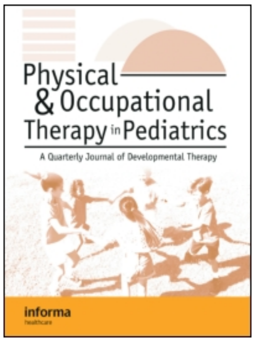
Intra- and Inter-Rater Reliability of the Infant Motor Profile in Infants in Primary Health Care

Tveten, Kine Melfald; Hadders-Algra, Mijna; Strand, Liv Inger; Van Iersel, Patricia Anna Maria; Rieber, Jannike; Dragesund, Tove

Published in:
Physical & occupational therapy in pediatrics

DOI:
10.1080/01942638.2020.1720331

Publication date:
2020



Taylor & Francis
Taylor & Francis Group

Physical & Occupational Therapy In Pediatrics

ISSN: 0194-2638 (Print) 1541-3144 (Online) Journal homepage: https://www.tandfonline.com/loi/ipop20

Intra- and Inter-Rater Reliability of the Infant Motor Profile in Infants in Primary Health Care

Kine Melfald Tveten, Mijna Hadders-Algra, Liv Inger Strand, Patricia Anna Maria Van Iersel, Jannike Rieber & Tove Dragesund

PHYSICAL & OCCUPATIONAL THERAPY IN PEDIATRICS
https://doi.org/10.1080/01942638.2020.1720331

Taylor & Francis
Taylor & Francis Group

Intra- and Inter-Rater Reliability of the Infant Motor Profile in Infants in Primary Health Care

Kine Melfald Tveten[c], Mijna Hadders-Algra[b], Liv Inger Strand[a], Patricia Anna Maria Van Iersel[b], Jannike Rieber[c], and Tove Dragesund[a]

[a]Department of Global Public Health and Primary Care, University of Bergen, Bergen, Norway; [b]University Medical Center Groningen Developmental Neurology, University of Groningen, Groningen, GZ, The Netherlands; [c]Children's Physiotherapy Center and Turbo, Bergen, Norway

ABSTRACT

Aim: To explore intra-rater and inter-rater reliability of the Infant Motor Profile (IMP). The IMP is a video-based method assessing movement quality (movement variation, adaptability, symmetry and fluency) and motor skills in infants aged 3 to 18 months.
Method: The IMP assessment was performed on 50 infants aged 3 to 12 months recruited in connection with health control in primary health care, mean gestational age at birth 39.4 weeks, mean birthweight 3462 g. Seven infants had a moderately increased risk of developmental disorders. Three pediatric physiotherapists performed independent rating of the video recordings. One rater assessed the video recordings twice with a four-week interval.
Results: Intraclass correlation coefficient (ICC) for intra-rater reliability was found satisfactory for the total IMP score (ICC = 0.95), and the domains: performance (ICC = 0.98), variation (ICC = 0.74), adaptability (ICC = 0.93) and fluency (ICC = 0.86). The ICC value for symmetry was 0.65. For inter-rater reliability, ICC values were satisfactory for the total IMP score (ICC = 0.86-0.91), and the domains: performance (ICC = 0.98), variation (ICC = 0.71-0.82), adaptability (ICC = 0.99) and fluency (ICC = 0.82-0.81). The ICC values for symmetry varied between 0.13-0.35.
Conclusion: In this sample, including mostly low-risk infants, satisfactory intra- and inter-rater reliability for all domains were demonstrated, except for symmetry.

Abbreviations: IMP: Infant Motor Profile

ARTICLE HISTORY
Received 11 May 2019
Accepted 19 January 2020

KEYWORDS
Infant motor development; Infant Motor Profile; motor assessment; primary health care; reliability

Impaired motor function is a major hallmark of childhood developmental disabilities such as cerebral palsy, minor neurological dysfunction and developmental coordination disorder (Rosenbaum et al., 2007). As developmental disabilities originate during early life, early intervention programs have been developed to prevent or limit the sequelae of these disorders and to improve functional outcome. The effect of early intervention stimulating motor function is supported by scientific evidence (Lekskulchai & Cole, 2001; McIntyre, Morgan, Walker, & Novak, 2011; Spittle, Orton, Anderson, Boyd, &

CONTACT Kine Melfald Tveten kint@hvl.no Department of Global Public Health and Primary Care, University of Bergen, Kalfarveien 31, 5018 Bergen, Norway.

Doyle, 2012; Ziviani, Feeney, Rodger, & Watter, 2010). In order to facilitate such intervention, there is a need for reliable, valid and responsive tools for early detection of children at risk of developmental motor impairments (Spittle et al., 2012).

