**Eur**opean **Rev**iew for **Med**ical and **Pharmacol**ogical **Sci**ences 2014; 18: 2507-2517

# Qualitative motor assessment allows to predict the degree of motor disturbances

E. GAJEWSKA, M. SOBIESKA, J. MOCZKO[1]

Department of Rheumatology and Rehabilitation, University of Medical Sciences of Poznan, Poland
[1]Department of Computer Science and Statistics, University of Medical Sciences of Poznan, Poland

**Abstract. – OBJECTIVE: Early diagnosis is necessary in order to determine neurological integrity and the potential risk of improper development, and also to undertake possible early intervention. The quantitative assessment consists of observation of motor development, and provides information about whether a child performs an activity (movement) expected at a given life period. The qualitative assessment of motor performance verifies whether a specific activity is performed properly. The papers aims to demonstrate the motor performance assessment sheet for infants at the age of 6 months and assessment of qualitative elements of 3rd month at the age of 6 months.**

**SUBJECTS AND METHODS: 173 infants (76f/97m) were assessed by a neurologist and a physiotherapist at the age of 6 and 9 months. The neurologist set the final diagnosis at the age of 16 months. Additionally, the physiotherapist assessed qualitative elements typical of the 6th month and of the 3rd month. Risk factors possibly affecting motor performance were considered.**

**RESULTS: The assessment performed by the neurologist and the physiotherapist demonstrated high conformity. Infants with varying degrees of developmental delay and with cerebral palsy at the age of 6 months have still not achieved all of the qualitative characteristics typical of the 3rd month of life, nor proper performance for the 6th month. The low Apgar score and the presence of intraventricular haemorrhage affected the motor development at the age of 6 months.**

**CONCLUSIONS: The author's motor development assessment sheet applied at the age of 6 months proves to be a sensitive research tool and demonstrates good predictive value.**

*Key Words:*
Motor performance, Infant, Quality.

## Introduction

The observation of spontaneous motor development is an important part of the assessment of both healthy infants and those with positive medical history in the perinatal period, who were born prematurely. The quantitative assessment consists of observation of motor development, and provides information about whether a child performs an activity (movement) expected at a given life period. Currently available discriminative motor tests specifically assess quantitative measures in comparison with peers. Most of these tests are reliable and validated[1,2]; however, they only point out whether or not a child has performed the assessed activity. The qualitative assessment of motor performance verifies whether a specific activity is performed properly. In the literature, we find descriptions of motor tests that include certain aspects of quality development[1]. There are also tests that are considered to be fully qualitative, such as the Infant Motor Profile (IMP), Movement Assessment Battery for Children (MABS), and the Maastricht Motor Test (MMT)[3,4,5]. However, some of these tests are time consuming since they are based on video recording (IMP), while others are limited in the applicable age range[1]. The assessment of general movements (GM) presented by Prechtl[6] for the youngest children, i.e. in the first trimester of life, proved to be a very good predictive tool of further development. However, it is based on the observation of the repertoire of movement patterns of the entire body, and does not depict individual developmental characteristics such as, for instance, the position of the head, correct positioning of the forearms, the position of the hands or the observation of the pelvic alignment. Prechtl eet al[7] assessment technique distinguishes between children who need close monitoring and intervention and those who do not need it[7]. The GMs technique is a very sensitive diagnostic tool for the assessment of development, however it is impossible to plan a therapy on its basis.

The milestone achieved at the age of 6 months, which is visible during spontaneous motor behavior, is rotation and support. The performance of

*Corresponding Author:* Ewa Gajewska, MD; e-mail: ewagajewska1011@gmail.com

these activities calls for the selection of the most efficient postural adjustment in which all direction-specific neck, trunk and proximal leg muscles are activated, according to Hadders-Algra and Van Haastert et al[8,9]. This adjustment becomes possible at month 6, if the infant at the age of 3 months achieved the proper curvature of the spine, while the shoulder protraction and the anteversion of the pelvis were eliminated[10].

In the previous studies conducted by Gajewska and Sobieska, who analyzed the prospective development at the age of 2, 3, 6 and 9 months [In Press] it was demonstrated that the period between month 3 and 6 is an important stage in the development. Even if the development until that point was delayed, but there is improvement in the prone position, it is highly probable that the infant can achieve the proper level of motor development until the age of 9 months.

Screening is based on the assumptions that the emergence of motor skills follows the same sequence across infants and that the rate of motor development is constant and linear within an infant. The examination of motor development should be carried out both by physicians and physiotherapists, so that the captured irregularities could immediately be used as the starting point for the planned therapy.

However, it should be noted that the assessment and the associated diagnosis should not be based on a single observation. The study conducted by Darrah et al[11] clearly shows that the variability of the results of a single assessment carried out in 102 infants is high. The lack of stability of the assessment shows the limitations of early screening performed only once. As suggested by the authors, early, reliable diagnosis should be performed several times, it should be based on observations of spontaneous motor behavior[12] and it should refer to well-defined sets of characteristics[10] specified for a particular point in time (age), with particular attention drawn to the quantitative aspect (global = whether a particular activity is performed or not), but also to the qualitative one (proper shape of the spine, correct position of the elements of extremities relative to each other and full symmetry of movement)[10].

