

## **7. Results**

This section examines the seven research questions originally proposed for study. The analysis was prepared by A. Rose Shaw, Ph.D., METRICA, P.O. Box 5167, Greeley, CO 80631. Dr. Shaw served as statistical consultant to the project.

**Research Question #1: Do children between birth and 59 months (5 years) of age who are visually handicapped attain developmental milestones at chronological ages that differ from those of sighted children?**

Milestones selected for study corresponded to those utilized by the Visually Impaired Infants Research Consortium (VIIRC) reported in Ferrell et al. (1990). The milestones were identified by VIIRC consortium members as developmental skills that either (a) seemed particularly important for the competence of children with visual disabilities, or (b) were areas of suspected difficulty. PRISM milestones were based on the VIIRC milestones, but were not always exact matches since different assessment instruments were used. Table D-8 in Appendix D shows the relationship between VIIRC and PRISM milestones and their sources and indicates the age of acquisition for typical children.

### **Limitations**

PRISM milestone attainment data were useful but not readily comparative to previous studies because recording of milestone attainment was delayed by the procedure used to gather these data. In all cases, recorded milestone attainment is too high, which is an artifact of the data due to the method of data collection and the age interval of the data gathered during the 6-month intervals. The method and times of collection always make this population appear delayed. In all cases, children measured late in an interval showed higher proportions of attainment than those measured earlier in the interval. Implications of the median age of milestone attainment are not direct but implied, because data were gathered in 6-month intervals (or longer) with measurement of the child being anywhere during the time interval and with data being recorded as attainment or not attainment at the time of assessment. Entry age is also a factor in the

milestone attainment measurement process and resulted in some attainment measures being greatly inflated. This research question cannot be answered directly. Indirectly, there is some evidence that the PRISM population are older when attaining most milestones, but it is impossible to say how much older they are at attainment.

In the presentation of the milestone attainment data, medians were calculated for those children who were assessed in the time interval that was meaningful to each of the milestones. For example, if the median age of milestone attainment for typical children was 5.4 months, children who entered PRISM after the 0-5 month interval were not included in the analysis in an attempt to decrease the amount of inflation of the milestone attainment measurement. There are still obvious milestone attainment inflations among children who were assessed during the 0-5 month time span, because 84.6% of those assessed during this interval were assessed prior to the median age for milestone attainment (5.4 months). For example, it would have been impossible for the 0 month old child to have attained this milestone during this time interval. This characteristic of the data in all intervals made it impractical to attempt to study extreme cases since no child was measured consistently across any of the 6-month intervals. Milestone sequence data are less influenced by the time of assessment, but in some cases are influenced by entry date.

### ***Statistical Methodology***

Median ages at which participants were measured and labeled as having previously attained the milestones are presented along with semi-interquartile ranges and the number of children used for these statistics (Table 53). Median ages from Table 53 were adjusted for prematurity and presented along with semi-interquartile ranges and number of participants in Table 54. Participants included in this analysis ranged from 0 months to 47 months.

The Kruskal-Wallis one-way nonparametric analysis of variance, which is usually more powerful than the median test, can be used to test samples where the mea-

surement scale is at least ordinal. For individual cases, data are not completely ordinal since milestones are usually attained during a sequence of dates, whereas in this study some of the natural ordinal sequence of attainment is ignored during the data collection process. (For example, a child may have accomplished milestone 1 at date A and milestone 2 at date B, and the assessment at date C would record both milestones 1 and 2 as having occurred on date C.) Understanding the ordinality limitation, the milestone data were assumed to be more ordinal than not ordinal and as many precautions were taken as possible. This included excluding those participants who were not tested in time intervals appropriate for each milestone. One might argue that the assumption of data ordinality was not in best judgment, hence caution must be taken in any use of the milestone analysis results. It was assumed that it was appropriate to use this test to discern whether or not statistically significant differences in attainment of developmental milestones differed among participants with varying levels of additional impairment.

Three categories of additional impairment were analyzed: none, mild, and severe. Two groups were formed dependent on length of gestation (Group 1: < 38 weeks and Group 2: 38 weeks), and developmental milestones were analyzed using the Kruskal-Wallis test and ANOVA applied to ranks. Tables for the milestones for which there were significant differences and appropriate statistics are presented in Tables 55-56 for additional impairment and Tables 57-58 for gestational age.

Developmental milestones are referred to by number in some of the following results (see Table D-8 in Appendix D for sources of these milestones):

- Milestone 2: Reaches for and touches object
- Milestone 3: Transfers object from hand to hand
- Milestone 4: Searches for a removed object
- Milestone 6: Sits alone without support 5 seconds
- Milestone 7: Feeds self bite-size pieces of food.
- Milestone 8: Produces one or more consonant-vowel sounds
- Milestone 9: Moves 3 or more feet by crawling
- Milestone 10: Plays an interactive game

- Milestone 11: Walks without support 10 feet
- Milestone 12: Points to at least one major body part when asked
- Milestone 13: Removes simple garment without assistance
- Milestone 14: Generally follows directions related to daily routine
- Milestone 15: Uses two-word utterances to express meaningful relationships
- Milestone 16: Uses pronouns I, you, and me
- Milestone 17: Controls bowel movements regularly
- Milestone 18: Repeats two-digit sequences
- Milestone 19: Walks down stairs alternating feet
- Milestone 20: Copies circle
- Milestone 21: Relates his or her past experiences

