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Alberta Infant Motor Scale: Cross-cultural analysis of gross motor development in Dutch and Canadian infants and introduction of Dutch norms

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ABSTRACT

Background: The Alberta Infant Motor Scale (AIMS) has been developed in Canada in the 90ies. The AIMS and its Canadian norms are frequently used across the world to monitor infants' gross motor development. Currently, it is disputed whether the Canadian norms are valid for non-Canadian infants.
Aims: To compare scores on the AIMS of Dutch infants with that of the Canadian norms, to compare the sequence of motor milestones in Dutch and Canadian infants, and to establish Dutch AIMS norms.
Study design: Cross-sectional study.
Subjects: 1697 infants, aged 2–18 months, representative of the Dutch population (gestational age 39.7 weeks (27–42)).
Outcome measure.
AIMS assessments, based on standardized video. Perinatal and social information was obtained by questionnaire and medical records. To create Dutch reference values quantile regression with polynomial splines was used.
Results: 1236 Dutch infants (73%) scored below the 50th (P50) percentile of the Canadian norms, 653 (38%) below the P10 and 469 (28%) below the P5. In infants aged 6 to 12 months these values were: 567 infants (81%) < P50, 288 infants (41%) < P10, 201 infants (29%) < P5. The sequence of achievement of motor milestones of Dutch and Canadian infants was similar. Dutch norm-reference values of the AIMS were calculated.
Conclusions and implications: Gross motor development of Dutch infants is considerably slower than that of the Canadian AIMS norms sample. To prevent overdiagnosis of developmental delay and overreferral to paediatric physiotherapy Dutch AIMS norms are required. The paper introduces these norms, including percentile ranks.

1. Introduction

The evaluation of gross motor development is part and parcel of the monitoring of infants at risk of developmental disorders, for instance infants born preterm. Various methods are available to monitor motor development, such as the psychomotor index of the Bayley Scales of Infant and Toddler Development (BSID) [1], the Infant Motor Profile (IMP) [2] and the Alberta Infant Motor Scale (AIMS) [3]. The AIMS focuses on gross motor development and has been developed for infants aged 2 to 18 months corrected age (CA).

The AIMS has been developed in Canada using normative data of infants born in 1990–1992 [3]. It is an observational tool with good intra-rater and inter-rater reliability. Its concurrent validity is good, whereas its ability to predict cerebral palsy is moderate [4]. The AIMS is used across the world, in particular to monitor the infant's gross motor development. Virtually everywhere the Canadian norms are applied. But

Abbreviations: AIMS, Alberta Infant Motor Scale; IMP, Infant Motor Profile; BSID, Bayley Scales of Infant Development; CA, Corrected Age; GODIVA, Gross mOtor Development of Infants using home-Video registration with the Alberta Infant Motor Scale; SINDA, Standardized Infant NeuroDevelopmental Assessment; US, United States of America.

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over the last 15 years, a discussion started whether the Canadian norms indeed are valid across the world and whether they are stable over time. The discussion started in 2007 with the publication of Fleuren et al. [5], who reported on the basis of a group of 100 healthy Dutch infants aged 0–12 months, that 75% of the infants scored below the 50th percentile (P50) of the Canadian norms. Similar findings were reported for infants in Belgium (assessed in 2007–2010) [6]. The Dutch and Belgian samples were small, but representative of their countries in terms of proportion term and preterm born infants, but not with respect to social background. The study of Saccani and colleagues (2011) reported that also Brazilian infants scored lower on the AIMS than the Canadian infants [7]. Others, studying infants in Greece and South Africa, described that the infants' AIMS scores did not differ from those of the Canadian sample (Syrengelas et al. 2010, 2014 [8,9], Manuel et al. 2012 [10]). However, it should be noted that the Greek and South African studies only included term born infants. A Canadian replication study published in 2014, reported that the Canadian infants still performed according to the previously established Canadian norms [11].

