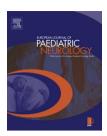


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# Original article

# Neurological examination of late-preterm infants at term age

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#### ABSTRACT

Background: Late-preterm infants represent 70% of the whole preterm population.

Aims: To establish the range and frequency distribution of neonatal neurological scores in a large cohort of low risk late-preterm infants and the possible differences with full-term infants.

Methods: Three hundred-seventy-five healthy infants born between 34 and 36 weeks gestational age (GA) without major brain lesions were assessed between 39 and 41 weeks post-menstrual age using the Hammersmith Neonatal Neurologic Assessment and compared to the scores obtained using the same examination in full-term infants.

Results: Infants born at 35 and 36 weeks GA had similar median scores in 32 of the 34 items. Infants born at 34 weeks GA had a different profile of scores compared to those born at 35 and 36 weeks, mainly in the tone items. While in infants born at 34 weeks the assessment at term age showed similar median scores to those obtained in full-term infants in 25/34 items, in those born at 35 and 36 GA the number of scores similar to full-term infants increased to 29/34. The main differences involved the tone items, with more marked flexor tone in the limbs and better head control for those born at 35 and 36 weeks.

Conclusions: This data can help as reference data when examining late-preterm infants at term age to see where the individual child stands compared to age matched low risk infants and to identify signs that are outside the reported range in infants with lesions or other risk factors.

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### 1. Introduction

The neurological assessment of the newborn has been widely studied in both preterm and full-term infant using the examination developed by Dubowitz and Dubowitz in 1981<sup>1</sup> and updated in 1998.<sup>2,3</sup> The examination has been applied to large cohorts of healthy full-term newborns and low risk

preterm infants in order to establish the frequency distribution of the scores for each item in both groups.<sup>2–5</sup> Data on preterm infants show that those born between 25 and 34 weeks have less flexor limb tone, poorer head control but better visual following than term-born infants.<sup>4,5</sup>

No data is available for late-preterm infants, i.e. infants born at 34—36 weeks gestational age (GA), who represent the