Following the above-mentioned assumptions, an examination was carried out based on the proposed motor development assessment sheet in infants at the age of 6 months.

At the age of 6 months, during spontaneous behavior, for the first time one can observe rotation from the back to the abdomen in supine position. In the prone position one can observe support on extended upper extremities with open palms and on thighs, which both form the support rectangle[13,14].

These two elements are global-quantitative patterns, and their occurrence is not sufficient to qualify an infant as showing proper motor performance. For the examination to be complete, according to our hypothesis, the quality of the performance of global patterns should be analyzed during the assessment. After the analysis of literature some elements necessary for the proper performance have been listed[10,13].

The aim of this study was to:

1. Demonstrate the reliability, sensitivity and the predictive value of the motor performance assessment sheet developed by the authors;
2. Investigate the relationship between the neurological assessment at the age of 6 months and the qualitative elements typical of 3rd month assessed at 6 months;
3. Indicate which risk factors affect the motor performance assessed at the age of 6 months.

## Subjects and Methods

A prospective study involving 173 infants, aged 6 months, was carried out and followed by the assessment at the age of 9 months with the final diagnosis provided by a neurologist at the age of 1 year. The study included 76 girls and 97 boys. The infants involved in the study reported to the Clinic of Neurology for a periodic assessment of the development with a referral from a general practitioner, a pediatrician or because of parents' concerns.

The group under investigation included only those infants who had no medical history of genetic or metabolic disorders or severe birth defects. Given the fact that motor development, at least with respect to purposeful movements of the upper extremities[15] is affected by the proper functioning of the senses and the proper mental development, a group of infants with no deficits or only with motor deficits was investigated for the purposes of this study. All subjects with genetic diseases, inborn defects, vision impairment, audition impairment, malformations, limb parts deficits or metabolic disorders were excluded.

On average infants in the investigated group were born at week 38 ± 2, the mean body weight was 3036 ± 756 g, the mean head circumference was 33 ± 2 cm, the mean body length was 52 ± 4 cm, the mean chest circumference was 32 ± 2 cm. There were 119 infants born at term and 54 born prematurely. The mean gestation age for this group was 34 ± 3 (min 25, max 37). The mean body weight for preterm children was 2136 ± 756 g. Prematurely born infants were assessed in their corrected age[16,17]. The investigated infants were not divided into groups according to whether they were born at term or prematurely as the studies conducted previously demonstrated no impact of this factor on the motor performance in the group with corrected age[10].

Risk factors that could affect motor development such as intraventricular hemorrhage (IVH) were analyzed.

In case of children with suspected IVH, brain sonography was performed immediately after birth and control assessment was performed at 3 and 6 months. In all other investigated children, for comparison, the brain sonography was also performed at 3 and 6 months, even if no risk factors were described in medical history. IVH was described in 16 preterm children: I in seven, II in seven and III in two children. IVH was also described in nine children born at term (I in six, III in two and IV in one child).

Further analyzed factors encompassed: Apgar score at 5, 10 minutes, the presence of respiratory distress syndrome (RDS), intrauterine hypotrophy, hyperbilirubinemia based on medical history, after consulting a neurologist and/or a neonatologist.

The examination was performed at the Clinic of the Greater Poland Center for Child and Adolescent Neurology in Pozna and the Child Clinic in Bydgoszcz in the years 2011-2013.

Informed consent was obtained from all parents or care-givers of the subjects and the study was approved by the Research Ethics Committee of Poznan University of Medical Sciences and registered under no. 22/10 (07-01-2010). It conformed to all ethical issues included in the Helsinki Declaration.

### Procedures

The neurologist and the physiotherapist performed the global assessment of the motor development in all infants at the age of 6 and 9 months. At the age of 9 months the neurologist pointed at infants with evolving cerebral palsy (CP) or delay in motor development. The final diagnosis was made later, at the age of 12 months, and the maximum achieved motor performance was assessed. The last available assessment was performed in 16$^{th}$ month and the diagnosis of CP was confirmed.

According to the opinion of neurologists the diagnosis of CP was made as follows: hypertony/hypotony, spontaneous motor behavior, reflexes, brain sonography and MRI if brain sonography result was suspected, follow-up observation, checking the motor development and alterations of motor behavior with age[18].

The examination was carried out independently and at the same time. The only information provided to both investigators was whether an infant was born at term or prematurely, for the purpose of calculating the corrected age. They were not aware of the infant's clinical history details or the parallel opinion.

### Physician's Assessment

The neurologist performed a comprehensive neurological examination. The examination was carried out in accordance with the procedures previously presented by Gajewska and Sobieska[10] based on the Denver Development Screening Test II (DDST II)[19,20] and the assessment of the reflexes, hypotonia/hypertonia, and symmetry. The DDTS II was used to check all areas, but in the examination two of them were used: fine motor skills, locomotion and postural coordination/gross motor skills.