Recently, Dutch infants' performance on the AIMS was re-investigated. This occurred in the GODIVA-project (Gross mOtor Development of Infants using home-Video registration with the Alberta Infant Motor Scale) [12] with a sample of 499 infants. The study confirmed previous findings, that Dutch infants score lower than the Canadian infants did. However, the GODIVA study group was not representative of the general Dutch population in terms of ethnical background and educational level of the parents. Nevertheless, the Dutch findings supported the conclusion of Mendonça et al. (2016) [13], that tools that assess motor development deserve culture or country specific norms in order to prevent over- and underreferral for services.

The Groningen IMP-SINDA project offered the opportunity to assess the AIMS scores in a large group of infants that was representative of the Dutch population. In the IMP-SINDA project norm data for the IMP [2] and the Standardized Infant NeuroDevelopmental Assessment (SINDA) [14] have been collected in 1700 infants aged 2 to 18 months. As the IMP is a video-based assessment of the infants' self-produced gross and fine motor activities, and the AIMS an observational instrument of gross motor behaviour, the IMP-videos allowed for the assessment of the AIMS [15].

The aims of the study were 1) to assess the AIMS scores in a population representative of the Dutch population and to compare the scores of this representative Dutch sample with that of the Canadian norms; 2) to assess whether the sequence in which the IMP-SINDA infants reached their milestones differs from that of the Canadian group; 3) to establish Dutch AIMS norms and percentile ranks.

2. Methods

2.1. Participants

The IMP-SINDA project included 1700 infants aged 2–18 months CA, who were assessed once. Note, that from this point all ages used are corrected ages, i.e. ages in preterm infants have been corrected. Infants were recruited via well-baby clinics and advertisements. Inclusion criteria were age between 2 and 18 months, living in the northern part of the Netherlands, and having caregivers with sufficient comprehension of the Dutch language. Infants were only excluded if they were too ill to be evaluated. The aims were to recruit 100 infants per month of age and to generate a sample that was representative of the Dutch population.

The caregivers filled out a standardized questionnaire on prenatal, perinatal and neonatal and socio-economic history. If the questionnaire revealed complications, medical records were consulted (see Table 1 for background characteristics). The Medical Ethical Committee of the University Medical Centre in Groningen (UMCG) approved of the study design (METC 206/284). Caregivers provided written informed consent.

Table 1
Background characteristics of the Dutch IMP-SINDA group.

Characteristics	n = 1697
Male sex, n (%)	887 (52)
Gestational age in weeks, median (range)	39,7 (27–42)
Preterm <37 weeks, n (%)	112 (7)
Birthweight in grams, n	1693/1697
median (range)[a]	3470 (1120–5020)
Ethnicity: at least one parent non-native Dutch, n (%)[a]	219/1675 (13)
Maternal age at child birth, n median (range)[a]	1695/1697
	30 (16–44)
Maternal education:	
	1537/1694 (91)
- at least post-secondary education	
including:	787/1694 (46)
- high education,[b] n (%)[a]	
Assessment age in months, median (range)	10 (2–18)

[a] The numbers indicate the proportion of data available, e.g. birthweight data available in IMP-SINDA in 1693/1697 (99%).
[b] Vocational college and university.

2.2. Procedure

The AIMS is a norm referenced, observational instrument to measure gross motor abilities in infants aged 0–18 months [3]. The infant's self-produced movements in four different positions (supine, prone, sitting and standing) are assessed. The movements may be induced and/or stimulated but not manually assisted by the assessor. The infant's motor behaviour may be assessed immediately in real life or from a video recording [3,16]. The AIMS consists of 58 items, that are scored as 'observed', 'not observed' or 'mastered'. The 'observed' and 'mastered' items each generate one point. The maximum AIMS score is 58 points. The AIMS has good psychometric properties. On the basis of the Canadian norms percentile scores can be determined [3].

The AIMS scores were based on video recordings of the infant's motor behaviour during the IMP-assessment. The IMP is like the AIMS based on the infant's self-produced movements, which are produced spontaneously or through interactive play. The infant's behaviour is assessed in supine, prone, sitting with or without support, standing and walking with or without support, and during reaching and grasping. The infants were assessed at the babylab of the UMCG, at well-baby clinics or at home, according to the caregivers' wishes. The AIMS assessment of the videos was performed by a paediatric physiotherapist with ample experience with the AIMS (PAMvI) and medical master students, who were supervised by the physiotherapist. In case of disagreement the scores were discussed with a second experienced paediatric physiotherapist (Y-CW) until consensus was reached. The assessors were masked for background characteristics of the infants. Due to server problems three videos could no longer be assessed, leaving 1697 AIMS assessments for analysis.