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	1	2	3	4	5	1 .5 2 .5 3 .5 4 .5 5
	arms & legs extended or very slightly flexed	legs slightly flexed	leg well-flexed but not adducted	leg well flexed & adducted near abdomen	abnormal posture: a) Opistotonus	0         0         1         1         54         5         36         0         3         34w           0         0         1         2         16         5         76         <1
IRE	anginiy nexed				b) Arm flexed, leg extended	0 0 0 1 24 5 69 0 1 36w 0 0 0 6 3 90 1 0 Full term
POSTURE		¥		<b>0</b>		
II.	arms do not flex	arms flex slowly, not always; not completely	arms flex slowly; more complete	arms flex quickly and completely	arms difficult to extend; snap back forcefully	1 .5 2 .5 3 .5 4 .5 5 1 0 0 1 49 13 34 1 0 34w
ARM RECOIL	<b>@</b>	(A)	∖⊜,	<u>,</u>		0 1 0 3 17 9 70 <1 0 35w 0 0 1 19 8 71 0 1 36w 0 0 5 2 22 3 67 1 0 Full term
ARM	<u> </u>	<b>₩</b>	V	V		
LION	arms remain straight; no resistance	arms flex slightly or some resistance felt	arms flex well till shoulder lifts, then straighten	arms flex at approx 100 & mantained as shoulder lifts	flexion of arms <100; mantained when body lifts up	1     .5     2     .5     3     .5     4     .5     5       3     3     24     5     54     6     5     0     0     34w       0     0     2     1     28     8     61     0     0     35w
ARM TRACTION	0/ ^	ملہ	A L	۵>.	Φ,	0 0 1 1 41 5 52 0 0 36w 0 0 1 0 22 8 69 0 0 Full term
AR	R L No flexion	R L incomplete or	R L complete but slow	R L complete fast flexion	R L L legs difficult to extend;	1 .5 2 .5 3 .5 4 .5 5
	No nexion	variable flexion	flexion	complete last flexion	snap back forcefully	0 0 4 1 34 3 57 0 1 34w 0 0 <1 <1 30 7 62 0 0 35w
COIL	ω <sub>~</sub>	⊙_~	0 &	0 4		0 0 10 <1 39 0 50 1 0 36w 0 0 3 1 4 1 91 0 0 Full term
LEG RECOIL	0)	<b>0</b>	<del>-</del>			
NOI	legs straight - no resistance	legs flex slightly or some resistance felt	legs flex well till bottom lifts up	knee flexes remains flexed when bottom up	flexion stays when back+bottom up	1 .5 2 .5 3 .5 4 .5 5 0 0 13 10 35 5 37 0 0 34w
LEG TRACTION	o 1	o ?	<b>3</b>	~ ?	ر ک	0         0         1         1         24         1         73         0         0         35w           0         0         0         1         31         0         68         0         0         36w           0         0         0         1         12         12         72         0         3         Full term
LEG	R L	R L	$\mathbb{C}$	R L	R L	0 0 0 1 12 12 72 0 3 Turrem
\L	3		۵ŀ	ο <b>λ</b>	۲ ۸	1 .5 2 .5 3 .5 4 .5 5 0 0 28 2 38 5 27 0 0 34w
POPLITEAL ANGLE	180	150	110	90	<90	0 0 4 1 54 4 37 0 0 35w 0 0 12 2 44 1 41 0 0 36w
PO	R L no attempt to raise	R L infant tries: effort	R L raises head but drops	R L raises head: remains	R L	0 0 5 5 19 20 51 0 0 Full term
ROL	head	better felt than seen	forward or back	vertical; it may wobble		1     .5     2     .5     3     .5     4     .5     5       0     0     15     2     51     9     23     0     0     34w       0     0     1     1     43     10     45     0     0     35w
HEAD CONTROL (1)	$\kappa$	8	$\mathfrak{P}$	<b>®</b>		0 0 5 1 42 11 41 0 0 36w 0 0 0 6 26 12 56 0 0 Full term
HEA1 (1)	$\approx$		k.	<u>k</u>		
OL (2)	no attempt to raise head	infant tries: effort better felt than seen	raises head but drops forward or back	raises head: remains vertical; it may wobble	head upright or extended; cannot be passively flexed	1 .5 2 .5 3 .5 4 .5 5 0 0 3 3 5 54 9 29 0 0 34w
HEAD CONTROL (2)	0	0	$\infty$			0         0         4         3         44         5         44         0         0         35w           0         0         2         2         44         8         44         0         0         36w           0         0         0         4         29         15         52         0         0         Full term
HEAD (	1	<u>k</u> .		E		
П	head drops & stays back	tries to lift head but it drops back	able to lift head slightly	lifts head in line with body	head in front of body	1 .5 2 .5 3 .5 4 .5 5 4 0 17 1 49 9 19 0 1 34w
HEAD LAG	0~	Q.	Or	Q.	Q.	0         0         4         4         56         15         21         0         0         35w           0         0         13         3         52         5         27         0         0         36w           0         0         9         4         44         12         31         0         0         Full term
неа	back curved, head	back curved, head	back slightly curved,	back straight, head in	hack stroight limbs	
L	& limbs hang straight	, limbs slightly flexed	limbs flexed	line, limbs flexed	back straight, limbs above body	1     .5     2     .5     3     .5     4     .5     5       3     0     19     4     47     10     16     0     1     34w       0     0     4     6     47     24     19     0     0     35w
VENTRAL SUSPENSION	<b>O</b>		058	<b>⊙</b> ₹	ω <del>,                                    </del>	0 0 5 3 63 7 22 0 0 36w 0 0 4 5 47 16 28 0 0 Full term
S.	77 2	Y 55	econo.			

Fig. 1 — Tone and posture items. The diagram of each item shows the range of scores in the 3 subgroups of late-preterm infants examined at term subdivided according to their gestational age and those of full-term infants examined in the first 48 h after birth, previously published.<sup>3</sup> The shading highlights the raw scores that were found in 90% of each group of preterm and term infants. The cell with highlighted border indicates the median scores.

