ORIGINAL ARTICLE

Assessment of the Reliability and Validity of the Alberta Infant Motor Scale and Peabody Development Motor Scale in High-risk Infants

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ABSTRACT

Introduction: The aim of this study was to investigate the correlation between Alberta Infant Motor Scale (AIMS) scores at 8 months and Peabody Developmental Motor Scale-2 (PDMS-2) and Peabody Developmental Gross Motor Scale-2 (PDMS-GM-2) scores at 18 months and 3 years in high-risk infants. **Methods:** This retrospective study included 105 high-risk infants at a Saudi Arabian tertiary care facility. Pearson correlation analysis was used for comparing scores. Additional subgroup analyses were performed for participants diagnosed with cerebral palsy at 18 months and for those who received physiotherapy. **Result:** AIMS scores at 18 months showed stronger correlations with PDMS-GM-2 scores than with PDMS-2 total scores, while these correlations decreased at 3 years. For the cerebral palsy subgroup, correlation with PDMS-2 scores at 18 months was relatively stronger than at 3 years. For the physiotherapy intervention subgroup, correlations with PDMS-GM-2 scores PDMS-2 total scores were similar at 18 months and 3 years. **Conclusion:** The AIMS predictive validity was lowest at 3 years in high-risk infants. A correlation was higher in participants with physiotherapy intervention and highest in participants with cerebral palsy. Outcome measures and treatment results should be cautiously reported during the first 3 years to prevent over-treating high-risk infants and decrease rehabilitation costs.
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Keywords: Developmental delay, Physiotherapy intervention, Cerebral palsy, Motor skills, Correlation analysis

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INTRODUCTION

Advances in medical care have led to increased survival of preterm infants and decreased preterm mortality rates, and lowered the limit of viability (1). Physiotherapists are involved in the early motor intervention and screening of infants at high risk of developmental delays due to low birth weight (≤1500 g) or prenatal, perinatal, or postnatal complications of childbirth that may lead to a prolonged stay in the intensive care unit (2). Early detection and favorable outcomes for such infants require repeated assessments at multiple time points during the first year of life (3). However, neurodevelopmental abnormalities observed in preterm infants during that time may be transient. Therefore, motor development assessment should not be limited to the first year of life because of variations in development among toddlers and the presence of other risk factors that may affect development in early childhood (4).

In 2006, the Committee on Children with Disabilities of the American Academy of Pediatrics recommended that standardized developmental screening tests be administered at ages of 9, 18, and 30 months (5,6). Furthermore, they published guidelines for follow-up of premature infants and recommended that infants with birth weights <1500 g should be assessed by age-appropriate motor examinations at least twice during the first year of life (5). School readiness screening before preschool or kindergarten enrollment is recommended as well. In preventive care visits, developmental concerns should be addressed because the failure of detection and treatment may lead to social and emotional issues in early school age. The predictive validities of such tools are of great value in determining whether an assessment tool used during infancy can predict the developmental outcome at a later age. Additionally, these tools assist clinicians in making decisions about the need and time to provide early intervention and are important in providing support and guidance to parents to help them understand the eventual motor disabilities during the critical first year of life of infants (7-12).

Several discriminative tools for evaluating developmental delays in infants and toddlers have been reported. These include the Alberta Infant Motor Scale (AIMS), Peabody Development Motor Scale-2 (PDMS-2), Bayley Scales of Infant Development-II (BSID-II), BSID-III, and Test of Infant Motor Performance (TIMP). AIMS and PDMS-2 are discriminative tools designed to detect developmental delays, and these tools have been validated for preterm and full-term infants in children aged 0–18 months and 0–5 years, respectively (13-16). The AIMS is a norm-referenced assessment tool that is consists of 58 test items assessed by observing the infant in four different positions: prone supine, sitting and standing (17). The PDMS-2 is also a norm-referenced discriminate, evaluative and predictive assessment tool, which consists of 2 subtests: First, a gross motor which consists of 3 subscales: reflexes, stationary, locomotion, and object manipulation. Second, fine motor and consist of two subscales: grasping and visual-motor integration (18). It has been identified as being more useful in the assessment of older children than in developing infants (18). A previous study has evaluated the predictive value of AIMS scores obtained at 4–6.5 months with BSID-II and BSID-III scores at 2 years and 3 years of age, respectively. However, few studies have investigated the predictive validity of AIMS scores at preschool age (age range, 3–5 years) (19). It is important to assess the reliability and validity of those tools and they are able to identify infants with developmental delay as accurately and as early as possible. However, no previous studies have examined the reliability and validity of AIMS, (PDMS-2) and (PDMS-GM-2) scores at 18 months and 3 years in high-risk infants (20). This study aimed to investigate the predictive validity of AIMS scores at 8 months and whether this score correlates with PDMS-2 scores at 18 months and 3 years of life in high-risk toddlers in Saudi Arabia.

