+SD) in the positive parental behavior than average showed a statistically significant linear increase in the standard scores of object-control skills with age (b = 0.22, p = 0.0029) and a statistically significant quadratic decrease with age (b= -0.01, p = 0.005). However, young children with DDs who have parents with one standard deviation lower (-SD) in the positive parental behavior showed both a non-statistically significant linear increase and quadratic decrease. Random effects of model 3 indicated that there was statistically significant individual object-control skill differences and no statistically significant individual difference in rate of linear change. The intraclass correlation of this model was 0.31. Because parenting behavior was a continuous variable, the standard deviation difference between groups was not tested. For more details, see table 5 and figure 1.

Insert table 5 about here

Insert figure 1 about here

The effects of positive parenting behaviors on locomotor skill development

Fixed effects of model 4 indicated that young children with DDs who have parents with one standard deviation higher (+SD) in the positive parenting behavior than average showed a statistically significant linear increase in the standard scores of locomotor skills with age (b = 0.27, p = 0.005) and a statistically significant quadratic decrease with age (b= -0.008, p = 0.03). However, young children with DDs who have parents with one standard deviation lower (-SD) showed both non-statistically significant linear increase and quadratic decrease. Random effects of model 4 indicated that there was statistically significant individual locomotor skill differences and no statistically significant individual difference in rate of linear change. The intraclass correlation of this model was 0.12. Because the parenting behavior variable was a continuous variable, the standard deviation difference between groups was not tested. For more detail, see table 6 and figure 2.

Insert table 6 about here

Insert figure 2 about here

Discussion

The findings confirmed that young children (3-5 years) with DDs progressively develop their motor skills over a two-year period and parental behaviors influenced the motor skill development of young children with DDs. Boys with DDs showed a statistically significant increase of both object-control skills and locomotor skills in a linear fashion and decrease in a quadratic fashion. This suggests the rate of motor skill development varied (i.e., increased or decreased) between each time period across two years and age did not guarantee the improvement of motor skill development. Young children with DDs, in the current study, developed their motor skills at a lower rate compared to the normed scores for their

chronological age, especially from 54 months to 60 months of age (see table 3). Given the malleability of motor skills at this age [25], this result highlights the need for attention, reinforcement and intervention focused on motor skill development in the early years. Five years of age is an especially important developmental period when children are transitioning to school and learning more complex skills. As school aged peers are learning more complex motor skills [26], children with DDs are at risk for falling behind due to existing delays in motor skill development. Furthermore, these early delays in motor skill development put these young children at risk for experiencing proficiency barriers in their development [26], which may lead to continuous motor skill delays and which has implications for other negative health consequences including lower physical activity levels [27].

The current study also noted lower rates of development in object-control skills compared to locomotor skill development. In short, this result was consistent with the principle of natural motor development in humans (i.e., locomotor skills are considered to be ontogeny). Compared to locomotor skills, object-control skills are relatively harder to develop as they require more motor coordination and the ability to appropriately change and adjust movement skills based on the object used [28]. Thus, early attention to object-control skill development in young children with DDs is particularly important to address.

In the current study, girls with DDs displayed a statistically significant increase of object-control skills in a linear slope, but in a quadratic slope across two years. Locomotor skills of girls showed non-statistically significant increase in both a linear fashion and a quadratic fashion across two years. This mean that in our sample of young girls with DDs, developed motor skills within the two-year timeframe, however their rate of development was much lower than their peers without disabilities. While empirical evidence suggests that known motor skills differences

276 at this age, where boys typically have higher motor skills compared to girls [15], our study did
277 not indicate child sex differences in intercept, linear slope or quadratic slope within the two
278 models (i.e., object-control skills and locomotor skills). This aligns with previous research that
279 has examined the motor skills of preschool aged children, between the ages of three and six
280 years, with disabilities, where no gender differences were found in both object control and
281 locomotor motor skills [14,29]. Perhaps in the preschool years, children with DDs are more
282 similar than different. It is known that in school aged children with DDs, boys have more
283 proficient motor skills than girls [30]. Thus, learning when gender differences in motor skill
284 development start to present in children with DD, is an important future research question,
285 especially for the purpose of intentional intervention.