After conducting the examination neurologists classified an infant into one of three groups: normal (no neurological abnormalities), suspected (not requiring rehabilitation – for observation) and abnormal. An infant was classified as abnormal if he or she exhibited clear neurological disorders, such as increased (hypertonia) or decreased (hypotonia) muscle tone accompanied by abnormal reflexes and failure to perform tasks in the area of motor skills for a given age group in the DDST II test. An infant was classified into the suspected group – not requiring rehabilitation – for observation if he or she exhibited mild symptoms of neurological disorders, such as mild muscle tone regulation disorders, slight reflex dysfunction, minor developmental asymmetry and a delay in the area of motor skills in the DDTS II test.

### Global Physiotherapeutic Assessment (Quantitative) Using the Motor Development Assessment Sheet

The global assessment at the age of 6 months in supine position involves the assessment of the rotation from the back to the abdomen in supine position, while in the prone position the support on extended upper extremities with open palms and on thighs, which both form the support rectangle, is assessed (Table I).

**Table I.** Inter- and intraobserver conformity of the motor performance in 6th month of life, according to the suggested assessment sheet.

| Physiotherapeutic assessment | Interobserver | Intraobserver |
|---|---|---|
| Quantitative assessment in prone position: support on palms and thighs | 0.994 | exact p 2-sided =1 |
| Qualitative assessment in prone position | | |
| R palm support | 1.000 | exact p 2-sided =1 |
| L palm support | 0.944 | exact p 2-sided =1 |
| R palm extended | 1.000 | exact p 2-sided =1 |
| L palm extended | 0.942 | exact p 2-sided =1 |
| R metacarpal bones abducted | 0.936 | exact p 2-sided =1 |
| L metacarpal bones abducted | 0.870 | exact p 2-sided =1 |
| Quantitative assessment in supine position: rotation from the back to the abdomen | 1.000 | exact p 2-sided =1 |
| Qualitative assessment in supine position | | |
| R side shoulder and thigh loading | 1.000 | exact p 2-sided =1 |
| L side shoulder and thigh loading | 1.000 | exact p 2-sided =1 |
| R the lower extremity at the facial side is extended, it is flexed at the occipital side | 1.000 | exact p 2-sided =1 |
| L the lower extremity at the facial side is extended, it is flexed at the occipital side | 1.000 | exact p 2-sided =1 |

### *Detailed Physiotherapeutic Assessment (Qualitative) Using the Motor Development Assessment Sheet*

The physiotherapist carried out an additional assessment of individual qualitative elements at month 6 (based on the literature)[13,14,21] observed in supine and prone positions specified for month 6. Six elements in the prone position and four elements in the supine position were verified (Table I).

The assessment of the quality of the support involves: the support on extended upper extremities with unfolded palms supported on the surface, with metacarpal bones in abduction and the alignment of the middle finger along the shoulder line. The upper part of the body is raised above the surface, the weight of the body rests symmetrically on the thighs, the lower extremities lie in an intermediate position on the surface.

The quality of the global pattern of rotation involves the following elements: equally frequent rotation both ways, loading of the shoulder and the thigh at the facial side performed in the same way and the assessment of the movement of the lower extremities during rotation: the lower extremity at the facial side begins to extend smoothly and the one at the occipital side is flexed.

Possible assessment score 0 – test performed only partially or completely incorrectly, 1 – test performed completely correctly. According to the above-mentioned assessment, conducted by the physiotherapist, the infants were classified into the following groups: developing properly (correct) or requiring rehabilitation (incorrect). Only the maximum qualitative assessment (score 6 in the prone position and score 4 in the supine position) allowed to qualify an infant into the “correct” group. Even correct global assessment (quantitative), but the incomplete qualitative assessment, qualified an infant into the “incorrect” group. The duration of the examination performed by the physiotherapist was between 10 and 15 minutes. Each assessed element had to be observed at least three to four times during the test.

In addition, at the 6th month of life the physiotherapist carried out an examination which involved the assessment of qualitative characteristics typical of the 3rd month of life, which were considered the basis for the proper motor development[10] (Appendix 1). This assessment involves 15 elements assessed in the prone position and 15 elements in the supine position. Each element was assessed as 0 – test performed only partially or completely incorrectly, 1 – test performed completely correctly.

Each time the assessment performed by the physiotherapist was compared with the diagnosis made by the neurologist (concurrent validity).

The analysis involved the evaluation of the conformity of the assessment of motor development at the age of 6 months between researchers in a group of 48 infants (the interobserver examination) using the motor development assessment sheet developed by the author. The examination