**Table 53: Median Age At Which Child Was Measured and Labeled as Having Previously Attained Milestone**

Milestone and Median Age of Attainment of Typical Child (in Months)	All Participants			Visually Impaired Only			Visually Impaired with Additional Impairments		
	Median Age	Number	Semi-interq. Range	Median Age	Number	Semi-interq. Range	Median Age	Number	Semi-interq. Range
Reaches for and touches object (5.4)	8.3 d	25	2.3	8.1 d	17	1.2	10.6 d	8	5.3
Transfers object from hand to hand (5.5)	9.3 d	26	2.3	8.3 d	17	2.4	10.1 d	9	1.9
Searches for a removed object (6.0)	15.0 d s	93	6.4	13.4 d s	43	4.7	18.2 d s	50	6.9
Sits alone without support 5 secs. (6.6)	10.9 d	119	2.0	9.2 d	52	1.6	11.9 d	67	4.1
Feeds self bite-size pieces of food (7.4)	12.6 d s	94	4.7	11.1 d s	44	2.3	18.8 d s	50	6.2
Produces 1 or more consonant-vowel sounds (7.9)	10.9 d	126	2.2	9.5 t	56	1.8	11.8 d	70	4.0
Move 3 or more feet by crawling (9.0)	12.8 d s	94	4.7	11.4 d s	45	2.4	18.3 d s	49	5.8
Plays interactive game (9.7)	11.4 t	109	4.4	9.3 e	47	1.6	13.1 d	62	8.3
Walks without support 10 feet (13.0)	19.8 d	67	5.0	19.0 d	37	3.1	26.6 d s	30	8.7
Points to at least 1 major body part when asked (17.5)	19.5 t	83	3.4	18.8 t	40	3.0	20.2 d	43	4.0
Removes simple garment without assistance (20.5)	22.7 d	72	5.6	19.2 e	37	3.1	24.8 d	35	8.6
Generally follows daily routine directions (20.5)	24.3 d	77	5.1	19.3 e	37	3.3	25.0 d	40	5.3
Uses 2-word utterances to express meaningful relationships (20.6)	28.2 d s	38	5.8	24.9 d	21	4.0	36.1 d	17	7.0
Uses pronouns I, you, me (24.0)	25.8 t	31	6.4	24.8 t	20	5.8	36.1 d	11	6.6
Controls bowel movements regularly (30.0)	36.5 d s	23	11.6	24.9 e	11	6.3	38.6 d s	12	10.8
Repeats 2-digit sequence (30.0)	33.4 t	33	6.3	25.0 e	19	4.5	37.0 d s	14	1.1
* Walks down stairs alternating feet (30.0)	33.4 t	17	6.4	30.2 t	11	6.6	36.2 d	6	6.6
* Copies circle (33.0)	31.8 e s	20	6.4	37.2 d s	9	9.5	30.0 e s	11	5.2
* Relates his/her past experiences (40.0)	37.3 e	14	6.1	36.9 e	8	0.9	37.7 e	6	6.0

**Table 53 NOTES.** Compared to median for typical children: d = delayed; t = on-target; e = earlier; s = out-of-sequence

\* 14 of 16 participants last assessed at 40.5-54.4 months had not met these milestones at project end. 85.7% of the 16 had additional impairments.

**Table 54: Median Age Adjusted for Prematurity At Which Child Was Measured and Labeled As Having Previously Attained Milestone**

Milestone and Median Age of Attainment of Typical Child (in Months)	All Participants			Visually Impaired Only			Visually Impaired with Additional Impairments		
	Median Age	Number	Semi-interq. Range	Median Age	Number	Semi-interq. Range	Median Age	Number	Semi-interq. Range
Reaches for and touches object (t.r)	8.3 d	25	2.1	8.2 d	16	1.4	10.1 d	8	5.3
Transfers object from hand to hand (5.5)	8.4 d	24	2.0	8.7 d	16	2.6	10.1 d	9	1.9
Searches for a removed object (6.0)	15.0 d s	91	6.3	12.5 d s	41	4.2	17.4 d s	50	6.6
Sits alone without support 5 secs. (6.6)	9.9 d	116	1.8	9.1 d	50	1.6	10.7 d	66	3.8
Feeds self bite-size pieces of food (7.4)	12.5 d s	92	4.6	11.1 d s	42	2.2	17.9 d s	50	7.3
Produces 1 or more consonant-vowel sounds (7.9)	10.0 d	124	1.9	9.2 t	54	1.8	10.6 d	70	3.2
Moves 3 or more feet by crawling (9.0)	12.8 d s	92	4.6	11.1 t s	43	2.3	17.7 d s	49	5.4
Plays interactive games (9.7)	10.9 t	106	3.7	9.2 e	45	1.7	12.3 d	61	4.2
Walks without support 10 feet (13.0)	19.8 d	65	4.8	18.2 d	35	3.9	25.5 d s	30	8.3
Points to at least 1 major body part when asked (17.5)	19.2 t	81	3.4	18.4 t	38	2.4	19.5 t	43	3.6
Removes simple garment without assistance (20.5)	21.2 d	70	4.5	19.0 e	35	3.1	23.8 d	35	7.2
Generally follows daily routine directions (20.6)	22.0 d	75	4.1	19.2 e	35	3.3	24.2 d	40	5.2
Uses 2-word utterances to express meaningful relationships (20.6)	26.5 d s	36	5.6	24.9 d	19	3.6	34.1 d	17	6.3
Uses pronouns I, you, me (24.0)	25.8 t	29	6.0	24.8 t	18	5.3	36.1 d	11	6.1
Controls bowel movements regularly (30.0)	36.5 d s	21	10.9	24.9 e	9	7.8	37.1 d s	12	10.4
Repeats 2-digit sequence (30.0)	33.3 t	31	6.1	24.9 e	17	4.9	36.4 d	14	2.0
Walks down stairs alternating feet (30.0)	36.1 t t	15	6.4	27.2 e e	9	6.7	36.2 d d	6	7.6
Copies circle (33.0)	30.0 e s	19	6.7	36.4 d	8	10.8	27.2 e s	11	6.2
Relates his/her past experiences (40.0)	36.8 e	14	0.8	36.4 e	8	1.0	37.2 e	6	4.8

**Table 54 NOTE.** Compared to median for typical children: d = delayed; t = on-target; e = earlier; s = out-of-sequence

**Table 55. Kruskal-Wallis One-way Nonparametric Analysis of Variance and Parametric Analysis of Variance Applied to Ranks of Milestone Attainment by Additional Impairment**

Milestone	K-W Statistic	Chi <sup>2</sup> Approximated p	Source	df	F	p
4	7.2926	0.0261	Within	90	3.87	0.0239
6	17.9069	0.0001	Within	116	10.38	0.0001
7	27.7750	0.0000	Within	91	19.38	0.0000
8	24.2022	0.0000	Within	2	14.77	0.0000
9	29.5170	0.0000	Within	91	21.16	0.0000
10	22.7082	0.0000	Within	106	14.11	0.0000
11	18.2119	0.0001	Within	64	12.20	0.0000
12	9.1080	0.0105	Within	80	5.00	0.0091
13	8.9477	0.0114	Within	69	4.97	0.0096
14	7.5630	0.0228	Within	74	4.09	0.0203
15	8.5690	0.0138	Within	35	5.27	0.0100
18	11.4103	0.0033	Within	30	8.31	0.0013

**Table 55 NOTE.** The degrees of freedom for the “between” source are equal to 2 for all milestones.

Table 56. Pairwise Comparisons of Mean Ranks of Milestones by Degree of Additional Impairment.