Existing tools that assess infant motor development vary with the age of the child and have been based upon different theoretical constructs (Spittle, Doyle, & Boyd, 2008). Available measurement tools can be time consuming, require specific and expensive equipment (Bayley, 2006), or can only be used during a short age span (Campbell, 2012; Hadders-Algra, 2018). Additionally, most measurement tools have focused primarily on the achievement of motor milestones (Chandler & Swanson, 1980; Piper & Darrah, 1994) and less on quality, variation, adaptability and fluency of the children's motor behavior. However variation in motor behavior is a good predictor of the child's developmental outcome (Hadders-Algra, 2018; Heineman, Bos, & Hadders-Algra, 2011) and selection of the appropriate strategy within the motor behavior is considered a marker of the integrity of the infant's brain (Hadders-Algra, 2010, 2018). Furthermore, loss of movement fluency is also a sign of a non-optimal neurological condition (Hadders-Algra et al., 2004).

Infant Motor Profile

The Infant Motor Profile (IMP) (Heineman, Bos, & Hadders-Algra, 2008) is a novel tool assessing motor development in typically and atypically developing infants. The age span is 3 to 18 months or - in infants with developmental delay - until the infant has experienced independent walking for a few months. Use of the instrument is intended for pediatric health care professionals who are experienced in assessing infant motor development. The IMP is based on a 15-minute video recording of self-produced motor behavior. The infant is observed and played with whilst supine, prone, sitting, standing, walking, and during reaching and grasping, all depending on the age and functional level of the infant. The IMP consists 80 items distributed over five domains: variation (25 items, two-point scales), adaptability (15 items, two-point scales), symmetry (10 items, three-point scales), fluency (7 items, two-point scales) and performance (23 items, two to seven point scales). A higher score indicates a more optimal motor behavior; for instance in symmetry, which has a three-point scale, the scoring is 1 for strong asymmetry, 2 for moderate asymmetry, and 3 for mild or no asymmetry. The items were first described in a paper by Heineman et al. (2008) and in a working manual by Hadders-Algra and Heineman. Over the years the working manual underwent minor changes in response to user comments. The final manual will be published at the end of 2020 or the beginning of 2021.

The construction of the IMP implies that it covers three traditional domains; symmetry, fluency and performance, and two novel domains; variation and adaptability. The latter two domains are based on principles of the Neuronal Group Selection Theory (NGST). The NGST explains motor development as a result of a complex interaction between genetic information and the environment, thus influenced by both nature and nurture. The tremendous amount of neurons and neuronal connections in the brain give rise to a large repertoire of motor behavior in the young infant. Subsequently, through self-produced motor behavior, trial and error, the infant will select the most appropriate motor strategies from its developed repertoires, adapting its motor behavior to the situation (Hadders-Algra, 2000a).

Little equipment is needed to conduct the IMP assessment: a thin mattress on the floor, a video camera on a tripod, a small table or chair allowing for pull-to-stand, toys like balls, rings, cars, puppets and a chair for the parents. Technical instructions and definitions are provided in the IMP-manual. Regarding psychometric properties, studies in high-risk samples have reported satisfactory inter- and intra-rater reliability, although reliability values varied across domains and studies (Hecker, Baer, Stark, Herkenrath, & Hadders-Algra, 2016; Heineman et al., 2008; Heineman et al., 2013).

The test developers reported in their first study ($n = 38$) a strong inter-rater agreement (r_s=0.90) for the total IMP score as well as for the domains adaptability and performance, but moderate for variation and fluency and weak for symmetry (r_s=0.40). Intra-rater reliability was also strong for the total IMP score and the domains adaptability, performance and variation, and moderate for fluency and symmetry (Heineman et al., 2008). Inter-rater reliability was also investigated in two smaller studies (Hecker et al., 2016; Heineman et al., 2013). They reported strong or moderate inter-rater and intra-rater reliability for the total IMP score and the domain scores, including the symmetry domain.

The IMP has been assessed for validity in several studies, showing concurrent validity (Heineman et al., 2013) and promising predictive validity for development of cerebral palsy and lower intelligence quotients (Heineman et al., 2011; Heineman, Schendelaar, Van den Heuvel, & Hadders-Algra, 2018). Construct validity for the IMP has been supported in one study (Heineman et al., 2010), and three studies have indicated that the IMP is responsive to change when used as an outcome measure in physiotherapy interventions (Hielkema et al., 2011; Sgandurra et al., 2016, 2017). In the present study we address applicability of the IMP in the context of Norwegian primary health care. Norwegian primary health care offers parents during their infant's first year of life regular consultations at a public health clinic to assess and discuss the infant's growth and development. Virtually the entire population of infants in Norway uses this health service.