MATERIALS AND METHODS

Design and sample collection

This was a retrospective study that included a review of 273 "high-risk" infants treated between 2007 and 2012 in the Neonatology Department at King Fahad Medical City "High-risk" infants were considered as premature infants who were at increased developmental disability risk; they were also at risk of chronic lung disease, deafness, and brain hemorrhages, which added to their developmental risk (17). Ethical approval was obtained from the institutional review board of King Fahad Medical City where the study was registered (Log No. 13-093E).

Participants

Inclusion criteria for this study include birthweight ≤ 1250 g, gestational age ≤ 29 weeks, Grade III or IV intraventricular hemorrhage, Periventricular leukomalacia with cyst formation, Hydrops fetalis, Retinopathy of prematurity requiring laser treatment, chronic lung disease (on O2 at 36 days corrected chronological age for babies aged <32 weeks or on O2 for >28 days for babies aged ≥32 weeks) and twin, triplet, or quadruplet.

The exclusion criteria include those with candida sepsis, those with post-exchange transfusion or level reaching exchange, those with hypoxic-ischemic encephalopathy associated with a seizure; and those with proven meningitis. These criteria were selected based on similar studies involving high-risk infants (21). The exclusion and inclusion of the infants in the study are described in Figure 1.

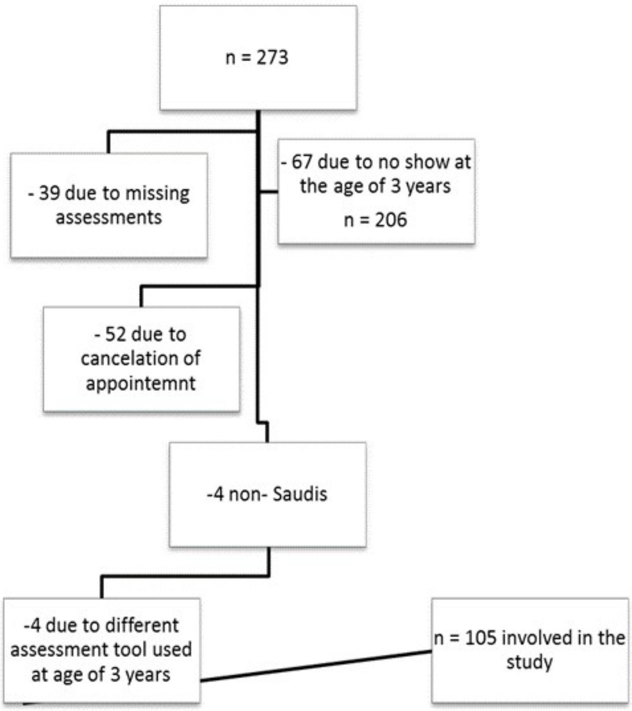

Figure 1: Exclusion and inclusion process of the sample involved in the study

Outcome measures

All outcome measures were scored by multiple trained pediatric therapists.

Primary outcome measure

AIMS score: All participants were assessed at the age of 8 months, and percentile and total scores were documented. Pearson correlation coefficients were calculated from the raw AIMS scores.

Secondary outcome measure

PDMS-2 comprised two subtests: gross motor assessed by physiotherapists and fine motor assessed by occupational therapists. All participants were assessed at the ages of 18 months and 3 years. It was not possible to calculate the total PDMS-2 scores for all participants because of the missing fine motor subscale score. The correlations between AIMS scores and PDMS-2 total scores and the

Peabody Developmental Gross Motor Scale-2 (PDMS-GM-2) score were determined separately.