Milestone	Additional Impairment	Mean Rank	Homogenous Groups	Sample Size	Comments Regarding Homogenous Groups
4	Severe	55.241		29	There are two groups (severe and none) in which the mean attainments of Milestone 4 are significantly different.
	Mild	52.119		21	
	None	38.942	..	43	
6	Severe	75.987		38	There are two groups (severe/mild and none) in which the mean attainments of Milestone 6 are significantly different.
	Mild	64.983		29	
	None	45.538	..	52	
7	Severe	66.655		29	There are two groups (severe/mild and none) in which the mean attainments of Milestone 7 are significantly different.
	Mild	52.000		21	
	None	32.727	..	44	
8	Severe	87.372		38	There are two groups (severe and mild/none) in which the mean attainments of Milestone 8 are significantly different.
	Mild	54.113	..	31	
	None	52.071	..	56	
9	Severe	70.370		27	There are two groups (severe and mild/none) in which the mean attainments of Milestone 9 are significantly different.
	Mild	46.386	..	22	
	None	34.322	..	45	
10	Severe	74.792		36	There are two groups (severe and mild/none) in which the mean attainments of Milestone 10 are significantly different.
	Mild	51.596	..	26	
	None	41.723	..	47	
11	Severe	50.812		16	There are two groups (severe and none) in which the mean attainments of Milestone 11 are significantly different.
	Mild	35.821		14	
	None	26.041	..	37	
12	Severe	54.160		25	There are two groups (severe and none) in which the mean attainments of Milestone 12 are significantly different.
	Mild	36.972		18	
	None	36.663	..	40	

13	Severe	44.848		23	There are two groups (severe and none) in which the mean attainments of Milestone 13 are significantly different.
	Mild	42.500		12	
	None	29.365	..	37	
14	Severe	46.352		27	There are two groups (severe and none) in which the mean attainments of Milestone 14 are significantly different.
	Mild	44.385		13	
	None	31.743	..	37	
15	Severe	27.400		10	There are two groups (severe and none) in which the mean attainments of Milestone 15 are significantly different.
	Mild	21.429		7	
	None	15.095	..	21	
18	Severe	25.750		8	There are two groups (severe and none) in which the mean attainments of Milestone 18 are significantly different.
	Mild	19.917		6	
	None	12.395	..	19	

Table 57. Two-Group Kruskal-Wallis One-way Nonparametric Analysis of Variance and Parametric Analysis of Variance Applied to Ranks of Milestone Attainment by Gestation < 38 Weeks and 38 Weeks.

Milestone	K-W Statistic	Chi <sup>2</sup> Approximated p	Source	df	F	p
2	4.5753	0.0324	Within	22	5.46	0.0289
4	12.9842	0.0003	Within	89	15.00	0.0002
6	13.5538	0.0002	Within	114	15.23	0.0002
7	14.5940	0.0001	Within	90	17.19	0.0001
8	17.6646	0.0000	Within	122	20.46	0.0000
9	10.7597	0.0010	Within	90	12.07	0.0008
10	14.8304	0.0001	Within	104	17.11	0.0001
12	6.2935	0.0121	Within	79	6.75	0.0112
13	7.4387	0.0064	Within	68	8.22	0.0055
14	24.1382	0.0000	Within	73	35.34	0.0000
15	4.2205	0.0399	Within	34	4.66	0.0380
16	10.0558	0.0015	Within	27	15.13	0.0006
18	7.0942	0.0077	Within	29	8.98	0.0055

Table 57 Note. The degrees of freedom for the “between” source are equal to 2 for all milestones.

Table 58. Mean Ranks and Sample Sizes of Milestones by Gestation Length.

Milestone	Mean Rank of Gestation < 38	Sample Size < 38 Weeks	Mean Rank of Gestation ≥38	Sample Size ≥38 Weeks
2	20.7	3	11.3	21
4	59.5	32	38.7	59
6	73.2	44	49.5	72
7	59.8	36	38.0	56
8	79.9	47	51.9	77
9	58.4	34	39.5	58
10	67.4	43	44.0	63
12	49.6	30	36.0	51
13	44.4	25	30.6	45
14	54.0	28	28.5	47
15	22.8	15	15.5	21
16	21.4	11	11.1	18
18	21.9	11	12.8	20

### ***Discussion of Results***

Measurement error is obviously introduced when median ages of actual attainment are compared to median ages at which the child was measured and labeled as having previously attained the milestones. In this analysis, conclusions pertaining to whether milestones were delayed or on-target were based on median differences from typical that were greater than 2 months for those milestones that were typically attained prior to 30 months. (For example, if the median typical attainment was 5.4 months, then it was concluded in this analysis that a milestone attained at 7.3 months was on-target while one attained at 8.0 months was judged to be delayed.) At 30 months, a difference of 3.4 months was allowed based on ranges recorded in previous research (Ferrell et al., 1990). Because all milestone error collected in this study inflates the medians, the milestones labeled as being attained earlier than that recorded for typical children actually occurred earlier than the medians recorded. In this study, attainment of milestones earlier than the median attainment ages for typical children do not include 14 of 16 participants, who at project end, had not yet met these milestones.

The last three milestones have median dates of measured attainment which

would be greater than those reported in Tables 53 and 54 if the study were to continue with ongoing measurement of milestone attainment. The early attainment of milestones 20 and 21 should be viewed with discretion. Although adversely influenced by the time-spans in which attainment was measured, the sequence results are changed less by the influence of the limitations cited previously than are the attainment results.

**Conclusions**

As a group, PRISM children attainment of 12 of the 19 milestones assessed appeared to be delayed in comparison to typical children, 5 appeared to be within the range of attainment for typical children, and attainment of 2 milestones was earlier than the median age recorded for typical children. The sequence of attainment of 6 of the 19 milestones differed from those of typical children. Visually impaired participants with additional impairments were also compared to visually impaired participants without additional impairments:

Differences among milestone attainment as measured post-attainment in this study were significant for milestones 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, and 18 with respect to additional impairment (see Table 59). Attainment of milestones 2 (reaches for and touches objects), 3 (transfers objects from hand to hand), 16 (uses pronouns), and 17 (controls bowels) for all PRISM participants, as measured in this study, were not significantly different for participants with or without additional impairment.