Therefore the aim of the current study was to assess intra-rater and inter-rater reliability of IMP in a sample of infants visiting primary health care.

Method

Participating Infants

Infants were recruited in primary health care in connection with public health controls through a clinic in south-eastern Norway ($n = 58$). Three additional infants were recruited by word of mouth during the same period. Eligible infants were between 3 to 18 months corrected age, who had not been walking independently for more than a few months. Infants with severe medical conditions that made assessment impossible and parents not speaking and understanding Norwegian or English, were excluded.

The Regional Committee for Medical and Health Research Ethics approved the study (2015/1501/REK vest). The Norwegian Social Science Data Service approved the study

Table 1. The clinical characteristics of infants with and without known risk of motor developmental delay.

Infant variables	At risk infants n = 7	Non-at risk infants n = 43	All infants n = 50
Sex, girl/boy (n)	5/2	23/20	28 /22
Birth weight, g, mean (SD)	2393 (1216)	3637 (524)	3462 (779)
Gestational age, weeks, mean (SD)	34.7 (5.4)	40.1 (1.1)	39.4 (2.9)
Age at assessment, months, mean (SD)	6.5 (3.9)	7.2 (2.3)	7.1 (2.6)

(project no. 45014/3/MSS). Parents or legal guardian received a written invitation and signed an informed consent before enrollment.

From 72 parents who signed an informed consent, eight were not available when the first author made contact to organize the assessment. Additionally, three parents withdrew their consent before assessment due to lack of time, leaving a sample of 61 infants for the video assessments. Among these infants, 11 were randomly selected for trial assessments (with the help of the SPSS program), and the video assessments of the remaining 50 infants were used in the reliability study, following recommendations of the COSMIN group of at least 50 participants (Terwee et al., 2007). Infants with a clinical history that could categorize them as having an increased risk of motor developmental delay, such as preterm birth (gestational age <37 week), (Spittle, Orton, Anderson, Boyd, & Doyle, 2015), low birth weight (< 2500 g) (Anderson & Dewey, 2011; World Health Organization, 2004), severe congenital heart disease requiring cardiac surgery in infancy (Latal, 2016), severe hypoglycemia (< 2.6 mmol/l or 47 mg/dl) (Duvanel, Fawer, Cotting, Hohlfeld, & Matthieu, 1999) or plexus brachial injury at birth (Ridgway, Valicenti-McDermott, Kornhaber, Kathirithamby, & Wieder, 2013), were grouped as "infants at risk of motor developmental delay". Among the participating infants, 7 had a risk for motor developmental delay due to premature birth (n = 4), severe congenital heart disease (n = 1), severe neonatal hypoglycemia (n = 1) or brachial plexus injury at birth (n = 1). Table 1 summarizes clinical characteristics of all participating infants.

Procedure

During a four-month period, the first author (KMT) assessed all infants either at the infant's home or at the public health clinic. The assessment was video-recorded and the scoring began after all videos had been collected. Infants were only assessed when they were in an alert, non-crying behavioral state. KMT played for about 15 minutes with the infant, in accordance with the IMP-procedures. The total and domain IMP scores were calculated and expressed in percentages with a maximum of 100% (Heineman et al., 2008). Parents also filled out a short form on clinical perinatal history and demographics. The medical staff at the public health clinic checked the information on the perinatal history.

IMP Assessment Training and Evaluation of Reliability

Inter-rater reliability of IMP was based on the ratings of three pediatric physiotherapists who independently observed and scored the videos. The first rater, (KMT) had three years of experience within pediatric physical therapy, while the two other raters (JR and PAMvI) were both highly experienced pediatric physical therapists with more than 20 years clinical experience each. The three raters had attended a two-day course in IMP assessment in 2012 (PAMvI) and 2015 (KMT and JR) provided by the test developers. Preliminary results suggested that the inter-rater correlations for the domains variation and adaptability were not satisfactory. In order to fine-tune their assessment skills, KMT and PAMvI had some additional training and received feedback on the technical qualities and interpretation of IMP-scores from the test developers based on the 11 trial videos. JR was updated with the feedback information by KMT. For the examination of intra-rater reliability, KMT re-assessed the 50 videos after a four-week interval. A four-week interval was considered sufficient for the rater not to remember her first scoring. All raters were blinded to the medical history of the infants.