2.3. Statistical analyses

The background characteristics were described with parametric or non-parametric statistics when appropriate. These statistics were performed with SPSS statistics, version 23 (IBM Corp, New York, USA).

For the construction of the age-specific reference values ('growth curves') for the AIMS, we investigated the performance of various statistical approaches while taking into account the specific ceiling effect ('bounded by 58') of the data, using quantreg and gamlss packages in R, version 3.6.3 [17,18]. The best fitting and best performing model was found by using quantile regression with polynomial splines, hence creating age-specific reference values for the AIMS total score based on the data of 1697 children, aged 7 to 81 weeks. We present centile curves for 5%, 10%, 25%, 50%, 75% and 90% for the age range of 2–18 months.

In order to evaluate whether the Dutch and Canadian infants achieved the AIMS motor milestones in a similar sequence, the Dutch and Canadian item locations of the individual items of the AIMS were compared. To this end, we followed the scaling method as described by the Canadian authors [11]. We determined the Dutch item locations (defined as the age at which 50% of the infants would pass an item) and selected those items, for which the proportion of infants passed was between 0.1 and 0.9. This eliminated 11 of the 58 individual items.

3. Results

Background factors of the 1697 infants of the IMP-SINDA project matched those of the Dutch population, for instance 787 (46%) mothers were highly educated, 219 (13%) had a non-native Dutch background and 112 (7%) of the infants were born preterm (for details see Table 1 and [19,20]).

According to the Canadian norm curves 1236 Dutch infants (73%) had AIMS scores below the 50th percentile (P50), the score of 653 infants (38%) fell below the P10 and that of 469 infants (28%) below the P5. The largest differences between Dutch and Canadian infants were observed in the age range of 6 to 12 months, i.e., the period during which the AIMS scores change most rapidly. Of the Dutch infants aged 6 to 12 months the score of 567 infants (81%) was below the Canadian P50, that of 288 infants (41%) below the P10 and that of 201 infants (29%) below the P5.

The comparison of the Canadian and Dutch item locations of the individual AIMS items revealed that with increasing age the Dutch infants gradually lagged behind when compared to their Canadian peers (Table 2). For instance, the age at which 50% of the Dutch infants passed the prone item 'head to 90^o with uncontrolled weight shifts' (prone 5) was 19 weeks, four weeks later than the Canadian infants. For the final AIMS items that evaluate standing and walking skills the difference had increased to 10 to 12 weeks. Overall, Dutch and Canadian infants showed a similar developmental sequence in the achievement of the AIMS items (Fig. 1).

The above data indicate that Dutch infants have a slower gross motor development than the Canadian ones. This warranted the calculation of Dutch percentile curves. They are depicted in Fig. 2; numerical details can be found in Table 3.

Table 2
Comparison of the Canadian and Dutch item locations of the individual items of the AIMS.