	1	2	3	4	5	1	.5	2	.5	3	.5	4	.5	5	
		arm flexion less than	arm flexion equal	arm flexion more than	arm flexion more	0	0	47	0	46	0	7	0	0	34w
		leg flexion	to leg flexion	leg flexion but	than leg flexion but	0	0	14	0	81	0	5	0	0	35w
E				difference 1 column or less	difference more than 1 column	0	0	16	0	84	0	0	0	0	36w
ŢOŢ				iess	Column	0	0	25	3	53	0	18	0	<1	Full term
OR															
FLEXOR TONE															
E															
			arms and legs	strong arm flexion with	strong arm flexion with	1	.5	2	.5	3	.5	4	.5	5	1
			flexed	strong leg extension	strong leg extension	0	0	0	0	97	0	3	0	0	34w
				intermittent	continuous	0	0	0	0	100	0	0	0	0	35w
E						0	0	0	0	98	0	2	0	0	36w
TO						0	0	0	0	99	0	<1	0	<1	Full term
FLEXOR TONE								'							
CEX															
E															
		leg traction less than	leg traction equal to popliteal angle	leg traction more than popliteal angle but	leg traction more than	1	.5	2	.5	3	.5	4	.5	5	
		popliteal angle	popiiteai angie	difference 1 column or	popliteal angle but difference more than 1	0	0	11	0	51	0	34	0	4	34w
				less	column	0	0	2	0	61	0	37	0	0	35w
M						0	0	1	0	64	0	35	0	0	36w
TONE						0	0	4	0	57	0	35	0	4	Full term
LEG															
		neck extension less	head extension	head extension more	head extension more than	1	.5	2	.5	3	.5	4	.5	5	Ì
		than neck flexion	equal to head	than head flexion. but	head flexion but	0	0	17	0	75	0	8	0	0	34w
			flexion	difference 1 column or less	difference more than 1 column	0	0	10	0	78	0	8	0	4	35w
801				1033	Column	0	0	12	0	69	0	19	0	<1	36w
E C						0	0	3	0	94	0	3	0	<1	Full term
SS											-	-			
HEAD CONTROL (SITTING)															
E (S)															
re)		ventral suspension	ventral suspension	ventral suspension	ventral suspension more	1	.5	2	.5	3	.5	4	.5	5	
NO		less than head lag	equal to head lag	more than head lag but difference 1 column or	than head lag but difference more than 1	0	0	18	0	67	0	13	0	2	34w
LT				less	column	0	0	8	0	81	0	11	0	0	35w
E XIA						0	0	7	0	84	0	6	0	3	36w
NECK AND AXIAL TONE (HORIZONTAL)						0	0	24	0	58	0	18	0	<1	Full term
N OZ											_				
KE CK															
NE)															
	ı														

Fig. 2 — Tone pattern items-derived from responses documented in Fig. 1. Refer to Fig. 1 for diagram interpretation.

great majority of infants born prematurely  $(\sim 70\%)$ .<sup>6–11</sup> Although it has been previously reported<sup>8</sup> that at 6, 9 and 12 months corrected age (CA) preterm infants born at 35 and 36 weeks have lower tone and reflexes when compared to term infants assessed at the same ages, nothing has been systematically reported for the term age.

The aim of this study was to establish the range and frequency distribution of neonatal neurological scores in a large cohort of low risk late-preterm infants and the possible differences with full-term infants.

# 2. Patients and methods

The infants described in this study are part of a large cohort admitted to the Neonatal Unit of the University of Catania between January 2005 and December 2006. They were consecutively enrolled as part of a follow-up research program, including all infants born at a gestational age (GA) < 37 weeks.

In order to establish the distribution of frequency of neurological findings in a low risk population, infants were included if

- a) they were born between 34 and 36 weeks GA; GA was calculated from antenatal ultrasound scan performed at 14–16 weeks of gestation.
- b) their cranial ultrasound scans (cUS) were normal or only showed transient flares or germinal layer haemorrhages (GLH) in the first 2 weeks after birth and had no parenchymal abnormality at term age and no evidence of atrophy i.e. dilated ventricles (>14 mm VI), irregular ventricular margins, widened interhemispheric fissures or an enlarged extracerebral space. Cranial ultrasound (US) was generally obtained within the 6th day and then at least weekly up to infant discharge, and always around term age.
- c) they had, on the neurodevelopmental assessment, performed at 24 months corrected age using the Mental Developmental Index of Bayley Scales of Infant Development second edition, <sup>13</sup> results within the normal range for age.

Infants were not included if they were not clinically stable at term age showed a morbid condition, as hospital stay >5 nights, respiratory distress, APGAR < 6 at 5 min, pH < 7.20, transfer to the NICU (regardless length of stay or reported diagnosis).