286 This current study also found that positive parenting behaviors were longitudinally
287 related to motor skill development in young children with DDs across two years. Specifically,
288 young children with DDs of parents who showed high positive parenting behaviors showed
289 higher rates of developing motor skills compared to their counterparts. The significant
290 association between parenting behaviors and motor skills in young children with DDs is aligned
291 with the *field of promoted action* theory highlighting the important role of parents in developing
292 their child's motor skills. Young children spend most of their time with their parents, thus ample
293 opportunities exist where young children's motor skills are reinforced by their parents behaviors.
294 In order to reinforce or teach motor skills to young children with DDs in an effective way,
295 parents should have positive parenting behaviors around this skill. In the current study, positive
296 parenting behaviors included positive parental attachment, encouragement, and sensitivity. These
297 behaviors may provide encouragement and reinforcement in teaching children motor skills. For
298 example, when young children with DDs were encouraged to play with a ball through an

299 interesting activity (i.e., high encouragement), they may be more likely to continue play and
300 initiate similar ball play in the future. In addition, parents who have high sensitivity may also
301 extend opportunities for their young children to practice motor skills. When young children with
302 DDs display maladaptive behavior, it is possible parents with high sensitivity may be able to
303 recognize the reason (e.g., keep the child from failing the activity) and provide a solution which
304 allows their child to continue the activity. Thus, it makes sense that positive parenting behaviors
305 may increase the likelihood of acquiring motor skills in young children with DDs.

306 It is important to note that positive parenting behaviors may not dramatically change
307 children's motor skills within a short timeframe, but rather have an accumulated effect on the
308 child's motor skill development over time. In the current study, the estimated difference in linear
309 slopes between groups (i.e., young children with DDs who have parents with one standard
310 deviation higher in the positive parenting behavior than average vs. young children with DDs
311 who have parents with one standard deviation lower in the positive parenting behavior than
312 average) was only 0.12, a relatively small increase for both object control and locomotor skills.
313 Thus, if research only focuses on the short-term effects of positive parenting behaviors on motor
314 skill development in young children with DDs, they may not find large effects, however the
315 accumulation of effects over time may be more substantial. It is recommended for parents of
316 children with DDs to show consistent positive parenting behaviors.

317 While more empirical research is needed to establish a clear mechanism between positive
318 parenting behaviors and motor skill development in children with and without disabilities, some
319 research has suggested that positive parenting behaviors (e.g., high parental encouragement and
320 sensitivity) significantly influences children's motor skill development [18,31–34]. In a study
321 conducted by Bindman and colleagues (2014), when parents showed high levels of

graphophonemic support (e.g., letting a child know what they are supposed to write; encouragement) during a joint writing activity, it significantly improved children's fine motor skills. While this motor task was focused on fine motor skills, it is possible that positive parenting behaviors could also have implications for gross motor skill development. For example, when parents effectively encourage children's activity during play, it could extend a child's opportunity to learn skills involved in the activity. More specifically, if a child is less skillfully hitting a ball, a parent could teach the child how to appropriately hit the ball. On the contrary, if the parent does not provide any feedback (i.e., low quality parenting behavior) to the child, his/her hitting skills may not be influenced by the parent's behavior.

Parental sensitivity (a parent's ability to perceive their child's signals, interpret the signals correctly, and to respond to them promptly and appropriately) may be another factor that influences motor skill development in young children with DDs. Even though little is known about the relationship between parental sensitivity and motor skill development in children with DDs, there is a possibility that high levels of parental sensitivity improve children's motor skill development. One study found that high levels of parental sensitivity allowed fathers of children with DDs to provide more effective instruction and support [35]. This may increase the quality of child's play by extending their understanding and interest of play and opportunities to interact with others. The increased quality of a child's play may improve their motor skill development (e.g., learning, reinforcing, and practicing) [36–38].