Data Analysis

IBM SPSS Statistics version 23 was used for statistical analysis. Demographic, perinatal and IMP data were examined by descriptive statistics. The basis for examining intra-rater reliability was first examined by inspecting graphs of the correlated IMP data. Intra- and inter-rater reliability values were calculated with Intraclass Correlation Coefficients (ICC) statistics with 95% Confidence Intervals (CIs). ICC allows for comparison of more than two variables of continuous data and is robust to minor violations of the normality assumption (Bland & Altman, 1996). ICC values were interpreted according to de Vet, Knol, Terwee, and Mokkink (2011) considering a value $\geq$ 0.70 as acceptable. Standard error of measurement (SEM) was calculated by the square root of the total within subject mean square from the ICC analysis. The smallest detectable change (SDC) was calculated by the formula 2.77 x SEM, meaning that the difference between two measurements for the same subject is less than the SDC for 95% of pairs of observations (Bland & Altman, 1996).

Results

The infants from primary health care tended to obtain rather high scores on IMP, but between-subject variability was demonstrated. The correlation of scores in the intra-tester reliability analysis is illustrated in scatter plots, see Figure 1. The diagonals inserted represent perfect concordance in scores from the first to the second time the videos were scored. Except for the performance domain, the domain scores were in the upper one third of the scales with little intra-rater variability, demonstrating satisfactory concordance in scores between tests. The scores of the symmetry domain, only ranged between 92 and 100 indicating limited between-subject variability.

Satisfactory intra-rater reliability was found for the total IMP score, ICC = 0.95, and the domains performance ICC = 0.98, variation ICC = 0.74, adaptability ICC = 0.93 and fluency ICC = 0.86. The ICC value for symmetry was 0.65 (Table 2). Inter-rater reliability was satisfactory for the total IMP score and all domains except symmetry