Table 59. Differences in Milestone Attainment Among Additional Disability Groups

Different for participants:			
Milestone	with and without additional impairments	with severe additional impairments and without additional impairments	with severe additional impairments and with mild or no additional impairments
Milestone 4 (searches for removed object)		X	
Milestone 6 (sits alone without support 5 secs)	X		
Milestone 7 (feeds self bite-size pieces of food)	X		

Milestone 8 (produces 1 or more c-v sounds)	X
Milestone 9 (moves 3 or more feet by crawling)	X
Milestone 10 (plays interactive game)	X
Milestone 11 (walks without support 10 feet)	X
Milestone 12 (points to at least 1 major body part when asked)	X
Milestone 13 (removes simple garment without assistance)	X
Milestone 14 (generally follows daily routine directions)	X
Milestone 15 (uses 2-word utterances to express meaningful relationships)	X
Milestone 18 (repeats 2 digit sequence)	X

Milestone attainment as measured in this study differed depending on gestation (< 38 weeks vs. 38 weeks) for Milestones 2 (reaches for and touches object), 4 (searches for removed object), 6 (sits alone without support 5 seconds), 7 (feeds self bite-size food), 8 (produces 1 or more c/v sounds), 9 (crawls 4 or more feet), 10 (plays interactive game), 12 (points to body part), 13 (removes simple garment), 14 (follows daily routine directions), 15 (uses 2-word utterances), 16 (uses pronouns), and 18 (repeats 2 digit sequence). The attainment of milestones 3 (transfers objects), 11 (walks without support 10 feet), 17 (controls bowel movements regularly), 19 (walks down stairs alternating feet), 20 (copies circle), and 21 (relates past experiences) as measured in this study were not different for length of gestation.

**Research Question 2: Do children between birth and five years of age who are visually handicapped attain developmental skills in a sequence that differs from the sequence followed by sighted children?**

### **Statistical Methodology**

Four groups of visual functioning were studied with respect to attainment of developmental milestones. Visual functioning was measured by Teller Acuity Cards and recoded into 4 functional groups: NLP (no light perception), LP (light perception), SLV (severe low vision), and MLV (moderate low vision). The Kruskal-Wallis one-way nonparametric analysis of variance was conducted for all milestones for these four groups. In generalizing from these data, one should keep in mind that the visual functioning measure is influenced by many factors such as fatigue and lighting, so visual function can fluctuate over time for the same individual. Any fluctuations are not accounted for in this analysis.

Medians for the four groups of visual functioning were computed, compared, and contrasted. These data are presented in Table 60. There was a significant difference between groups only for milestone 10 (plays interactive games), indicating that children with NLP acquired milestone 10 significantly later than children with LP, SLV, or MLV. Rank order of milestone attainment by visual functioning group is indicated in Table 61.

### **Presentation of Results**

Table 60. Median Age At Which Child Was Measured and Labeled as Having Previously Attained Milestone by Visual Functioning As Measured by Teller Acuity

Milestone	NLP Medians	LP Medians	SLV Medians	MLV Medians
2	8.2	8.6	11.9	10.0
3	8.4	9.1	11.8	11.0
4	18.3	13.6	13.9	17.7
6	11.5	9.9	11.2	10.9
7	18.6	13.6	14.2	12.0
8	11.9	10.9	11.2	10.9
9	18.3	15.6	12.6	12.0
10	17.4	10.0	11.0	10.9
11	25.4	24.8	19.6	19.2
12	19.5	24.4	19.6	18.9
13	19.0	24.4	20.3	24.2
14	24.8	20.8	24.9	21.3
15	25.4	35.1	24.8	30.2
16	31.1	24.3	33.4	28.0
17	36.9	32.2	35.0	25.8
18	25.0	37.3	36.7	36.2
19	37.2	21.2	34.8	30.2
20	37.2	36.1	31.8	26.3
21	37.9	36.7	48.4	36.6

**Table 61. Rank Order of Attaining 19 Milestones Grouped by Visual Functioning Group**

Milestone	NLP	LP	SLV	MLV
2	1	1	5	1
3	2	2	4	5
4	6.5	6.5	7	8
6	3	3	2.5	3.0
7	8	6.5	8	6.5
8	4	5	2.5	3.0
9	6.5	8	6	6.5
10	5	4	1	3.0
11	13.5	14	9	10
12	10	13.5	10	9
13	9	13.5	11	12
14	11	9	13	11
15	13.5	16	12	17.5
16	15	11	15	15
17	16	15	17	13
18	12	19	18	18
19	17.5	10	16	17.5
20	17.5	17	14	14
21	19	18	19	19

Table 61 Note. Rank orders expressed with decimals had identical attainment medians.

**Table 62. Kruskal-Wallis One-Way Nonparametric Analysis of Variance for Milestone 10 by Vision (NLP, LP, SLV, and MLV)**

Visual Function	Mean Rank	Sample Size
NLP	67.4	25
LP	44.1	12
SLV	48.5	23
MLV	44.5	41
Total	51.0	101

Kruskal-Wallis Statistic 10.6965  
P-value, using Chi-Squared approximation 0.0135

Source	DF	SS	MS	F	p
Between	3	9182.29	3060.76	3.87	0.0116
Within	97	76661.2	790.322		
Total	100	85843.5			

**Discussion of Results**

The sequence of developmental milestone acquisition as measured in this study

did not differ for Milestone 2 through 10 for the four visual functioning groups. Sequences do appear to differ for the remainder of the milestones for the four visual functioning groups. The number of participants used to obtain medians ranged from 14 for Milestone 21 to 114 for Milestone 8.

Visual functioning impacted milestone 10 (plays interactive games) as measured by the Kruskal-Wallis test where the latest attainment, as measured in this study, was in the no light perception group. Since milestone 10 was also impacted by both additional impairment and prematurity, it is possible that there is a common cause or interaction among these three (visual impairment, additional impairment, and gestation). The sample sizes were not large enough to create separate groups across these three dimensions.

**Research Question 3: Are there differences in the rate and sequence of development among sub-groups of children with varying etiologies of visual impairment?**  
***Statistical Methodology***

Differences in rate and sequence were analyzed for the most frequent visual diagnoses for study participants. These were cortical visual impairment (CVI); retinopathy of prematurity (ROP); optic nerve hypoplasia (ONH); and albinism. Children with structural anomalies (n = 22, 11.1%) were not included in this analysis, because this group included a variety of visual disorders.

Milestones were analyzed using the Kruskal-Wallis nonparametric test and rate of development was analyzed using the total scores for the Vineland and Battelle assessments. These data were analyzed using analysis of variance.

Rate of development was based on Battelle total scores. The means of the PRISM participants with no additional impairments were compared to the means of the normed group using a one-sample t-test for all age groups. The mean of the participants with no light perception who functioned intellectually normal as determined by the Abilities Index Assessment and without additional impairments were compared to the mean of the normed group using a one-sample t-test.

**Presentation of Milestone Results**

Table 63. Kruskal-Wallis One-way Nonparametric Analysis of Variance and Parametric Analysis of Variance Applied to Ranks of Milestone Attainment by Visual Diagnosis.