This study is not without limitations. The predictor variable (i.e., parenting behaviors) was treated as a time-invariant variable. However, according to the parenting determinant model [39], parenting behaviors are not constant and can be changed. Specifically, the child's age is a strong contributing factor that influences parenting behaviors. Future studies should assess

parental behaviors across multiple years and should be treated as a time-variant variable, in order to capture the complexity of the relationship between parenting behaviors and motor skill development in young children with DDs. Furthermore, this study may not be generalizable to all young children with DDs because of the small sample size, especially since this study only included 14 female participants. Yet, this study identifies a starting point for motor skill trajectories in young children with DDs. Another limitation is that the current study did not calculate inter-rater reliability between coders when measuring motor skills in young children with DDs. The TGMD-2 scores were based on consensus (agreement between coders). Future studies should measure inter-rater reliability between coders.

Summary

This study was the first, to our knowledge, to examine the longitudinal association between positive parental behaviors and motor skills in young children with DDs. The findings of the current study support the field of promoted action theory [17] suggesting that parents play an important role in developing their children's motor skills. Specifically, the current study found the important roles of positive parental behaviors including encouragement, high sensitivity, and high responsiveness in developing motor skills in young children with DDs. Further studies are warranted to investigate the mechanism how positive parental behaviors are associated with motor skill development in young children with DDs. The findings of the current study may be used for creating and developing a family-based motor skill intervention for young children with DDs.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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Table 1. Characteristics of participants

Variable	n (%)
Parent Gender	
Male	6 (9.94)
Female	58 (90.60)
Child Sex	
Boys	50 (78.12)
Girls	14 (21.88)
Parent Age (year/SD)	32.5 (7.50)
Child Age (month/SD)	36.5 (4.70)
Diagnosis (parental report)	
Autism spectrum disorder	7 (10.93)
Developmental delay	37 (57.81)
Speech delay	5 (7.80)
Other	16 (23.46)
Child Race-Ethnicity	
White-Caucasian	52 (81.25)
Non-white-Caucasian	12 (18.75)
Household Income	
$0 - $39,999	40 (62.50)
$40,000 -$100,000	24 (37.50)
Parental Education	
High school or less	20 (31.25)
Greater than high school	44 (68.75)

Note. Other = children with global delay or unknown etiology (delays are pervasive).

Table 2. Average scores of object-control and locomotor skills in boys and girls with developmental disabilities and averaged scores of positive parenting behaviors across

	36months M(SD)	42months M(SD)	48months M(SD)	54months M(SD)	60months M(SD)
Girl (n = 14)					
Object-control Skills	10.35 (2.70)	11.12 (3.13)	10.86 (2.64)	11.04 (3.14)	9.43 (2.80)
Locomotor Skills	8.16 (2.98)	8.30 (3.47)	9.88 (4.21)	10.45 (4.45)	8.35 (4.05)
Boy (n = 50)					
Object-Control Skills	10.80 (2.65)	11.18 (3.28)	11.85 (2.90)	13.08 (2.64)	11.09 (3.83)
Locomotor Skills	8.20 (2.44)	9.18 (2.89)	10.01 (2.24)	11.16 (4.17)	10.81 (5.13)
Parental positive behavior	6.38 (0.98)	6.47 (0.86)	6.51 (0.71)	6.29 (0.57)	6.27 (0.80)

Table 3. Object-control skill progression in boys and girls with developmental disabilities

Fixed Effects	**Estimate**	**SE**	**p**
Intercept- boys	10.85	1.12	<0.01
Linear Slope - boys	0.14	0.06	0.02
Quadratic Slope - boys	-0.007	0.002	<0.01
Intercept- girls	10.66	1.31	<0.01
Linear Slope - girls	0.22	0.11	0.04
Quadratic Slope - girls	-0.007	0.004	0.08
Random Effects	**Estimate**	**SE**	**p**
Intercept	1.78	1.03	0.04
Covariance	0.04	0.05	0.37
Slope	0.002	0.003	0.14
Residual	3.89	0.46	<0.01