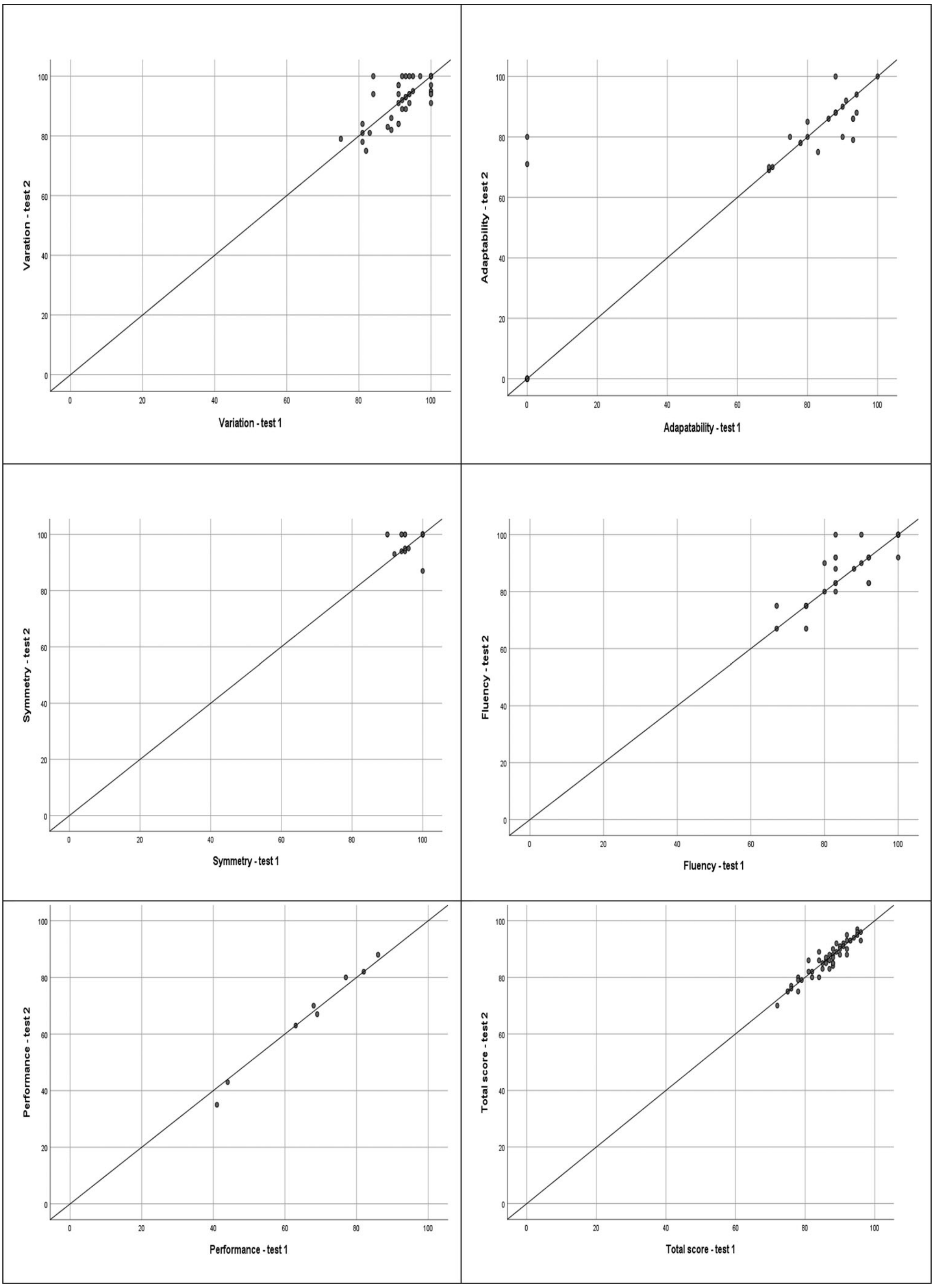


Figure 1. Scatter plots giving a graphical illustration of the correlation in scores for all participants (n = 50) based on rater 1 (intra-tester reliability).

(ICC = 0.13-0.35). The largest disparity was found between rater 2 and 3 on the domain symmetry (ICC = 0.13) (Table 2). The SEM across the domains varied between 1.89 and 4.86 for the inter-rater, and between 1.18 and 3.86 for intra-rater reliability,

Table 2. ICC values and confidence intervals in total IMP score and the five IMP domains.

Raters (R)	Variation ICC (95% CI)	Adaptability ICC (95% CI)	Symmetry ICC (95% CI)	Fluency ICC (95% CI)	Performance ICC (95% CI)	Total ICC (95% CI)
R1 vs R2	0.82 (0.70-0.85)	0.99 (0.98-0.99)	0.29 (0.03-0.52)	0.81 (0.69-0.89)	0.98 (0.97-0.99)	0.91 (0.85-0.95)
R1 vs R3	0.74 (0.30-0.89)	0.99 (0.98-0.99)	0.35 (0.10-0.57)	0.73 (0.56-0.84)	0.98 (0.97-0.99)	0.88 (0.80-0.93)
R2 vs R3	0.71 (0.44-0.85)	0.99 (0.98-0.99)	0.13 (-0.11 -0.37)	0.72 (0.55-0.83)	0.98 (0.97-0.99)	0.86 (0.76-0.92)
R1 intra	0.74 (0.59-0.85)	0.93 (0.88-0.96)	0.65 (0.45-0.79)	0.86 (0.76-0.92)	0.98 (0.97-0.99)	0.95 (0.91-0.97)

Table 3. Standard error of measurement and smallest detectable change for different IMP domains. Abbreviations: SDC, smallest detectable change, SEM, Standard Error of Measurement ($\sqrt{}$ Residual Mean square).

IMP domain	Reliability	SEM	SDC
Variation	Inter-rater	3.23	8.95
	Intra-rater	3.47	9.61
Adaptability	Inter-rater	4.58	12.69
	Intra-rater	3.58	9.92
Symmetry	Inter-rater	2.16	5.98
	Intra-rater	1.18	3.27
Fluency	Inter-rater	4.86	13.46
	Intra-rater	3.86	10.69
Performance	Inter-rater	1.89	5.24
	Intra-rater	1.92	5.32
Total score	Inter-rater	2.36	6.54
	Intra-rater	1.48	4.10

see Table 3. In both cases, the highest SEM values were found on the novel terms of motor behavior i.e., variation and adaptability.

Discussion

The study indicates that inter-rater reliability between three testers and intra-rater reliability in one tester in a sample of low-risk infants were satisfactory for all domains except symmetry. This indicates that the IMP can be used reliably as an assessment tool in primary health care of infants, provided sufficient training among the testers.

The high reliability values for the performance domain may reflect that pediatric physiotherapists are especially familiar with assessing motor performance in infants. For example, infant motor assessment tools commonly used by physiotherapists include the evaluation of the ability to roll from supine to prone, sitting up and standing up independently. The IMP test uses in addition complex motor concepts like variation and adaptability. These concepts and their expression in motor behavior may not be familiar to physiotherapists as they first emerged from the NGST at the beginning of this century (Hadders-Algra, 2000a, 2000b). Yet, the novel concepts may require additional supervision or a reference sample with well-defined video examples when introducing the tool IMP in clinical practice. The IMP manual (forthcoming publication) fulfills both requirements; it includes norm-values based on a sample of 1700 infants representative of the Dutch population. This means that in the future a two-day training course in combination with the manual allows for the implementation of the IMP in clinical practice.