AIMS	Item name	Can loc[b] in weeks	Can prop passed[c]	NL loc[b] in weeks	NL prop passed[c]	Diff in weeks[d]
5	PR5[a]	15.05	0.89	19.26	0.82	4.21
6	PR6	18.60	0.85	22.45	0.78	3.85
7	PR7	21.76	0.80	28.73	0.70	6.97
8	PR8	27.79	0.67	34.41	0.62	6.62
9	PR9	25.78	0.71	33.36	0.63	7.58
10	PR10	25.10	0.74	30.06	0.68	4.96
11	PR11	28.62	0.66	28.73	0.70	0.11
12	PR12	32.87	0.57	39.81	0.55	6.94
13	PR13	33.23	0.56	38.99	0.56	5.76
14	PR14	33.99	0.55	39.68	0.55	5.69
15	PR15	34.98	0.52	39.08	0.56	4.10
16	PR16	36.96	0.49	42.03	0.52	5.27
17	PR17	43.56	0.37	43.79	0.49	0.23
18	PR18	38.01	0.46	44.23	0.49	6.22
19	PR19	39.44	0.43	48.94	0.42	9.50
20	PR20	41.21	0.40	50.89	0.40	9.68
21	PR21	41.49	0.39	53.53	0.36	12.04
26	SUP5[a]	18.56	0.84	20.91	0.79	2.35
27	SUP6	19.59	0.82	23.67	0.76	4.08
28	SUP7	22.40	0.78	25.36	0.74	2.96
29	SUP8	27.85	0.67	26.99	0.72	−0.86
30	SUP9	31.79	0.59	33.76	0.63	1.97
32	SIT2[a]	13.98	0.90	24.13	0.76	10.15
33	SIT3	16.35	0.87	19.29	0.82	2.94
34	SIT4	21.39	0.80	30.34	0.67	8.95
35	SIT5	22.89	0.78	31.56	0.66	8.67
36	SIT6	25.79	0.72	33.24	0.63	7.45
37	SIT7	27.84	0.68	34.30	0.62	6.46
38	SIT8	29.94	0.64	37.17	0.58	7.23
39	SIT9	31.92	0.59	40.72	0.53	8.80
40	SIT10	39.74	0.43	41.76	0.52	2.02
41	SIT11	36.59	0.49	43.89	0.49	7.30
42	SIT12	40.95	0.40	46.57	0.45	5.62
45	STD3[a]	22.93	0.76	33.47	0.63	10.54
46	STD4	37.53	0.47	43.55	0.49	6.02
47	STD5	38.47	0.45	44.80	0.48	6.33
48	STD6	38.50	0.45	45.83	0.46	7.33
49	STD7	44.45	0.35	46.91	0.45	2.46
50	STD8	39.54	0.43	49.12	0.42	9.58
51	STD9	41.99	0.38	49.17	0.42	7.18
52	STD10	43.45	0.35	55.27	0.34	11.82
53	STD11	47.65	0.28	59.36	0.28	11.71
54	STD12	50.99	0.23	61.81	0.25	10.82
55	STD13	52.70	0.20	65.46	0.20	12.76
56	STD14	55.91	0.18	66.02	0.20	10.11
57	STD15	53.89	0.19	65.42	0.20	11.53
58	STD16	56.19	0.17	66.43	0.19	10.24

[a] SUP5 = supine, fifth item; PR5 = prone, fifth item; SIT2 = sitting,second item; STD3 = standing, third item etc.
[b] Canadian or Dutch (NL) item location.
[c] Proportion of Canadian or Dutch (NL) study group, that passed the item.
[d] Difference in weeks between Canadian and Dutch study groups.

4. Discussion

This AIMS-based study demonstrated that Dutch infants have a slower gross motor development than the Canadian infants of the AIMS norms sample. Yet, infants in both countries reach their milestones in the same sequence.

Our results of a group that is representative of the Dutch population in terms of maternal education, ethnicity, preterm birth and other perinatal factors [21,22] confirm what other studies, including the GODIVA study had suggested: about 75% of Dutch infants score below the Canadian P50 [5,12]. Also Belgian infants have been reported to have lower AIMS scores than the Canadian ones. Yet, they appear to perform somewhat better than the Dutch infants, with about 65% of the infants scoring below the Canadian P50 [6].

The Dutch norm study of the BSID-III [23,24] reported that Dutch infants scored lower on gross motor development than infants from the United States (US), but that a similar slower development was absent in the fine motor, cognitive and communication domains. What could be the reason that Dutch infants have a slower gross motor development than infants of the North American continent? A major explanation could be ethnic diversity [13]. Ethnic diversity is rapidly increasing in the US, Canada and the Netherlands. Mendonça et al. [13] indicated that in 2020 about 50% of the US and about 20% of the Canadian population have a so-called minority ethnic background. Ethnic background and its associated culture may affect motor development. For instance, it is well known that infants raised in an African culture have a substantially faster gross motor development than infants raised in Western cultures [25]. Yet, the proportion of infants with a minority ethnic background did not differ between the two Canadian studies (10% and 16%; Darrah et al. 2014) [11] and the present Dutch one (13%). Another explanation could be maternal education [13]. However, this explanation seems to fail as in both the Canadian and in the Dutch sample about 90% of mothers had post-secondary education. Slower gross motor development has also been attributed to the Back to Sleep campaign that had been launched in the 1990ies to prevent sudden infant death syndrome. But this also does not explain the difference between Canada and the Netherlands, as the campaign was introduced in both countries with similar success.