Milestone	K-W Statistic	Chi <sup>2</sup> Approximated p	Source	df	F	p
6	14.7195	0.0021	Within	65	5.99	0.0012
7	12.7229	0.0053	Within	49	5.29	0.0031
8	21.1537	0.0001	Within	69	9.57	0.0000
9	18.0480	0.0004	Within	46	8.94	0.0001
10	8.6300	0.0346	Within	60	3.17	0.0301
11	9.0195	0.0290	Within	35	3.63	0.0221
12	20.0361	0.0002	Within	44	10.90	0.0000
13	9.3798	0.0246	Within	39	3.74	0.0187
15	11.4524	0.0095	Within	17	7.59	0.0020
16	10.6162	0.0140	Within	14	7.76	0.0027

Table 63 Note. The degrees of freedom for the “between” source are equal to 2 for all milestones.

Table 64. Pairwise Comparisons of Mean Ranks of Milestones by Type of Visual Diagnosis.

Milestone	Visual Diagnosis	Mean Rank	Homogenous Groups	Sample Size	Comments Regarding Homogenous Groups
6	ROP	46.783		23	There are two groups (ROP and ONH) in which the mean attainments of Milestone 6 are significantly different.
	CVI	38.100		10	
	Albinism	29.136		11	
	ONH	25.500	..	25	
7	CVI	37.750	-	6	There is a significant difference between the two groups: CVI and Albinism
	ROP	34.278	-	18	
	ONH	21.559	-	17	
	Albinism	18.417	-	12	
8	CVI	51.250		10	There are two groups (CVI/ROP and ONH/Albinism) in which the mean attainments of Milestone 8 are significantly different.
	ROP	48.333		24	
	ONH	26.537	..	27	
	Albinism	26.000	..	13	
9	CVI	39.750		4	Milestone 9 attainment differs significantly for (1) Albinism and CVI and (2) Albinism and ROP.
	ROP	33.235		17	
	ONH	23.056		18	
	Albinism	12.364	..	11	
10	ROP	40.700		20	There are two groups (ROP and Albinism) in
	CVI	34.167		9	

	ONH	30.630		23	which attainment of Milestone 10 differ significantly.
	Albinism	21.167		12	
11	CVI	28.500	-	2	There is a significant difference between two groups: ROP and Albinism.
	ROP	24.682	-	11	
	ONH	21.500	-	15	
	Albinism	11.727	-	11	
12	ROP	35.833		15	Milestone 12 attainment differs significantly for (1) ROP and ONH and (2) ROP and Albinism.
	CVI	30.833		6	
	ONH	18.500	..	18	
	Albinism	13.389	..	9	
13	ROP	29.875		12	There are two groups (ROP and ONH) in which attainment of Milestone 13 differ significantly.
	CVI	25.786		7	
	Albinism	18.045		11	
	ONH	16.038	..	13	
15	CVI	16.667		3	Milestone 15 attainment differs significantly for (1) CVI and ONH and (2) ROP and ONH.
	ROP	14.571		7	
	Albinism	10.400		5	
	ONH	4.500	..	6	
16	ROP	14.250		4	There are two groups (ROP and ONH) in which attainment of Milestone 16 differs significantly.
	CVI	14.000		3	
	Albinism	9.000		5	
	ONH	4.500	..	6	

### ***Discussion of Milestone Results***

The following differences in means as measured by the Kruskal-Wallis test were present for Milestones 6, 7, 8, 9, 10, 11, 12, 13, 15, and 16.

Table 65. Differences in Means as Tested by Kruskal-Wallis For Attainment of Milestone As Measured in This Study

Milestone	Differences in Visual Diagnosis Groups
6 (sits alone 5 secs.)	Retinopathy of prematurity and optic nerve hypoplasia
7 (feeds self bite-size food)	Cortical visual impairment and albinism
8 (produces c/v sound)	The group consisting of cortical visual impairment and retinopathy of prematurity differed from the group consisting of optic nerve hypoplasia and albinism
9 (crawls 3 or more ft.)	Albinism differed from cortical visual impairment and albinism differed from retinopathy of prematurity
10 (plays interactive game)	Retinopathy of prematurity differed from albinism
11 (walks without support 10 ft.)	Retinopathy of prematurity and albinism differed
12 (points to at least 1 major body part)	Retinopathy of prematurity differed from optic nerve hypoplasia and retinopathy of prematurity differed from albinism
13 (removes simple garment)	Retinopathy of prematurity differed from optic nerve hypoplasia
15 (uses 2 word utterances)	Cortical visual impairment differed from optic nerve hypoplasia and retinopathy of prematurity differed from optic nerve hypoplasia
16 (uses pronouns)	Retinopathy of prematurity and optic nerve hypoplasia differed

**Presentation of Rate of Development Results (Battelle and Vineland)**

Table 66. One-Way Analysis of Variance for Vineland and Battelle Total Scores by Visual Diagnosis.

Instrument	Age Group	Within Df	F	p
Vineland	0-5	27	0.48	0.6999
Battelle	0-5	27	0.61	0.6152
Vineland	6-11	146	16.22	0.0000*
Battelle	6-11	147	18.05	0.0000*
Vineland	12-17	85	7.13	0.0001*
Battelle	12-17	93	8.46	0.0000*
Vineland	18-23	92	8.93	0.0000*
Battelle	18-23	93	11.01	0.0000*
Vineland	24-35	87	2.51	0.0469*
Battelle	24-35	96	5.60	0.0005*
Vineland	36-47	46	0.94	0.4473
Battelle	36-47	53	1.16	0.3409
Vineland	48-59	19	2.84	0.0529
Battelle	48-59	23	2.98	0.0405*

\* Significant at .05 level.

Table 67. Descriptive Statistics for Battelle and Vineland by Age Group and Diagnosis.