**Appendix 1.**

| | | |
|---|---|---|
| Infant: 3 months old, PRONE POSITION. | | |
| Sum of the qualitative characteristics | **Yes** | **No** |
| HEAD: | | |
| 1. Isolated head rotation | | |
| SHOULDERS AND UPPER LIMBS: | | |
| 2. Arm in front, forearm in intermediate position, elbow outside of the line of the shoulder (R) | | |
| 3. Arm in front, forearm in intermediate position, elbow outside of the line of the shoulder (L) | | |
| 4. Palm loosely open (R) | | |
| 5. Palm loosely open (L) | | |
| 6. Thumb outside (R) | | |
| 7. Thumb outside (L) | | |
| SPINE AND PELVIS | | |
| 8. Spinal cord segmentally in extension | | |
| 9. Scapula situated in medial position (R) | | |
| 10. Scapula situated in medial position (L) | | |
| 11. Pelvis in intermediate position | | |
| LOWER LIMBS | | |
| 12. Situated loosely on the substrate (R) | | |
| 13. Situated loosely on the substrate (L) | | |
| 14. Foot in intermediate position (R) | | |
| 15. Foot in intermediate position (L) | | |
| *Maximum of 15 points for qualitative characteristics.* | | |
| Infant: 3 months old, SUPINE POSITION | | |
| Sum of the qualitative characteristics: | **Yes** | **No** |
| 1. Head symmetry | | |
| 2. Spinal cord in extension | | |
| 3. Shoulder in balance between external and internal rotation (R) | | |
| 4. Shoulder in balance between external and internal rotation (L) | | |
| 5. Wrist in intermediate position (R) | | |
| 6. Wrist in intermediate position (L) | | |
| 7. Thumb outside (R) | | |
| 8. Thumb outside (L) | | |
| 9. Palm in intermediate position (R) | | |
| 10. Palm in intermediate position (L) | | |
| 11. Pelvis extended (no anteversion and retroversion) | | |
| 12. Lower limb situated in moderate external rotation (R) | | |
| 13. Lower limb situated in moderate external rotation (L) | | |
| 14. Lower limb bent at a right angle at hip and knee joints, foot in intermediate position – lifting above the ground (R) | | |
| 15. Lower limb bent at a right angle at hip and knee joints, foot in intermediate position – lifting above the ground (L) | | |
| *Maximum of 15 points for qualitative characteristics* | | |

was carried out independently by two physiotherapists on the same day and the results were kept blinded until the final statistical analysis (Table I). The intraobserver part was done by comparing direct observations with the outcome of video footage analysis, on 30 infants at 6$^{th}$ month. The observer was blind with respect to the clinical status of the infants. Interobserver conformity was assessed by weighted kappa with linear weights (Medcalc Statistical Software, version 13.1.0; Ostend, Belgium). Intraobserver conformity was assessed by Wilcoxon test (paired samples) and in case of observed differences exact estimation of p-value was performed using STATXACT software.

## Statistical Analysis

A statistical analysis of the results was performed by means of the following tests:

- Mann-Whitney test with correction for tied ranks (for comparisons between two groups of measurements made on the ordinal scale of the free data scheme),
- Kruskal-Wallis test for multiple comparisons of the post-hoc type by Dunn (for comparisons between a larger number than two measurement groups, carried out on the ordinal scale of the free data scheme),
- Chi-square test according to Pearson (for comparisons of two or more groups of measurements made on the nominal scale).

The StatSoft, Inc. (2011) software package was used for the calculations. STATISTICA (data analysis software system), version 10.

In case of the Chi-square test, when Cochran's conditions regarding the expected cell count were not satisfied, the exact (and not the asymptotic) statistic value was determined using permutation algorithms included in the STATXACT package, version 10.0.0 by Cytel Software Corporation. $p < 0.05$ was considered to be statistically significant.

## Results

A comparison of the motor development assessment carried out by the neurologist and the physiotherapist at 6th month was made and statistically significant conformity was demonstrated (z= -5.72483, $p < 0.001$) (Table II). Positive assessment was concordant in 82.5% (66/80 children), whereas negative in 96% (89/93 children). Physiotherapeutic assessment was "correct" if a child showed properly all investigated elements of the motor performance, listed in the assessment sheet, as described in the methodology.

Children described as normal by the neurologist and assessed as correct by the physiotherapist (with no risk factors nor abnormalities mentioned in the medical history) may be regarded as healthy controls (n=66). This group achieved maximum in all assessment aspects. In this group 24 children were born below 38 week of gestation (starting at 28 gestation week), but assessed in the corrected age they also showed maximum according to the assessment sheet. Thus the final "control group" of absolutely healthy children would consist of 42, and all achieved maximum in the assessment sheet.

The neurologist carried out the assessment of the investigated group at the age of 9 months (referred later as max at nine months) and distinguished infants developing properly, with slight delay (development assessed as typical of 7-8 months), with significant delay (development assessed as typical of the age of 6 months) and with very significant delay (development assessed as typical of below the age of 6 months). In the final assessment infants with cerebral palsy (CP) were also selected. In the investigated group the motor development in 102 infants at the age of 9 months was assessed as normal, in 43 as slightly delayed, in 14 infants the development was assessed as significantly delayed, while five infants manifested very significant delay.

The final diagnosis of CP was confirmed in 9 infants at the age of 16th month.

Depending on the neurological assessment (max at nine months) an analysis of the results of the quantitative and qualitative assessment of development using the author's motor development sheet for the age of 6 months and of the qualitative characteristics at the age of 3 months was made (Table III). Improper performance of qualitative elements typical of month 3 at the age of 6 months indicates varying degrees of motor disorders. None of the infants, who were ultimately diagnosed with CP, performed the qualitative elements typical of the age of 3 months at the age of 6 months properly. Based on the performance of more than 11 out of 15 elements in the prone position and 12 out of 15 elements in the supine position one can expect that at the age of 9 months an infant may manifest a slight motor development delay at most.