Most likely the difference in gross motor development between Dutch and Canadian infants has a multifactorial cultural origin. It has been suggested previously [26] that one of the factors that may have an unfavourable effect on neuromotor development is increasing maternal age when giving birth to the first child (estimates indicate that maternal

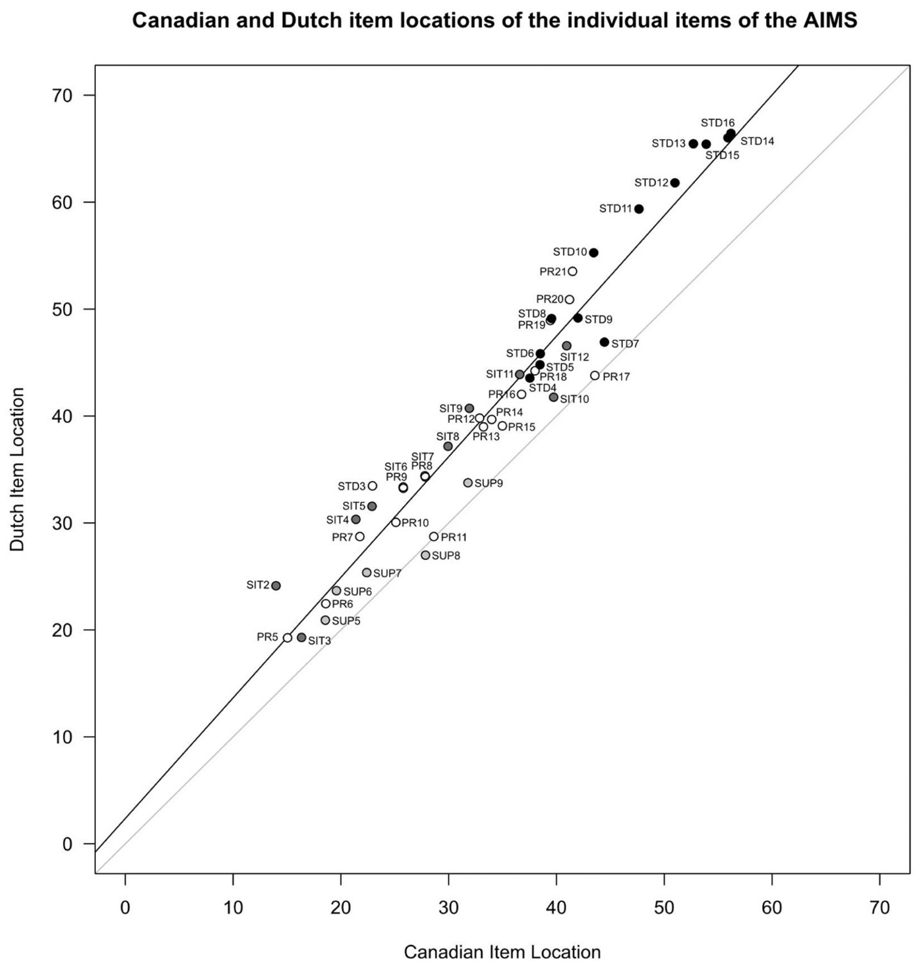

Fig. 1. Canadian and Dutch item locations of the individual items of the AIMS.
The black line denotes the result of regressing the Dutch item locations against the Canadian item locations, the grey line represents the reference line of "no difference between item locations of the two countries". The grey shading of the dots denote the position during which the AIMS items were assessed: white denotes prone, light grey refers to supine, dark grey to sitting and black to standing.