Statistical analyses

Categorical variables are presented as numbers and percentages, whereas continuous variables are presented as mean ± standard deviation or range and confidence interval as appropriate. Because this study initially assessed the predictive validity by categorical analysis, sensitivity, specificity, and sample size power were determined by preset sensitivity of 80% and preset specificity of 90% with a confidence interval of 10%. These values of specificity and sensitivity were set considering that they were the best estimate to detect motor developmental delay at 8 months of age using AIMS (Darrah et al., 1998). The power calculation resulted in the requirement of 256 participants to achieve a sensitivity of 80%, and 144 participants to achieve a specificity of 90%. However, after data collection, it was found that the participants scored between 5 percentile and 10 percentile when 8 months was chosen as the cutoff point for assessing AIMS scores, as recommended by Darrah et al. (1998). Therefore, the Pearson correlation coefficient was used to assess the association between AIMS and PDMS.

The Pearson correlation coefficient was used to indicate the association between AIMS and PDMS-2. Four comparisons were performed as follows:
(1) AIMS at 8 months and PDMS-GM-2 at 18 months;
(2) AIMS at 8 months and PDMS-2 at 18 months;
(3) AIMS at 8 months and PDMS-GM-2 at 3 years; and
(4) AIMS at 8 months and PDMS-2 at 3 years.

To limit the effect of confounding factors, additional analyses using these same four comparisons were performed in the two subgroups: participants with and without physiotherapy intervention and participants with or without a diagnosis of cerebral palsy at 18 months of age.

RESULTS

The demographic characteristics of the patients are provided in Tables I and II. The initial sample of patients included 105 patients, with a male-to-female ratio of 63:42. The mean ± standard deviation birthweight and gestational age were 1276.30 ± 1106.58 g and 29.28 ± 3.44 weeks, respectively. The mean AIMS score at 8 months of age was 26.91 ± 7.67. Furthermore, 16 (15.8%) patients received physical therapy intervention, and 9 (8.6%) patients were diagnosed with cerebral palsy at 18 months. Among the total participants, 21 had incomplete fine motor scores at 18 months. Hence, 84 participants were available for the correlation analysis between AIMS and PDMS-2 total scores at 18 months.
The correlation analysis between AIMS scores at 8 months and PDMS-2 total and PDMS-GM-2 scores at 18 months and 3 years were compared. The Pearson correlation coefficient between AIMS scores at 8 months and PDMS-GM-2 score at 18 months was the highest (r = 0.589), indicating a moderate positive relationship ($p < 0.001$). The correlation coefficient between AIMS at 8 months and PDMS-GM-2 score at 3 years were r = 0.330 (p = 0.001), indicating a positive but weaker correlation than that of AIMS scores with PDMS-2 total (r = 0.452) or PDMS-GM-2 scores at 18 months. Further, two participants were excluded from the analysis of the correlation between AIMS scores at 8 months and PDMS-2 total scores at 3 years because of missing fine motor subtest assessments. The correlation coefficient between AIMS and PDMS-2 total scores at 3 years was higher than between AIMS and PDMS-GM-2 scores at 3

Table I: Demographic characteristics of the patients (n = 105); continuous variables

	Mean	Standard deviation	Standard error	95% confidence interval
Birth weight (g)	1276.30	1106.583	107.991	(1062.15–1490.46)
Gestational age (weeks)	29.28	3.443	0.523	(27.47–29.58)
AIMS total score at 8 months	26.91	7.669	0.748	(25.43–28.40)
AIMS percentile	26.31	44.383	4.352	(17.68–34.94)

Table II: Demographic characteristics of the patients (n = 105); categorical variables

	Male (n, %)	Female (n, %)
Sex	63 (40)	42 (60)
Twin	Yes (n, %)	No (n, %)
	Twin: 30 (28.6) Triplet: 9 (8.6) Quadruplet: 4 (3.8)	62 (59)
P.V.L.	1 (1)	99 (99)
I.V.H.	8 (7.6)	97 (92.4)
C.L.D.	8 (7.6)	97 (92.4)
R.O.P	61 (58.1)	44 (41.9)
Hydrops fetalis	2 (1.9)	103 (98.1)
Living in Riyadh	82 (78.1)	23 (21.9)
Diagnosis of neurological disorder at age 18 months	9 (8.6)	96 (91.4)
Physiotherapy intervention	16 (15.8)	89 (84.8)

n, number of subjects; %, percentage; P.V.L., periventricular leukomalacia; I.V.H, intraventricular hemorrhage; C.L.D., chronic lung disease; R.O.P, retinopathy of prematurity.

years (r = 0.348 vs. r = 0.330; p < 0.001), both indicating weak positive relationships.