We also analyzed the results of the physiotherapeutic assessment of the qualitative characteristics typical of month 3 (prone and supine positions) conducted at the age of 6 months in rela-

**Table II.** Comparison of the physiotherapeutic and neurological assessment at the age of 6 months.

| Neurological assessment | Physiotherapeutic assessment correct | Physiotherapeutic assessment incorrect | Total |
|---|---|---|---|
| Normal | 66 | 14 | 80 |
| Suspected | 2 | 34 | 36 |
| Abnormal | 2 | 55 | 57 |
| Total | 70 | 103 | 173 |

**Table III.** The final neurological assessment compared with the quantitative and qualitative assessment of motor performance at month 6 and of quality characteristics typical of the age of 3 months. The number of infants who failed to execute or who executed a given element (0/1) was provided.

| **Elements 0/1 (R- right, L- left)** | | | **The entire group n=173** | **CP N=9** | **Very significant delay (under the age of 6 months)** | **Significant delay (6 months) N=14** | **Slight delay (7-8 months) N=43** | **Normal development N=102** | **H test with p<0.001** |
|---|---|---|---|---|---|---|---|---|---|
| Quantitative assessment at the age of 6 months in prone position | | | 87/86 | 9/0 | 5/0 | 12/2 | 36/7 | 25/77 | 68.88 |
| Quantitative assessment at the age of 6 months in supine position | | | 60/113 | 7/2 | 5/0 | 8/6 | 24/19 | 16/89 | 44.37 |
| Qualitative elements typical of the age of 6 months in prone position | R palm support | | 84 /89 | 9/0 | 5/0 | 12/2 | 34/9 | 24/78 | 63.80 |
| | L palm support | | 85/88 | 9/0 | 5/0 | 12/2 | 35/8 | 24/78 | 66.26 |
| | R palm extended | | 77/96 | 9/0 | 5/0 | 12/2 | 34/9 | 17/85 | 79.42 |
| | L palm extended | | 78/95 | 9/0 | 5/0 | 12/2 | 35/8 | 17/85 | 82.07 |
| | R metacarpal bones abducted | | 64/109 | 9/0 | 5/0 | 9/5 | 27/16 | 14/88 | 63.91 |
| | L metacarpal bones abducted | | 64/109 | 9/0 | 5/0 | 9/5 | 27/16 | 14/88 | 63.91 |
| Qualitative elements typical of the age of 6 months in supine position | R side shoulder and thigh loading | | 67/106 | 8/1 | 5/0 | 9/5 | 25/18 | 20/82 | 43.59 |
| | L side shoulder and thigh loading | | 67/106 | 7/2 | 5/0 | 9/5 | 26/17 | 20/82 | 41.58 |
| | R the lower extremity at the facial side is extended, it is flexed at the occipital side | | 68/105 | 9/0 | 5/0 | 9/5 | 25/18 | 20/82 | 47.98 |
| | L the lower extremity at the facial side is extended, it is flexed at the occipital side | | 68/105 | 8/1 | 5/0 | 9/5 | 26/17 | 20/82 | 47.98 |
| Overall qualitative assessment in the prone position at the age of 6 months | | Median; quartile: lower Q=25, | 4<br>0-6 | 0<br>0-0 | 0<br>0-0 | 0<br>0-2 | 0<br>0-2 | 6<br>6-6 | 77.12 |
| Overall qualitative assessment in the supine position at the age of 6 months | | | 4<br>0-4 | 0<br>0-0 | 0<br>0-0 | 1<br>0-2 | 0<br>0-4 | 4<br>4-4 | 49.65 |
| Overall qualitative assessment of elements typical of the age of 3 months in the prone position at the age of 6 months | | | 15<br>12-15 | 0<br>0-2 | 0<br>0-13 | 13<br>11-15 | 15<br>12-15 | 15<br>15-15 | 50.75 |
| Overall qualitative assessment of elements typical of the age of 3 months in the supine position at the age of 6 months | | | 15<br>13-15 | 0<br>0-3 | 0<br>0-11 | 13<br>12-15 | 15<br>14-15 | 15<br>15-15 | 60.85 |

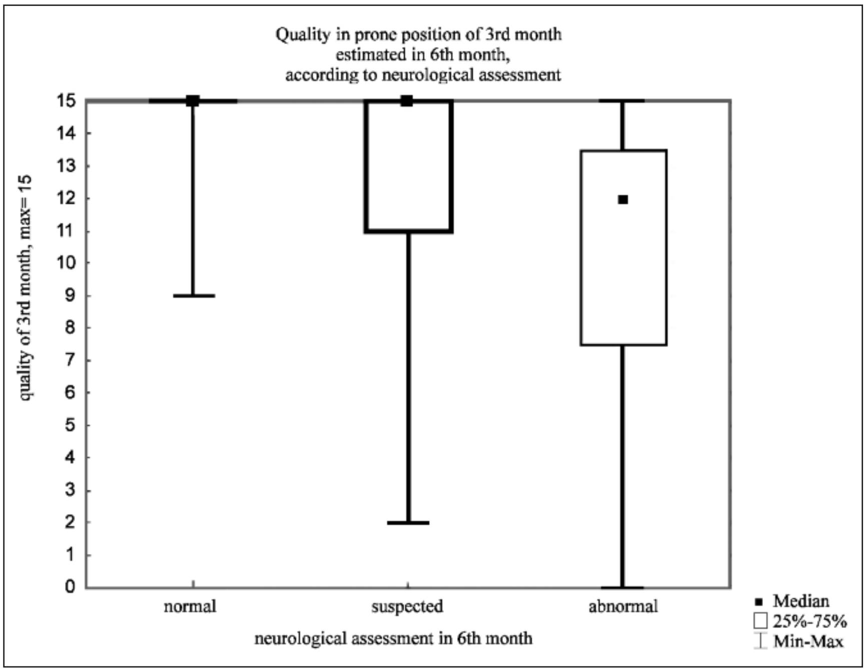


**Figure 1.** Elements of quality assessment in the prone position of 3rd month estimated in 6th month, according to the neurological assessment.