Age Group	Diagnosis	Battelle			Vineland		
		Mean	N	s.d.	Mean	N	s.d.
0-5 mos	CVI	22.92	24	11.15	22.25	4	4.27
	ROP	31.16	31	12.32			
	ONH	42.21	29	16.78	25.89	9	8.28
	Albinism	62.09	11	19.45	23.33	3	6.43
	All others	42.80	56	16.41	21.93	15	8.69
6-11 mos	CVI	39.52	23	22.71	22.92	24	11.15
	ROP	62.04	28	27.92	31.16	31	12.32
	ONH	74.21	29	28.48	42.21	29	16.78
	Albinism	117.18	11	21.36	62.09	11	19.44
	All others	85.95	61	32.55	42.80	56	16.41
12-17 mos	CVI	69.37	19	36.68	38.24	17	18.88
	ROP	90.12	17	28.32	45.80	15	20.02
	ONH	106.44	18	39.49	59.47	17	24.82
	Albinism	143.25	8	24.32	83.50	6	18.93
	All others	121.00	36	43.58	63.06	35	22.37
18-23 mos.	CVI	89.06	17	70.92	41.17	18	30.53
	ROP	125.75	16	38.61	66.30	20	22.26
	ONH	134.47	19	61.67	73.80	20	38.48
	Albinism	224.40	10	11.31	117.00	6	29.97
	All others	158.94	36	54.55	79.67	33	27.37
24-35 mos.	CVI	110.37	16	73.22	59.60	15	41.80
	ROP	159.80	20	67.05	94.29	17	32.27
	ONH	166.15	20	82.64	93.4	20	52.16
	Albinism	263.63	8	69.96	130.33	3	62.85
	All others	170.86	37	77.53	92.97	37	43.62
36-47 mos.	CVI	150.67	9	96.08	72.88	8	47.38
	ROP	212.75	12	73.66	120.13	8	42.95
	ONH	181.55	11	112.57	126.90	10	76.39
	Albinism	286.33	3	112.12	131.50	2	75.66
	All others	214.43	23	124.41	112.39	23	68.94
48-59 mos.	CVI	83.00	4	68.49	29.50	4	21.49
	ROP	308.67	6	133.97	169.50	6	75.65
	ONH	221.17	6	118.07	113.20	5	61.94
	Albinism	447.50	2	40.30	232.00	1	-
	All others	251.60	10	163.30	115.25	8	89.09

**Table 68. Scheffe Pairwise Comparisons at .05 Level of Significance for Vineland and Battelle with Significant *p* in ANOVAs.**

Age Group	Assessment	Diagnosis (with Mean)	Homogenous Groups
6-11 mos	Vineland	Albinism (62.09)	
		All others (42.80)	..
		Optic nerve hypoplasia (42.21)	..
		ROP (31.16)	....
		Cortical visual impairment (22.92)	.....
	Battelle	Albinism (117.18)	
		All others (85.95)	..
		Optic nerve hypoplasia (74.21)	..
		ROP (62.04)	....
		Cortical visual impairment (39.52)	.....
12-17 mos	Vineland	Albinism (83.50)	
		All others (63.06)	
		Optic nerve hypoplasia (59.47)	
		ROP (45.80)	..
		Cortical visual impairment (38.23)	....
	Battelle	Albinism (143.25)	
		All others (121.00)	
		Optic nerve hypoplasia (106.44)	
		ROP (90.12)	..
		Cortical visual impairment (69.37)	.. ..
18-23 mos	Vineland	Albinism (117.00)	
		All others (79.67)	
		Optic nerve hypoplasia (73.80)	
		ROP (66.30)	..
		Cortical visual impairment (41.17)	....
	Battelle	Albinism (224.40)	
		All others (158.94)	..
		Optic nerve hypoplasia (134.47)	..
		ROP (125.75)	..
		Cortical visual impairment (89.06)	....
24-35 mos	Vineland	Albinism (130.33)	
		ROP (94.29)	
		Optic nerve hypoplasia (93.40)	
		All others (92.97)	
		Cortical visual impairment (59.60)	
	Battelle	Albinism (263.63)	
		All others (170.86)	
		Optic nerve hypoplasia (166.15)	
		Retinopath prematur (159.80)	
		CVI (110.37)	i
48-59	Battelle	Albinism (447.50)	
		ROP (308.67)	
		All others (251.60)	
		Optic nerve hypoplasia (221.17)	
		Cortical visual impairment (83.00)	

### ***Discussion of Rate of Development Results of Intra-PRISM Groups***

Participants with albinism scored consistently higher than those with cortical visual impairment and retinopathy of prematurity in age groups 6-11, 12-17, and 18-23 on both the Vineland and the Battelle. In age group 24-35, there were no significant pairwise differences in Vineland scores for any of the diagnoses, but on the Battelle, participants with albinism scored higher than those with cortical visual impairment and the other-diagnoses group. In age groups 36-47 and 48-59, there WERE no significant pairwise differences among any of the Battelle or Vineland scores for participants grouped by the five groups. Developmental differences may be disappearing as the participants get older, but the sample sizes in age groups 36-47 and 48-59 are too small to make that generalization. Continued study of the participants in this study would be highly beneficial to understanding whether participants are “catching up” with one another.

In age group 6-11, those in the other-diagnoses group and the optic nerve hypoplasia group scored higher than the cortical visual impairment group on both the Battelle and the Vineland. In age group 12-17, the other-diagnoses group scored higher than those with cortical visual impairment. In age group 18-23, the other-diagnoses group scored higher on the Battelle and Vineland than those with cortical visual impairment. In age group 24-35, the albinism group scored higher than all the other groups except for the optic nerve hypoplasia group. As was indicated previously, there were no significant statistical pairwise differences in Vineland and Battelle scores for children over 3 years of age.

**Presentation of Results for PRISM Compared to Normed Population and Battelle Age Equivalent Scores**

**Table 69. Battelle Scores for PRISM Participants Without Additional Impairment Compared to the Normed Battelle Population Scores**

Age Group and Normed/PRISM	n	Mean	SD	t	p
0-5: Normed Population	- 21	58.03 49.67	21.86 14.38	1.75	> .05
PRISM Participants					
6-11: Normed Population	- 56	121.33 97.82	21.22 26.50	8.29	< .05*
PRISM Participants					
12-17: Normed Population	- 35	194.30 138.09	23.11 34.84	14.39	< .05*
PRISM Participants					
18-23: Normed Population	- 35	247.29 192.91	23.57 37.54	13.65	< .05
PRISM Participants					
24-35: Normed Population	- 32	332.93 238.06	48.57 59.64	11.05	< .05*
PRISM Participants					
36-47: Normed Population	- 15	436.52 299.80	61.21 82.91	8.65	< .05*
PRISM Participants					
48-59: Normed Population	- 6	516.13 401.50	51.26 139.53	5.47	< .05*
PRISM Participants					

\*Significant at .05 level.

Table 69 NOTE: The PRISM participants are those without any additional impairments.