	1	2	3	4	5	1	.5	2	.5	3	.5	4	.5	5	1
-	absent	felt, not seen	seen	'exaggerated'	clonus	0	0	10	0	54	0	32	0	4	34w
		,				0	0	19	<1	64	2	15	0	0	35w
						0	0	15	1	68	4	12	0	0	36w
ON						<1	0	21	0	78	0	<1	0	<1	Full term
TENDON REFLEX															
TE RE															
$\vdash$	no gag /	weak irregular suck	weak regular suck	strong suck:	no suck	1	.5	2	.5	3	.5	4	.5	5	
AG	no suck	only: No stripping	Some stripping	(a) irregular (b) regular	but strong clenching	0	0	1	0	17	0	82	0	0	34w
/ G		No stripping	Some stripping	Good stripping		0	0	<1	0	8	<1	90	0	<1	35w
SUCK / GAG						0	0	2	0	11	0	87	0	0	36w
SI						0	0	1	0	5	0	92	0	2	Full term
	no response	short, weak flexion	strong flexion of fingers	strong finger flexion,	very strong grasp;	1	.5	2	.5	3	.5	4	.5	5	
		of fingers		shoulder	infant can be lifted off couch	0	0	9	0	63	2	22	0	4	34w
AR.					couch	1	0	5	0	75	0	18	0	1	35w
PALMAR GRASP	R L	R L	R L	R L	R L	0	0	7	0	72	<1	19	0	2	36w
PA GR	K L	K E	K L	K L	K L	<1	0	6	0	84	0	9	0	<1	Full term
$\vdash$	no response	partial plantar flexion	toes curve around the			1	.5	2	.5	3	.5	4	.5	5	1
	no response	of toes	examiner's finger			0	0	4	0	96	0	0	0	0	34w
PLANTAR GRASP						0	0	3	0	97	0	0	0	0	35w
NT/ SP	R L	R L	R L			0	0	2	0	98	0	0	0	0	36w
PLA						<1	0	2	0	98	0	0	0	0	Full term
							_								1 un term
	No response	dorsiflexion of ankle only	full placing response with flexion of hip, knee &			1	.5	2	.5	3	.5	4	.5	5	
(2)		o,	placing sole on surface			0	0	14	0	86	0	0	0	0	34w
INC						0	0	9	0	91	0	0	0	0	35w
PLACING	R L	R L	R L			0	0	5	0	95	0	0	0	0	36w
P						1	0	18	0	81	0	0	0	0	Full term
	no response or	full abduction at	full abduction but only	partial abduction at	no abduction or	1	.5	2	.5	3	.5	4	.5	5	
	opening of hands only	shoulder and extension of the	delayed or partial adduction	shoulder and extension of arms	adduction; only forward	0	0	10	0	57	1	30	0	1	34w
		arms;		followed by smooth	extension of arms from	0	0	11	0	49	0	40	0	0	35w
		no adduction		adduction	the shoulders marked	0	0	10	0	35	0	55	0	0	36w
			_		adduction only	0	0	1	0	20	0	79	0	0	Full term
		□ 😉		. 😅 , 😅											
		\ \Y\	YY YY	MY A	I X X										
MORO			$I^{I} U \to U^{I}$	」∪→ひ	$\cup$										
Σ					or										

Fig. 3 - Reflexes. Refer to Fig. 1 for diagram interpretation.

We also excluded infants with major congenital malformations, chromosomal abnormality, congenital infection or any other sign of encephalopathy.

# 2.1. Clinical examination

Neurological examination was performed and recorded using the Hammersmith Neonatal Neurologic Assessment,<sup>2</sup> consisting of 34 items. Items were grouped in six categories (tone, tone patterns, reflexes, movements, abnormal signs and behaviour). Infants were examined between 39 and 41 weeks post-menstrual age (PMA).

Infants were examined undressed on an open bed or in their cot in a warm quiet room. Behavioural state, graded according to Brazelton criteria<sup>14</sup> at the time of examination was recorded. In order to achieve comparable results, whenever possible, all the infants were tested in the same state, midway between feeds, predominantly in state 4 or 5.

The proforma consists of numbered columns, between 3 and 5 for each item. If an item fell between 2 columns, it was given the appropriate half score between the columns (e.g. items scoring between 2 and 3 scored 2.5; between 2 and 1 scored 1.5). These scores are defined as raw scores.

In order to be able to evaluate the range and the distribution of the scores at different gestational ages and to compare these findings to our normative full-term, <sup>2,3</sup> the distribution of the raw scores (cells with highlighted border) for the cohort of late-preterm was plotted for each item and the median and 10th centile score noted as reported in previous studies. <sup>3,5</sup> The results of the cohort were analysed according to their gestational age at birth into: 34 weeks, 35 weeks, and 36 weeks.