Table 4. Locomotor skill progression in boys and girls with developmental disabilities

Fixed Effects	**Estimate**	**SE**	**p**
Intercept- boys	9.54	1.38	<0.01
Linear Slope - boys	0.22	0.07	0.02
Quadratic Slope - boys	-0.008	0.003	0.02
Intercept- girls	9.63	1.61	<0.01
Linear Slope - girls	0.19	0.14	0.18
Quadratic Slope - Female	-0.003	0.005	0.49
Random Effects	**Estimate**	**SE**	**P**
Intercept	1.48	1.29	0.12
Covariance	0.13	0.01	0.07
Slope	0.006	0.006	0.17
Residual	6.60	0.78	<0.01

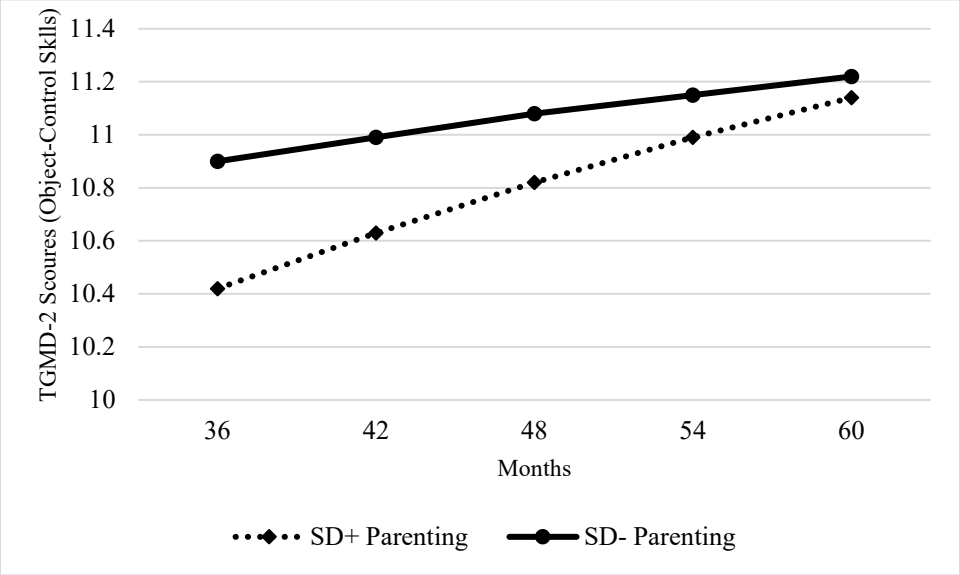
Table 5. The effects of positive parenting behaviors on object-control skills in young children with developmental disabilities

Fixed Effects	**Estimate**	**SE**	**p**
Sample Average - +1SD Parenting	10.42	1.22	<0.01
Linear Slope – +1SD Parenting	0.22	0.75	<0.01
Quadratic Slope - +1SD Parenting	-0.01	0.002	<0.01
Sample Average – -1SD Parenting	10.90	1.16	<0.01
Linear Slope – -1SD Parenting	0.10	0.07	0.16
Quadratic Slope – -1SD Parenting	-0.005	0.002	0.06
Random Effects	Estimate	SE	P
Intercept	1.83	1.05	0.04
Covariance	0.04	0.05	0.37
Slope	0.002	0.003	0.23
Residual	3.90	0.46	<0.01

Table 6. The effects of positive parenting behaviors on locomotor skills in young children with developmental disabilities