**Table 70. Battelle Total Scores for PRISM Participants With No Light Perception at Project End, No Additional Impairment, and Normal Intellectual Functioning**

Age Group	n	Mean	SD
0-5	4	40.50	21.977
6-11	11	87.36	15.429
12-17	5	137.40	27.537
18-23	3	186.33	13.868
24-35	7	226.57	43.889
36-47	3	316.00	62.024

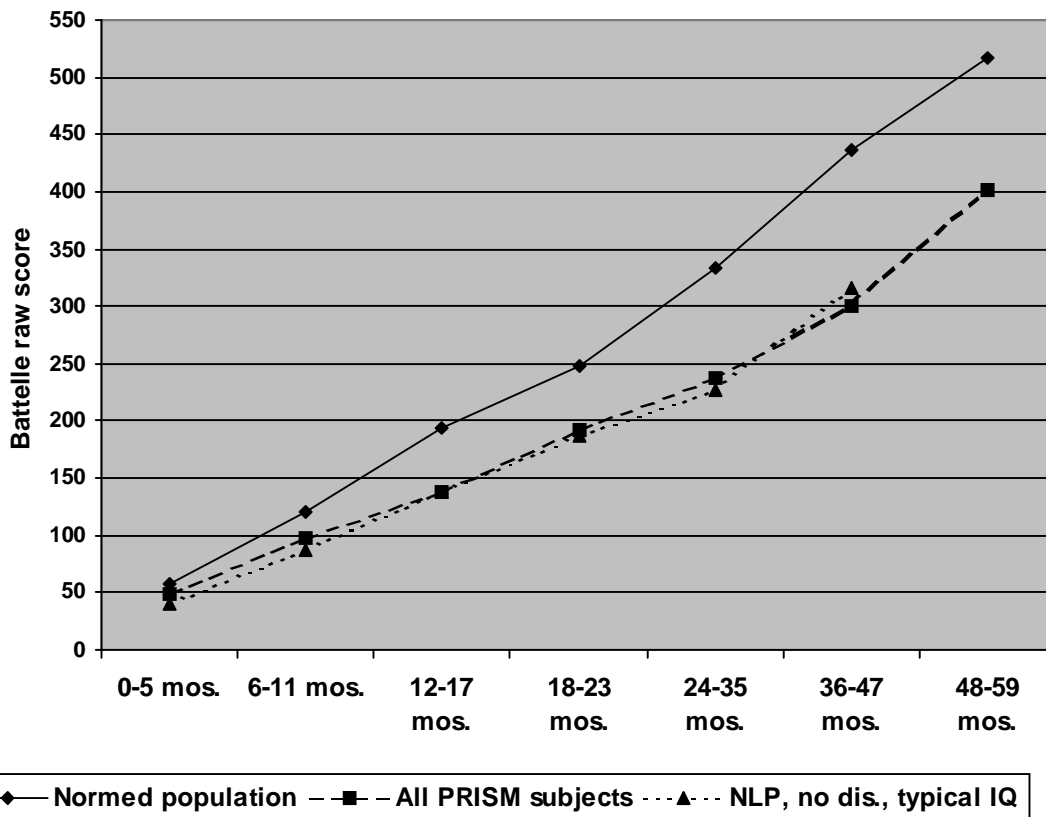
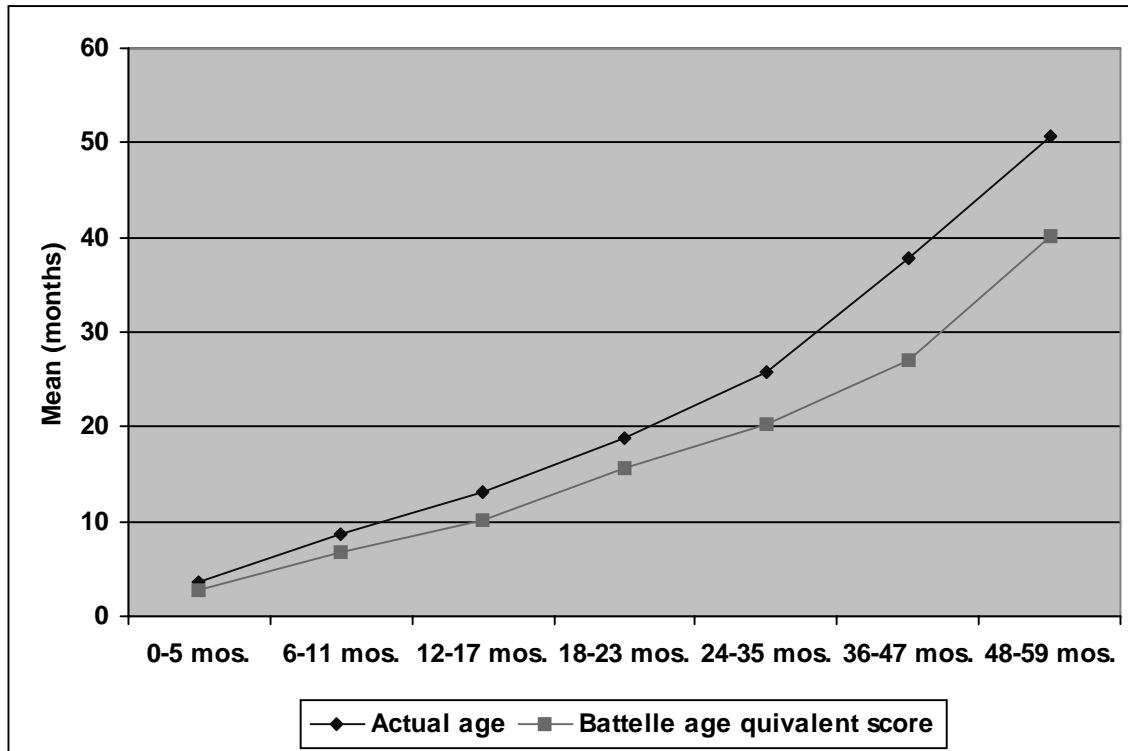


Figure 6. Battelle Scores for Normed Population, All PRISM Participants, and Participant Children with NLP, No Additional Disabilities, and Typical IQ

Table 71. Battelle Age Equivalent Comparisons Compared to Actual Age For Participants Without Additional Impairments

AGE GROUP	Actual Age			Battelle Age Equivalent			t	p
	N	Mean	SD	N	Mean	SD		
0-5 months	21	3.6	1.3	21	2.7	1.0	4.99	.0001
6-11 months	56	8.6	1.6	56	6.8	3.9	3.36	.0016
12-17 months	35	13.0	1.5	35	10.1	3.2	5.71	.0000
18-23 months	35	18.9	1.3	35	15.6	3.9	5.57	.0000
24-35 months	30	25.8	3.0	30	20.3	6.0	4.66	.0001
36-47 months	15	37.8	3.4	15	27.1	4.7	4.37	.0003
48-59 months	6	50.8	2.7	6	40.2	16.1	1.73	.1449

Figure 7. Mean Battelle Age Equivalent Scores and Mean Actual Chronological Ages , Children with No Additional Disabilities



***Discussion of Normed Population, Age Equivalent Scores, and PRISM Participants on Battelle***

The PRISM participants with no additional disabilities scored significantly below the mean total scores on the Battelle for all age groups except 0-5 months. The children who had no light perception at project end, no additional impairments, and were of normal intellectual functioning recorded Battelle scores that remained below the mean of the scores for the norming population throughout all age groups. The number of participants in this latter group is very small so caution must be used in making generalizations.