In the subgroup analysis involving participants diagnosed with cerebral palsy at 18 months of age (n = 9), moderate positive relationships were observed between AIMS scores at 8 months and both PDMS-2 and PDMS-GM-2 scores at 18 months (r = 0.591 vs. r = 0.738), but PDMS-2 total scores had higher coefficients that PDMS-GM-2 score at 3 years (r = 0.493 vs. r = 0.528; Table III).

For the subgroup analysis involving patients who received physiotherapy intervention, moderately positive relationships were observed in all four comparisons (Table III). However, it was highest (r = 0.646) for PDMS-GM-2 scores at 18 months of age, indicating a moderately positive relationship, similar to that for the total PDMS score (r = 0.620). Although the correlations were slightly weaker with scores at 3 years, both PDMS-GM-2 scores and PDMS-2 total scores showed a moderately positive relationship (r = 0.570 vs. r = 0.571).

In the additional analysis for participants who were diagnosed with cerebral palsy at 18 months of age, AIMS scores showed the highest correlation with PDMS-GM-2 scores (r = 0.738). The correlation was lower when compared with PDMS-2 total scores (r = 0.591), but the number of participants was lower in the second comparison (n = 8 vs. n = 9). Furthermore, for the comparison at 3 years, when the numbers of participants were the same, the correlation was higher with PDMS-2 total scores than with PDMS-GM-2 scores (r = 0.528 vs. r = 0.493).

Table III: Pearson correlation coefficients of participants diagnosed with cerebral palsy and who underwent physiotherapy intervention

	AIMS at 8 months and PDMS-GM-2 at 18 months	AIMS at 8 months and PDMS-2 at 18 months	AIMS at 8 months and PDMS-GM-2 at 3 years	AIMS at 8 months and PDMS-2 at 3 years
Cerebral palsy sample (n)	n = 9	n = 8	n = 9	n = 9
Score (mean standard deviation)				
PDMS-GM-2/ PDMS	70.67 ± 22.26	94.62 ± 28.32	69.56 ± 36.08	108.66 ± 44.03
AIMS	19.56 ± 8.53	20.63 ± 8.45	19.56 ± 8.53	19.56 ± 8.53
Pearson correlation coefficient (*r*)	*r* = 0.738	*r* = 0.591	*r* = 0.493	*r* = 0.528
Physiotherapy intervention sample (n)	AIMS at 8 months and PDMS-GM-2 at 18 months	AIMS at 8 months and PDMS at 18 months	AIMS at 8 months and PDMS-GM-2 at 3 years	AIMS at 8 months and PDMS at 3 years
	n = 16	n = 15	n =16	n = 16
Score (mean standard deviation)				
PDMS-GM-2/ PDMS	77.38 ± 15.91	111.80 ± 25.89	80.94 ± 26.77	119.44 ± 36.31
AIMS	20.19 ± 7.39	20.80 ± 7.21	20.19 ± 7.39	20.19 ± 7.39
Pearson correlation coefficient (*r*)	*r* = 0.646	*r* = 0.620	*r* = 0.570	*r* = 0.571

DISCUSSION

In 2001, the Committee on Children with Disabilities of the American Academy of Pediatrics recommended that all infants and toddlers be screened for developmental delay by using screening tools that have strong psychometric properties (6). Furthermore, the committee published guidelines for follow-up of premature infants and recommended that infants with low birth weights (<1500 g) should be assessed by age-appropriate motor examinations at least twice during the first year of life (5,6). Physiotherapists have a major role in the early motor assessment and provide a timely intervention with a focus on motor skills for high-risk infants. However, many previous studies have suggested that abnormalities in the development of high-risk infants may be transient during the first year of life (22-25). For this reason, predictive validity studies are of great importance to provide a better understanding of appropriate tools, the optimal age of assessment, and the correct interpretation of findings to guide service providers and parents.