The symmetry domain had the lowest ICC value, both in the present study, and the study introducing the IMP (Heineman et al., 2008). Yet, two other studies reported satisfactory reliability for the symmetry domain (Hecker et al., 2016; Heineman et al., 2013). The low number of items in this domain may affect its reliability. For infants who did not stay three minutes supine and who lacked the ability to sit and walk independently, the sum score of the symmetry domain was based upon a few items (two in prone, three in sitting with support and one in reaching and grasping). Additionally, from inspecting the scatter plot for intra-rater reliability (Figure 1) there was low between-subject variability in the symmetry domain, i.e., most infants got the same score (score 3 indicating no or mild asymmetry). This explains why the ICC value was rather low although the children got very similar scores on the two scoring occasions (low within-subject variability). The sample in the study of mostly healthy children, recruited from public health control, may explain why they had high (good) scores on this test, as well as rather high scores on the other quality domains. Nonetheless, as the qualitative domains are regarded as crucial markers of infant development (Hadders-Algra, 2018, 2010), health professionals using the IMP need to be accurate and confident in all qualitative domains.

The reliability values of the present study were more similar to the ones of Hecker et al. (Hecker et al., 2016) than to the values of the studies performed by the test developers (Heineman et al., 2008; Heineman et al., 2013). The difference with the reliability of the test developers may be attributed to the difference in samples evaluated. In the present study, most participants were not at risk for motor developmental delay, in contrast to the studies of the test developers that comprised a high proportion of at risk infants. It is conceivable, that a larger heterogeneity in study sample with a larger dispersion of scores is associated with higher reliability values, taking into consideration that ICC values are depending, not only on within subject variability, but also on between subject variability (Polit & Beck, 2010).

The strength of the present study is that we assessed reliability of the IMP in a sample of infants recruited from primary health care in Norway. Our study also has some limitations. We included only infants aged 3 to 12 months, while the IMP test has been developed for infants up to 18 months. Hence, our study does not provide results on the reliability of motor development in the upper age range for the IMP test. This study also faced a challenge regarding choice of statistical analysis. Using Spearman r_s would allow for comparison with the previously mentioned study by Hecker et al. assessing the reliability of the IMP (Hecker et al., 2016). However, the statistical method is designed for comparison of only two ranked variables (de Vet et al., 2011), which does not fit with the construction of the IMP. As the ICC also counts for systematic errors, COSMIN guidelines recommend using ICC statistics in reliability studies. Nevertheless, our results must be interpreted with care, since data did not always meet the criterion of normal distribution.

Conclusion

After sufficient training and supervision, reliability of the IMP-assessment in infants from primary health care was satisfactory, except for the symmetry domain as most infants obtained high (good) scores. The IMP may be a valuable, supplementary tool in longitudinal assessment of infants whose motor development gives rise to concerns. We suggest that future studies pay attention in particular to the predictive validity of the IMP.

Acknowledgements

The authors would like to thank all the contributing families and their infants, the staff at the public health care clinic in Porsgrunn municipality for recruiting patients and providing facilities for data collection. The authors also acknowledge Rolf Moe-Nilssen for statistical support.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data Availability Statement

The datasets used and analyzed during the current study is available from the corresponding author on reasonable request.

Authors' Contributions

KMT contributed to the design of the study, collected the data, performed the clinical evaluations of the video recordings, wrote the initial draft of the manuscript, edited and approved the final manuscript. MHA contributed to the editing of the manuscript, and approved the final manuscript. LIS contributed to the design of the study, contributed toward the interpretation of results, read, edited and approved the final manuscript. PAMvI scored the video recordings, read, edited and approved the final manuscript. JR scored the video recordings, read, edited and approved the final manuscript. TD contributed in the design of the study, contributed toward the interpretation of results and read, edited and approved the final manuscript.

Funding

GC Rieber Funds supported the work on planning the study and writing the research protocol. The Norwegian Fund for Post-Graduate Training in Physiotherapy supported the conduction of the study.

About the Authors

KMT is a clinical pediatric physiotherapist working at Children's Physiotherapy Center in Bergen and a researcher in the Physiotherapy Research Group, Department of Global Public Health and Primary Care, University of Bergen, Norway.

MHA (MD, PhD) is professor of developmental neurology and head of the Institute of Developmental Neurology at the University Medical Center Groningen, The Netherlands.

LIS is professor emerita in the Physiotherapy Research Group, Department of Global Public Health and Primary Care, University of Bergen, Norway.

PAMvI is a PhD pediatric physiotherapist from the Netherlands and post-doc researcher at the Institute of Developmental Neurology of the University Medical Center Groningen, The Netherlands.

JR is a pediatric physiotherapist and head of the Children's Physiotherapy Center in Bergen.