The comparison of means is not sufficient for studying the Battelle scores be-

cause of characteristics such as the large standard deviations compared to the standard deviations for the norming population (see Figure 8). It is obvious that the standard deviations for the PRISM participants are much greater (frequently twice as large) than the standard deviations for the norming population. This could be a wide spread of development among PRISM participants or the large spread may be due to the test itself.

When using Battelle age equivalent scores compared to actual age among PRISM participants with no additional impairment, the large differences in standard deviations continue (see Figure 9), which indicates that the range in developmental scores is greater the older the children become. The differences in development could be a factor associated with the testing process rather than the actual development of the children. Perhaps the difference in sequence of attainment of milestones which is evident in this study (especially those associated with sight) may be adding to the large spread in scores that is evident in these data. It is beyond the scope of this study to

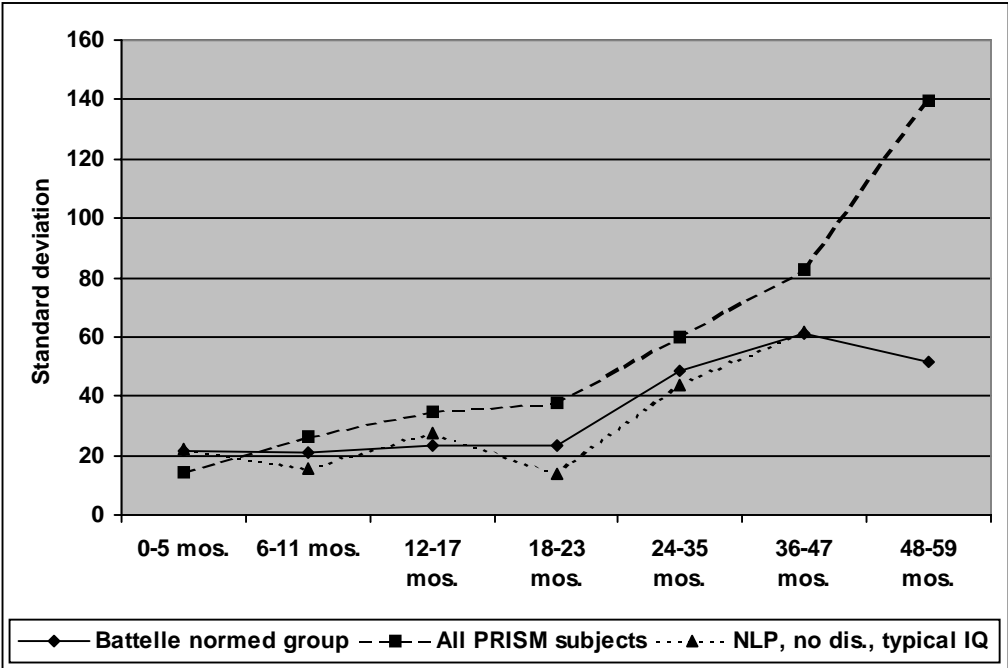


Figure 8. Standard Deviations of Battelle Norm Group, All PRISM Participants, and Participant Children with NLP, No Additional Disabilities, and Typical IQ

attempt to develop a process for assessing developmental rate for visually impaired children, but it is possible that the Battelle (Vineland results are similar to Battelle results) assessment process is overly dependent on vision.

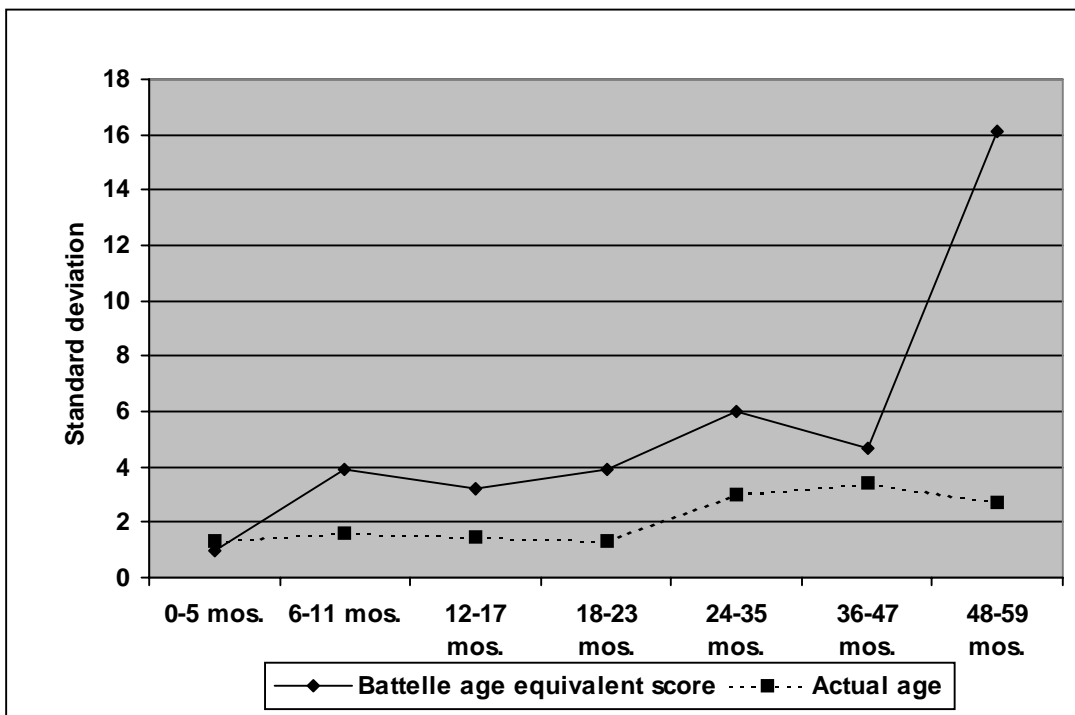


Figure 9. Standard Deviations of Actual Age and Battelle Age Equivalent Scores, Children with No Additional Disabilities