tion to the neurological assessment conducted at the age of 6 months (Figures 1, 2). The assessment of qualitative characteristics in the prone position demonstrated greater conformity with the neurological assessment.

The assessment of the risk factors demonstrated the impact of Apgar score (at the 5th and 10th minute) and the occurence of IVH on the motor development of infants at the age of 6 months (Table IV).

According to the Apgar score in the 5th minute the infants were divided into the following groups: born in good condition (the score was 8-10, n= 158) and in semi-severe condition (4-7 points, n=15). In the 10th minute all infants were classified as 9-10 points. None of the infants in the investigated group were born in severe condition.

There was no correlation between the respiratory distress syndrome (n= 19), the occurrence of intrauterine hypotrophy (n=10), hyperbilirubinemia

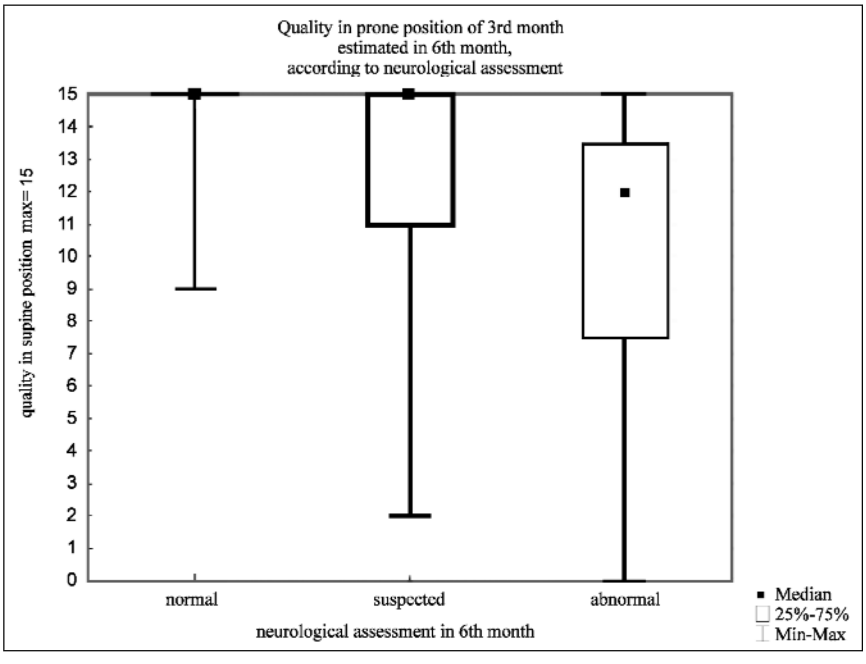


**Figure 2.** Elements of quality assessment in the supine position of 3rd month estimated in 6th month, according to the neurological assessment.

**Table IV.** The impact of IVH and the Apgar scale values on the assessment of motor performance.

| Elements of the performance assessment | Apgar scores in the 5th minute of life (median; quartiles Q = 25, Q = 75) Apgar4-7 n = 15 vs. Apgar8-10 n=158 | *p* = | | Intraventricular haemorrhage (median; quartiles Q = 25, Q = 75) IVH n = 25 vs. absence of IVH n =148 | *p* = | |
|---|---|---|---|---|---|---|
| Qualitative assessment in the prone position at the age of 6 months | 0 (0-6) | 0.019 | 6 (6-0) | 0 (0-6) | 0.031 | 6 (0-6) |
| Qualitative assessment in the supine position at the age of 6 months | 0 (0-2) | 0.001 | 4 (0-4) | 0 (0-4) | 0.036 | 4 (0-4) |
| Qualitative assessment of elements typical of the age of 3 months in the prone position at the age of 6 months | 11 (0-15) | 0.001 | 15 (12-15) | 12 (5-15) | 0.004 | 15 (13-15) |
| Qualitative assessment of elements typical of the age of 3 months in the supine position at the age of 6 months | 13 (0-15) | 0.000 | 15 (15-15) | 15 (9-15) | 0.022 | 15 (14-15) |

(n=26) and the severity of IVH (IVH I n=13, II n=7, III n=5 and IV n=1) and the assessment of motor performance at the age of 6 months.

## Discussion

Gajewska et al[10] in her report, while assessing the prospective development of infants at the age of 3 months, demonstrated that the qualitative assessment is a more accurate predictor of further normal or abnormal motor development than merely the global assessment. Similar results were obtained in the present research while investigating infants' performance at the age of 6 months using the motor development assessment sheet.