In this study, we primarily aimed to examine the correlations between AIMS scores at 8 months and PDMS-2 scores at two-time points: 18 months and 3 years. PDMS-2 was the best choice among other assessment tools because it focuses on motor skills with two subtests: fine and gross motor skills, excluding behavioral and social skills. Therefore, this study compared the Pearson correlation coefficients between AIMS scores at 8 months, and both PDMS-2 total scores and PDMS-GM-2 scores in subjects at 18 months and 3 years. The correlation between AIMS scores and the PDMS-GM-2 scores at 18 months was higher than PDMS-2 total scores (r = 0.589vs. r = 0.452; p ≤ 0.001 for both), which may be explained by the differences in the sample size in the analysis (n = 105 vs. n = 84) that may have led to the lower correlation coefficient in the second comparison. However, our study differs from the study conducted by Snyder et al. (2); in their study, AIMS scores were compared to the separated locomotion subscale of the gross motor subtest and stronger correlations (PGDMS-2-reflex: r = 0.9, PGDMS-2-stationary: r = 0.92, and PGDMS-2 –locomotion: r = 0.97) were found in a much smaller study population (n = 21). The differences may be explained by the fact that the present study examined the correlation between these two assessments over a longer period (18 months), whereas the Snyder study examined the concurrent validity in a sample with an age range of 9–12 months. Additionally, Snyder et al. (2) compared AIMS scores to only PDMS-GM-2 scores, whereas the present study compared AIMS scores to PDMS-2 total scores in addition to PDMS-GM-2 scores. The correlation was similar to that in a study by Jeng et al. (2000), wherein they assessed the predictive validity between AIMS scores at 6 months and BSID-II scores, which is another popular assessment tool, in Taiwanese subjects aged 12 months and obtained a correlation coefficient of r = 0.56 (14). Although both tools assess gross and fine motor skills, it is difficult to compare this study to others because of differences in the assessment tools used, type of analysis conducted, age of assessments, and sample ethnicity. Cross-cultural applicability is very high in the studies conducted on this topic in different parts of the world (25-27). However, there are concerns regarding the cultural sensitivity of PDMS-2. Native American toddlers scored significantly lower ($p \leq 0.001$) in PDMS-1 in a study conducted by Crowe et al. (28), whereas toddlers from the Indian subcontinent showed some significant differences, mainly in the gross motor domain in the age range of 12–22 months, in a study conducted by Tripathi et al. (29). These findings were similar to the anecdotal experience of the assessors in our study. Furthermore, Greek infants in the age range of 2–3 months scored significantly higher than the original Canadian infant population with a p-value of 0.02 (27).