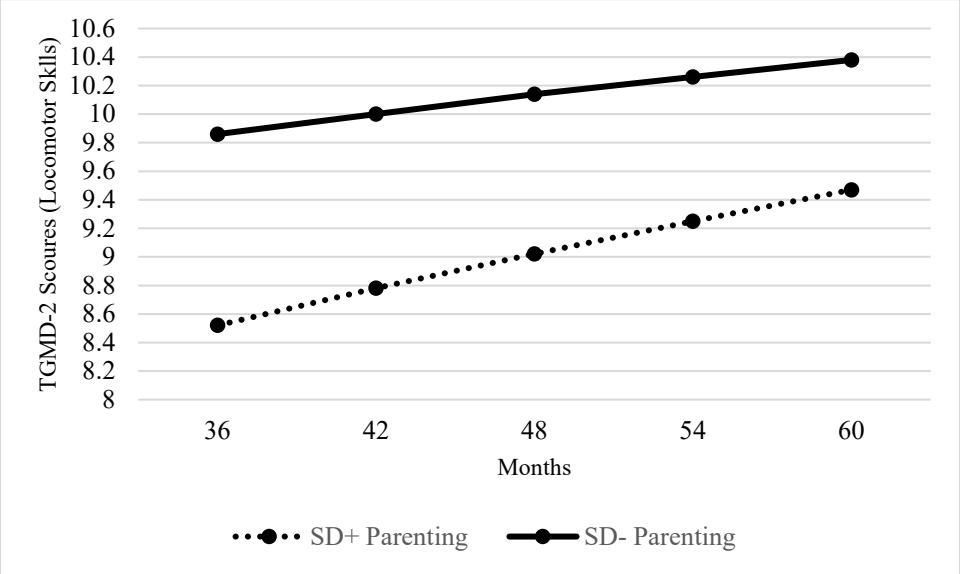
Fixed Effects	**Estimate**	**SE**	**p**
Sample Average - +1SD Parenting	8.52	1.46	<0.01
Linear Slope – +1SD Parenting	0.27	0.09	<0.01
Quadratic Slope - +1SD Parenting	-0.008	0.003	0.03
Sample Average – -1SD Parenting	9.86	1.40	<0.01
Linear Slope – -1SD Parenting	0.15	0.09	0.12
Quadratic Slope – -1SD Parenting	-0.005	0.003	0.13
Random Effects	**Estimate**	**SE**	**p**
Intercept	0.96	1.2	0.21
Covariance	0.17	0.07	0.01
Slope	0.004	0.006	0.24
Residual	6.73	0.46	<0.01

Figure 1. The Effect of Positive Parenting Behaviors on Object-Control Skills in young children with DDs



Note. SD+ Parenting = Young children with DDs who have parents with one standard deviation higher (+SD) in the positive parenting behavior than average. SD- Parenting = Young children with DDs who have parents with one standard deviation lower (-SD) in the positive parenting behavior than average

Figure 2. The Effect of Positive Parenting Behaviors on Locomotor Skills in Young Children with DDs



Note. SD+ Parenting = Young children with DDs who have parents with one standard deviation higher (+SD) in the positive parenting behavior than average. SD- Parenting = Young children with DDs who have parents with one standard deviation lower (-SD) in the positive parenting behavior than average

Appendix

Model fit 1. The Object-control skill development in young children with DDs.

Model Fit	Unconditional model	Linear growth model	Quadratic Curve model
-2LL	1218.2	1214	1200
Δ in Parameters		3	1
Δ in − 2LL		4.2	3.4
p		0.04	0.0001

Model fit 2. The locomotor skill development in young children with DDs.

Model Fit	Unconditional model	Linear growth model	Quadratic Curve model
-2LL	1345.3	1332.1	1324.2
Δ in Parameters		3	1
Δ in − 2LL		13.2	7.9
p		0.004	0.004

Model fit 3. The association between positive parenting and object-control skill development in young children with DDs.

Model Fit	Unconditional model	Linear growth model	Quadratic Curve model
-2LL	1316.2	1214	1189
Δ in Parameters		3	1
Δ in − 2LL		4.4	4.1
p		0.032	0.001

Model fit 4. The association between positive parenting and locomotor skill development in young children with DDs.

Model Fit	Unconditional model	Linear growth model	Quadratic Curve model
-2LL	1247.3	1132.1	114.3
Δ in Parameters		3	1
Δ in − 2LL		12.4	6.5
p		0.007	0.002