The study shows that the quantitative (global) assessment conducted at the age of 6 months, both in the prone and supine positions, clearly differentiates between infants developing normally from those with severe motor developmental disorders, though it fails to differentiate between the degrees of developmental delay. Only a detailed qualitative assessment allows us to predict the possible delay in motor development with greater accuracy.

Having analyzed individual qualitative characteristics in the prone and supine positions at the age of 6 months it can be concluded that a closer relationship between the assessment in the prone position and the ultimate level of motor performance can be observed. It turned out that the highest value of the H test was obtained for the unfolded palm characteristic, and this activity depends on the proper proximal characteristics, i.e. the extension of the upper extremities. In studies of infants at the age of 2 and 3 months the distal characteristics related to palms and feet seemed not to be useful from the point of view of the prognostic assessment [in press]. Support at the age of 6 months, without the proper position of the shoulders and arms, is impossible, even if the correct position of the palm was assumed previously. Thus, the proximal characteristics are the determinants of proper motor development.

From the prognostic point of view, support seems to be of definitely greater importance than rotation, which is further confirmed by the analysis of infants with diplegic and hemiplegic CP, who managed to perform rotation but failed to execute support. This may be due to the absence of spine extension, i.e. incomplete cranio-caudal development, which should have occurred at the age of 3 months[22].

Many authors have proven that the 3$^{rd}$ month of life is crucial to the further proper development[10,13,21]; therefore, this study also included the assessment of qualitative elements typical of the age of 3 months[10]. In the final assessment it has been shown that infants with varying degrees of developmental delay and with cerebral palsy at the age of 6 months have still not achieved all of the qualitative characteristics typical of the 3$^{rd}$ month of life. Given this analysis it is possible to indicate the elements that disrupt the development of higher motor functions (support, rotation), and thus to plan a therapy with very high accuracy. It also makes it possible to trace the progress of the development in the course of ongoing exercises, and thus to prove the efficiency of the Vojta or NDT therapy used worldwide. According to Blauw-Hospers and Hadders-Algra[23] very little is known regarding the effectiveness of the NDT or Vojta therapy due to the relatively insensitive diagnostic tools.

The analysis of risk factors is of importance in the assessment of motor development[24]. The Apgar score is used in medicine for the assessment of the condition of a neonate and to predict its further development[15]. It is not only the low value in the first minute after birth, but also the continued low score in the 5$^{th}$ minute of life that increases the likelihood of the occurrence of problems in the further development of an infant[26]. In our study it was demonstrated that infants born in semi-severe condition manifested greater problems with motor performance than those born in good condition.

The conclusion from our study is that the occurrence of intraventricular haemorrhage negatively affects motor development. We analyzed the severity of intraventricular haemorrhage, but due to the fact that the groups under investigation were very small and manifested varying degrees of bleeding, no statistical relationship was demonstrated.

It was shown that the presence of hyperbilirubinemia, the respiratory distress syndrome and intrauterine hypotrophy did not affect motor development. Similar conclusions were presented in the study by Eickmann et al[27] who analyzed the factors that affect the psychomotor development of infants aged 6-12 months.

The proposed assessment sheet showed differences between children developing properly, with minor motor deficits and major disturbances. It is easy to use and concordant with the neurological assessment. It may also serve as a starting point for therapy planning.

## Conclusions

The author's motor development assessment sheet applied at the age of 6 months proves to be a sensitive research tool and demonstrates good predictive value.

Improper performance of qualitative elements typical of month 3 at the age of 6 months indicates varying degrees of motor disorders.

The values on the Apgar scale and the presence of intraventricular haemorrhage (IVH) affect the motor development at the age of 6 months.

### Ethics Statement

Informed consent was obtained from all of the subjects and the study was approved by the Research Ethics Committee of Poznan University of Medical Sciences and registered under no. 22/10 (07-01-2010). It conformed to all ethical issues included in the Helsinki declaration.

### Acknowledgements

The authors thank dr Piotr Jakubowski for the language assistance provided in the preparation of this paper.

### Competing of Interest

The study was conducted under a research grant of the Ministry of Science and Higher Education KBN N N404269639.

### Conflict of Interest Stetement

The authors declare no conflicts of interest.

## References

1) Janssen AJ, Diekema ET, van Dolder R, Kollée LA, Oostendorp RA, Nijhuis-van der Sanden MW. Development of a movement quality measurement tool for children. Phys Ther 2012; 4: 574-594.
2) Westcott McCoy S, Bowman A, Smith-Blockley J, Sanders K, Megens AM, Harris SR. Harris Infant Neuromotor Test: comparison of US and Canadian normative data and examination of concurrent validity with the Ages and Stages Questionnaire. Phys Ther 2009; 2: 173-180.
3) Smits-Engelsman BC, Fiers MJ, Henderson SE, Henderson L. Interrater reliability of the Movement Assessment Battery for Children. Phys Ther 2008 2: 286-294.
4) Kroes M , Vissers YL, Sleijpen FA, Feron FJ, Kessels AG, Bakker E, Kalff AC, Hendriksen JG, Troost J, Jolles J, Vles JS. Reliability and validity of a qualitative and quantitative motor test for 5- to 6-year-old children. Eur J Paediatr Neurol 200; 3: 135-143.
5) Heineman KR, Bos AF, Hadders-Algra M. The Infant Motor Profile: a standardized and qualitative method to assess motor behavior in infancy. Dev Med Child Neurol 2008; 4: 275-282.
6) Prechtl HRF. Qualitative changes of spontaneous movements in fetus and preterm infant are a marker of neurological dysfunction. Early Hum Dev 1990; 3: 151-158.