These cultural factors such as ethnicity, child-rearing practices, and nutrition may have contributed to the differences in the correlation between AIMS scores at 8 months and the total PDMS-2 and PDMS-GM-2 scores at age 3 years because some motor skills assessed specifically at an older age are not representative of the common skills practiced by Saudi Arabian toddlers who may score lower because of their unfamiliarity with the tested tasks (r = 0.348 vs. r = 0.330). AIMS scores at 8 months showed a higher correlation with PDMS-2 total scores than PDMS-GM-2 scores at 3 years. This is consistent with the hypothesis that combined gross and fine motor subtests may give a better idea about the motor skills of an infant; additionally, a study mentioned that the most common problems observed in high-risk toddlers are behavioral. This could be because of the similar numbers of toddlers involved in both arms of the analysis (n = 105 and n = 103), both of which were higher than those in the analysis between AIMS scores and PDMS-2 total scores at age 18 months (n = 84) in our study. Both scores had lower correlations with AIMS scores at 3 years than at 18 months. This finding is consistent with those of the study conducted by Synder et al. in 2008 (2) wherein they observed that AIMS scores were less predictive in infants >9 months than PDMS-2 scores because of the fewer number of items in the AIMS test for locomotor skills than in PDMS-2. In the only study (30) that examined the predictive validity between AIMS scores at ages from 10 to 12 months and BSID-III scores at 3 years, the correlation with the gross motor subtest of BSID-III scores (r = 0.55) was higher than that with both PDMS-GM-2 and PDMS-2 total scores (r = 0.330 and r = 0.348, respectively) at 3 years in this study. However, the correlation of AIMS scores with the fine motor subtest of BSID-III scores was similar to the correlation of the gross motor subset of PDMS-2 in the present study (r = 0.35). Although this cannot be considered as conclusive evidence, this shows that total domain scores tend to correspond to subtest scores. The BSID-III scores at 3 years appear to be better in predicting gross motor skills assessed by AIMS than by PDMS-2, but a number of factors, including lower sample size (n = 86) and the absence of subgroup analysis for toddlers who had physiotherapy intervention or who were diagnosed with cerebral palsy at age 18 months, which is needed to examine influences of these groups on the total sample correlation coefficients, were absent in the BSID-III study. The correlation in toddlers who had physiotherapy intervention was stronger than that of the whole sample. First, the correlation coefficient of AIMS scores at 8 months in comparison with PDMS-GM-2 scores was r = 0.646 and with PDMS-2 total score was r = 0.620, both at 18 months. Conversely, the correlations of AIMS scores at 8 months with PDMS-GM-2 scores and PDMS-2 total scores at 3 years were similar, probably because the numbers of toddlers were the same for the comparisons (r = 0.570 vs. r = 0.571). Although physiotherapy intervention may be a confounding factor, none of the other studies examining the predictive validity of AIMS performed additional analyses on toddlers who underwent physiotherapy intervention. Running an additional analysis in this group of toddlers was intended to provide a clearer picture of whether the correlations were different from those of the whole sample, and we found that the correlation was the highest among this group of toddlers (31). It is interesting to question if this result was obtained because physiotherapy intervention is directed toward specific motor skills that are commonly assessed by physiotherapists similar to the scoring items in PDMS-2 that may lead to a better correlation than that in toddlers who did not receive an intervention. Another reason may be that this group of toddlers is more likely to have lower scores showing that AIMS is more likely to predict motor outcomes of toddlers who have lower scores and therefore place them in the lower score percentiles.

The study results showed an acceptable correlation at different times of assessment when AIMS scores were compared to PDMS-GM-2 scores and PDMS-2 total scores, which suggests that AIMS is likely to be an acceptable assessment tool that can detect changes over time in toddlers who have lower scores and are more likely to be persistent over time. AIMS can also be used as a discriminative tool to detect delays that could be borderline or lower than the norms and may be transient or persistent over time. One of the interesting findings of this study is when the additional analysis was performed for the toddlers who were diagnosed with cerebral palsy at 18 months, the correlation was higher with PDMS-GM-2 scores than with PDMS-2 total scores, probably because of the lower number of toddlers in the latter comparison. The correlation with PDMS-2 total scores was higher when the numbers of toddlers in the subgroups were similar. These findings are similar to those of the study by Barbosa et al. (32) wherein they looked at AIMS and TIMP longitudinal performance in infants and toddlers diagnosed with cerebral palsy. This suggests that AIMS has a better correlation with other assessments in older-age children with motor skills poorer than the norm. Another important aspect of the early detection of developmental delay is the predictive value of initial assessments. In our study, many infants detected as having a disability by AIMS score at 8 months were found to not have a disability by PDMS scores at 3 years, highlighting the fact that developmental delays can be transient and disappear after the age of 1 year. This trend should be factored in by healthcare professionals while designing therapeutic protocols based on the assessment results in the first 3 years of life. This will help prevent over-treating high-risk toddlers and decrease costs incurred in rehabilitation programs.

This study had several limitations. First, it was a retrospective study wherein confounding factors were not controlled, which is done for other study designs. Second, categorical analysis in addition to the correlation analysis would have given a better picture of the predictive validity and the relationship between the two assessment tools. Children with lower initial scores might have been excluded because of loss of follow-up. Correlation between AIMS scores at 8 months and PDMS-2 scores was always higher at 18 months than at 3 years, which suggests that assessment at 18 months is more likely to predict motor outcomes at the age of 8 months when transient deficits may be more likely to be observed.

CONCLUSION

AIMS scores were weak predictors of motor delay beyond 18 months of age. More studies in a larger study sample will help in formulating clearer guidelines for the evaluation of infants at high risk to aid assessments and intervention.

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