TD is an associate professor at the Western Norway University of Applied Science and works as a clinical physiotherapist in private practice.

References

Anderson, P. J., & Dewey, D. (2011). Introduction: The consequences of being born very early or very small. *Developmental Neuropsychology*, *36*(1), 1–4. doi:10.1080/87565641.2011.540522

Bayley, N. (2006). *Bayley scales of infant and toddler development*. doi: 10.1177%2F0734282906297199

Bland, J. M., & Altman, D. G. (1996). Measurement error. *BMJ*, *313*(7059), 744. doi:10.1136/bmj.313.7059.744

Campbell, S. (2012). *The test of infant motor performance. Test user's manual version 3.0 for the TIMP version 5. Infant motor performance scales*. Chicago IL: LLC.

Chandler, L. S. A. M.S., & Swanson, M. W. (1980). In A. Haugaard Larson (Ed.), *Movement assessment of infants: A manual*. Washington DC: Rolling Bay.

de Vet, H. C. W., Knol, D. L., Terwee, C. B., & Mokkink, L. B. (2011). *Measurement in medicine*. Cambridge: Cambridge University Press.

Duvanel, C. B., Fawer, C. L., Cotting, J., Hohlfeld, P., & Matthieu, J. M. (1999). Long-term effects of neonatal hypoglycemia on brain growth and psychomotor development in small-for-gestational-age preterm infants. *The Journal of Pediatrics*, *134*(4), 492–498. doi:10.1016/S0022-3476(99)70209-X

Hadders-Algra, M. (2000a). The neuronal group selection theory: A framework to explain variation in normal motor development. *Developmental Medicine* & *Child Neurology*, *42*(8), 566–572. doi:10.1017/S0012162200001067

Hadders-Algra, M. (2000b). The neuronal group selection theory: Promising principles for understanding and treating developmental motor disorders. *Developmental Medicine* & *Child Neurology*, *42*(10), 707–715. doi:10.1017/S0012162200001316

Hadders-Algra, M. (2010). Variation and variability: Key words in human motor development. *Physical Therapy*, *90*(12), 1823–1837. doi:10.2522/ptj.20100006

Hadders-Algra, M. (2018). Early human motor development: From variation to the ability to vary and adapt. *Neuroscience & Biobehavioral Reviews*, *90*, 411–427. doi:10.1016/j.neubiorev.2018.05.009

Hadders-Algra, M., Mavinkurve-Groothuis, A. M., Groen, S. E., Stremmelaar, E. F., Martijn, A., & Butcher, P. R. (2004). Quality of general movements and the development of minor neurological dysfunction at toddler and school age. *Clinical Rehabilitation*, *18*(3), 287–299. doi:10.1191/0269215504cr730oa

Hecker, E., Baer, G. D., Stark, C., Herkenrath, P., & Hadders-Algra, M. (2016). Inter- and intrarater reliability of the Infant Motor Profile in 3- to 18-month-old infants. *Pediatric* Physical Therapy, *28*(2), 217–222. doi:10.1097/PEP.0000000000000244

Heineman, K. R., Bos, A. F., & Hadders-Algra, M. (2008). The Infant Motor Profile: A standardized and qualitative method to assess motor behaviour in infancy. *Developmental Medicine & Child Neurology*, *50*(4), 275–282. doi:10.1111/j.1469-8749.2008.02035.x

Heineman, K. R., Bos, A. F., & Hadders-Algra, M. (2011). Infant Motor Profile and cerebral palsy: Promising associations. *Developmental Medicine & Child Neurology*, *53*(Suppl 4), 40–45. doi:10.1111/j.1469-8749.2011.04063.x

Heineman, K. R., La Bastide-Van Gemert, S., Fidler, V., Middelburg, K. J., Bos, A. F., & Hadders-Algra, M. (2010). Construct validity of the Infant Motor Profile: Relation with prenatal, perinatal, and neonatal risk factors. *Developmental Medicine & Child Neurology*, *52*(9), e209–e215. doi:10.1111/j.1469-8749.2010.03667.x

Heineman, K. R., Middelburg, K. J., Bos, A. F., Eidhof, L., La Bastide-Van Gemert, S., Van Den Heuvel, E. R., & Hadders-Algra, M. (2013). Reliability and concurrent validity of the Infant Motor Profile. *Developmental Medicine* & *Child Neurology*, *55*(6), 539–545. doi:10.1111/dmcn.12100

Heineman, K. R., Schendelaar, P., Van den Heuvel, E. R., & Hadders-Algra, M. (2018). Motor development in infancy is related to cognitive function at 4 years of age. *Developmental Medicine & Child Neurology*, *60*(11), 1149–1155. doi:10.1111/dmcn.13761