7) PRECHTL HRF, EINSPIELER C, CIONI C, BOS AF, FERRARI F, SONTHEIMER D. An early marker for neurological deficits after perinatal brain lesions. Lancet 1997; 10: 1361-1363.

8) VAN HAASTERT IC, GROENENDAAL F, VAN DE WAARSENBURG MK, EIJSERMANS MJ, KOOPMAN-ESSEBOOM C, JONGMANS MJ, HELDERS PJ, DE VRIES LS. Active head lifting from supine in early infancy: an indicator for non-optimal cognitive outcome in late infancy. Dev Med Child Neurol 2012; 6: 538-543.

9) HADDERS-ALGRA M. The neuronal group selection theory: promising principles for understanding and treating develop- mental motor disorders. Dev Med Child Neurol 2000; 10: 707-715.

10) GAJEWSKA E, SOBIESKA M, KACZMAREK E, SUWALSKA A, STEINBORN B. Achieving motor development milestones at the age of three months may determine, but does not guarantee, proper further development. Scientific World Journal 2013; 9. Published online.

11) DARRAH J, HODGE M, MAGILL-EVANS J, KEMBHAVI G. Stability of serial assessments of motor and communication abilities in typically developing infants – implications for screening. Early Hum Dev 2003; 2: 97-100.

12) EINSPIELER C, PRECHTL HFR, BOS AF, FERRARI F, CIONI G. Prechtl's method on the qualitative assessment of general movements in preterm, term and young infants. Clinics in Developmental Medicine, Mac Keith Press Cambridge, 2004.

13) VOJTA V, PETERS A. The Vojta Principle. Springer-Verlag, 2007.

14) PIN TW, DARRER T, ELDRIDGE B, GALEA MP. Motor development from 4 to 8 months corrected age in infants born at or less than 29 weeks' gestation. Dev Med Child Neurol ; 9; 739-745.

15) GAJEWSKA E, SOBIESKA M, SAMBORSKI W. Associations between manual abilities, gross motor function, epilepsy and mental capacity in children with cerebral palsy. Iran J Child Neurol 2014; 8: 45-52.

16) NUYSINK IJ, VAN HAASTERT IC, EIJSERMANS MJ, KOOPMAN-ESSEBOOM C, HELDERS PJ, DE VRIES LS, VAN DER NET J. Prediction of gross motor development and independent walking in infants born very preterm using the Test of Infant Motor Performance and the Alberta Infant Motor Scale. Early Hum Dev 2013; 89: 693-697.

17) RESTIFFE AP, GHERPELLI JL. Comparison of chronological and corrected ages in the gross motor assessment of low-risk preterm infants during the first year of life. Arq Neuropsiquiatr 2006; 64: 418-425.

18) SURVEILLANCE OF CEREBRAL PALSY IN EUROPE: a collaboration of cerebral palsy surveys and register. Dev Med Child Neurol 2000; 42: 816-824.

19) LENZAK J, MICHAŁOWICZ R. Test Denver orientacyjny test psychoruchowego rozwoju dziecka [in Polish] Problemy Medycyny Wieku Rozwojowego 1973; 3: 47-76.

20) DRACHLER MDE L, MARSHALL T, DE CARVALHO LEITE JC. A continuous-scale measure of child development for population-based epidemiological surveys: a preliminary study using Item Response Theory for the Denver Test. Paediatr Perinat Epidemiol 2007; 21: 138-153.

21) HADDERS-ALGRA M. General movements: a window for early identification of children at high risk of developmental disorders. J Pediatr 2004; 145: 12-18.

22) DUSING SC, KYVELIDOU A, MERCER VS, STERGIOU N. Infants born preterm exhibit different patterns of center-of-pressure movement than infants born at full term. Phys Ther 2009; 89: 1354-1362.

23) BLAUW-HOSPERS CH, HADDERS-ALGRA M. A systematic review of the effects of early intervention on motor development. Dev Med Child Neurol 2005; 47: 421-432.

24) BOS AF, VAN BRAECKEL KN, HITZERT MM, TANIS JC, ROZE E. Development of fine motor skills in preterm infants. Dev Med Child Neurol 2013; 55: 1-4.

25) BASKETT TF. Virginia Apgar and the newborn Apgar score. Resuscitation 2000; 47: 215-217.

26) MOSTER D, LIE RT, IRGENS LM, BJERKEDAL T, MARKESTAD T. The association of Apgar score with subsequent death and celebral palsy: a population-based study in term infants. J Pediatr 2001; 138: 798-803.

27) EICKMANN SH, MALKES NF, LIMA MDE C. Psychomotor development of preterm infants aged 6 to 12 months. Sao Paulo Med J 2012; 130: 299-306.