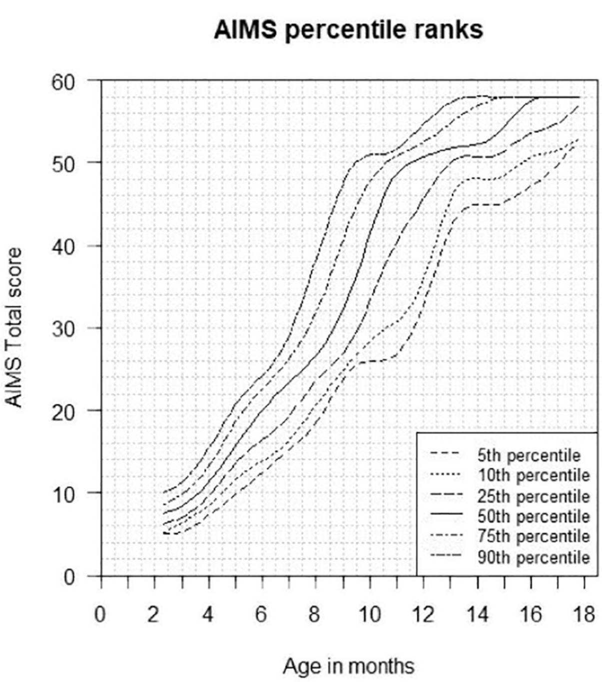

Fig. 2. Dutch percentile ranks of the AIMS.

Table 3
Percentile ranks.

Age (months)	C5	C10	C25	C50	C75	C90
2	4.2	4.9	5.6	6.2	7.2	8.0
3	5.2	6.4	7.0	8.4	9.9	11.3
4	8.3	9.7	11.2	13.0	15.2	17.5
5	10.6	12.5	14.6	17.1	20.0	22.0
6	12.5	13.9	16.4	20.0	22.7	24.2
7	15.6	17.0	20.0	23.9	26.9	30.3
8	21.3	23.0	25.4	29.2	36.4	43.5
9	22.5	24.0	26.1	30.6	38.5	45.6
10	25.8	27.4	30.9	38.2	46.0	50.6
11	26.2	30.0	38.0	46.8	50.0	51.1
12	30.8	34.1	44.5	50.4	52.1	54.0
13	43.0	46.5	50.4	51.8	55.1	57.5
14	44.9	47.9	50.6	52.6	57.4	58.0
15	46.5	50.1	53.0	56.8	58.0	58.0
16	47.5	50.8	53.8	57.7	58.0	58.0
17	48.6	51.2	54.2	58.0	58.0	58.0
18	50.9	52.7	57.6	58.0	58.0	58.0

age in the Netherlands is higher than in Canada: 29.6 versus 28.1 years) [26]. Two studies on child rearing practices suggested that Dutch caregivers in general are not actively promoting their infant's motor development [27], rather they are relatively keen to let the infant sleep [28]. However, no standardized information on infants' daily life activities in the Netherlands and Canada are available [29].

Our data underscored the need of specific Dutch AIMS norms - which we were able to create on the basis of our representative sample. Application of the Canadian norms would result in overdiagnosis of developmental delay and to overreferral to physiotherapeutic services.

The strengths of this study are its large sample of infants representative of the Dutch population, the standardized AIMS assessment by a team of trained assessors and being able to use the latest mathematical models to create reliable growth curves. A weakness of the study, that is inherent to its study design, is that infants were only assessed once. Thus information on the stability of the AIMS scores is lacking. It may be argued that the scoring of the AIMS from video recordings intended for IMP assessments is a weakness of the study. However scoring from video recordings has been proven reliable for the AIMS by the developers of this tool [3] and later during the GODIVA research [12,16]. Also other studies used IMP-assessment videos to assess the AIMS [30–32]. IMP-videos allow for AIMS assessment as both AIMS and IMP require that the infant shows self-produced motor behaviour in all positions.

In conclusion, our data confirmed that gross motor development of Dutch infants is considerably slower than that of the infants of the Canadian AIMS norms. We therefore calculated Dutch AIMS norms on the basis of a sample representative of the general Dutch population in order to prevent overdiagnosis of developmental delay and overreferral to paediatric physiotherapy.

Declaration of competing interest

None declared.

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