Hielkema, T., Blauw-Hospers, C. H., Dirks, T., Drijver-Messelink, M., Bos, A. F., & Hadders-Algra, M. (2011). Does physiotherapeutic intervention affect motor outcome in high-risk infants? An approach combining a randomized controlled trial and process evaluation. *Developmental Medicine & Child Neurology*, *53*(3), e8–15. doi:10.1111/j.1469-8749.2010.03876.x

Latal, B. (2016). Neurodevelopmental outcomes of the child with congenital heart disease. *Clinics in Perinatology*, *43*(1), 173–185. doi:10.1016/j.clp.2015.11.012

Lekskulchai, R., & Cole, J. (2001). Effect of a developmental program on motor performance in infants born preterm. *Australian Journal of Physiotherapy*, *47*(3), 169–176. doi:10.1016/S0004-9514(14)60264-6

McIntyre, S., Morgan, C., Walker, K., & Novak, I. (2011). Cerebral palsy-don't delay. *Developmental* Disabilities Research Reviews, *17*(2), 114–129. doi:10.1002/ddrr.1106

Piper, M., & Darrah, J. (1994). *Motor assessments of the developing infant*. Philadelphia, PA: W.B. Saunders Company.

Polit, D. F., & Beck, C. T. (2010). *Essentials of nursing research: Appraising evidence for nursing practice* (7th ed.). Philadelphia, PA: Wolters Kluwer/Lippincott Williams & Wilkins.

Ridgway, E., Valicenti-McDermott, M., Kornhaber, L., Kathirithamby, D. R., & Wieder, H. (2013). Effects from birth brachial plexus injury and postural control. *The Journal of Pediatrics*, *162*(5), 1065–1067. doi:10.1016/j.jpeds.2012.12.073

Rosenbaum, P., Paneth, N., Leviton, A., Goldstein, M., Bax, M., Damiano, D., & Jacobsson, B. (2007). A report: The definition and classification of cerebral palsy April 2006. *Developmental Medicine & Child Neurology*, *109*, 8–14. doi:10.1017/S001216220500112X

Sgandurra, G., Bartalena, L., Cecchi, F., Cioni, G., Giampietri, M., Greisen, G., … Dario, P. (2016). A pilot study on early home-based intervention through an intelligent baby gym (CareToy) in preterm infants. *Research in Developmental Disabilities*, *53-54*, 32–42. doi:10.1016/j.ridd.2016.01.013

Sgandurra, G., Lorentzen, J., Inguaggiato, E., Bartalena, L., Beani, E., Cecchi, F., … On behalf of The CareToy Consortium. (2017). A randomized clinical trial in preterm infants on the effects of a home-based early intervention with the 'CareToy System. *PLoS One*, *12*(3), e0173521. doi:10.1371/journal.pone.0173521

Spittle, A., Orton, J., Anderson, P., Boyd, R., & Doyle, L. W. (2012). Early developmental intervention programmes post-hospital discharge to prevent motor and cognitive impairments in preterm infants. *The Cochrane Database of Systematic Reviews*, *12*, CD005495. doi:10.1002/14651858.CD005495.pub3

Spittle, A., Orton, J., Anderson, P. J., Boyd, R., & Doyle, L. W. (2015). Early developmental intervention programmes provided post hospital discharge to prevent motor and cognitive impairment in preterm infants. *The Cochrane Database of Systematic Reviews*, (11), CD005495. doi:10.1002/14651858.CD005495.pub4

Spittle, A. J., Doyle, L. W., & Boyd, R. N. (2008). A systematic review of the clinimetric properties of neuromotor assessments for preterm infants during the first year of life. *Developmental Medicine & Child Neurology*, *50*(4), 254–266. doi:10.1111/j.1469-8749.2008.02025.x

Terwee, C. B., Bot, S. D.M., de Boer, M. R., van der Windt, D. A.W.M., Knol, D. L., Dekker, J., … de Vet, H. C.W. (2007). Quality criteria were proposed for measurement properties of health status questionnaires. *Journal of Clinical Epidemiology*, *60*(1), 34–42. doi:10.1016/j.jclinepi.2006.03.012

World Health Organization. (2004). *International statistical classification of diseases and related health problems, tenth revision* (2nd ed.). Geneva: World Health Organization.

Ziviani, J., Feeney, R., Rodger, S., & Watter, P. (2010). Systematic review of early intervention programmes for children from birth to nine years who have a physical disability. *Australian Occupational Therapy Journal*, *57*(4), 210–223. doi:10.1111/j.1440-1630.2010.00850.x