Comparison between the distribution of infants born at the 3 different GA in the three groups subdivided according to the term equivalent age (TEA) assessment (39, 40, 41 weeks) was done by a non-parametric test (Kruskall—Wallis test followed by Dunn's post test). Comparison between cUS scans findings (normal Vs minor abnormalities) and genders for scores of each item were done by using the non-parametric test of Mann-Witney U. The level of significance was set at p < 0.05.

### 3. Results

Three hundred-seventy-five late-preterm infants fulfilled the inclusion criteria. The preterm delivery was related to placenta abruption, placenta previa, infection (unspecified

а															
	1	2	3	4	5	1	.5	2	.5	3	.5	4	.5	5	
$\vdash$	no	sporadic and	frequent isolated	frequent generalised	continuous exaggerated move	0	0	10	0	24	0	66	0	0	34w
_	movement	short isolated	movements	movements		0	<1	2	0	8	0	89	0	<1	35w
jį.		movements				0	0	4	0	23	0	71	0	2	36w
s in						<1	0	3	0	5	0	92	0	<1	Full term
SPONTANEOUS MOVEMENT (quantity)															
SPONT															
$\vdash$	only	stretches and	fluent movements	fluent alternating	cramped synchronised	1	.5	2	.5	3	.5	4	.5	5	1
	stretches	random abrupt movements	but monotonous	movements of arms + legs;	mouthing	0	0	5	0	25	0	70	0	0	34w
lity		some smooth		good variability	jerky or other abnormal. movement.	1	0	5	0	12	0	81	0	1	35w
Su (qua		movements			ino remenu	0	0	9	0	14	0	75	0	2	36w
NT NT						2	0	5	0	<1	0	93	0	<1	Full term
ME												10.00	_		run term
SPONTANEOUS MOVEMENT (quality)															
SP MO															
	no response	infant rolls	infant raises chin,	infant brings head	infant brings head up and										
	no response	head over, chin	rolls head over	and chin up	keeps it up	1	.5	2	.5	3	.5	4	.5	5	
l		not raised				0	0	34	0	44	3	15	0	4	34w
I S						1	0	20	0	55	0	24	0	0	35w
HEAD RAISING PRONE						0	0	18	0	51	1	30	0	0	36w
NE DE						<1	0	10	0	50	0	40	0	<1	Full term
RO															
b	_					_			1 -						
$\vdash$	1	2	3	4	5	1	.5	2	.5	23	.5	3	.5 0	5	
11		hands open, toes straight most of	intermittent fisting or thumb adduction	continuous fisting or thumb adduction;	continuous big toe extension or flexion of all	0	0	73	0	25	0	4	0	1	34w
ĕ		the time	thumb adduction	index finger flexion,	toes .			71	0		0	+		0	35w
<u> </u>				thumb opposition		0	0	72	0	23	0	5	0	0	36w
HA				1		0	0	85	0	12	0	3	0	<1	Full term
ABNORMAL HAND OR TOE POSTURES															
$\vdash$		no tremor or	tremor only after	frequent tremors	continuous tremors	1	<b>□.</b> 5	2	.5	3		4	.5	5	
П		tremor only when	Moro or occasionally		continuous tremors	1	.5 0	70	.5	3 25	.5 0	4 3	.5 0	<b>5</b>	34w
П					continuous tremors			_		_					34w 35w
		tremor only when	Moro or occasionally		continuous tremors	0	0	70	0	25	0	3	0	2	35w
ä		tremor only when	Moro or occasionally		continuous tremors	0	0	70 80	0	25 16	0	3	0	2	35w 36w
TREMOR		tremor only when	Moro or occasionally		continuous tremors	0	0 0	70 80 77	0 0	25 16 20	0 0	3 4 3	0 0 0	0 0	35w
TREMOR	no startle	tremor only when crying  no spontaneous	Moro or occasionally when awake  2-3 spontaneous	when awake	continuous tremors	0	0 0	70 80 77 88	0 0	25 16 20	0 0	3 4 3	0 0 0	0 0	35w 36w
TREMOR	no startle even to sudden noise	tremor only when crying	Moro or occasionally when awake	when awake		0 0 0	0 0 0 0	70 80 77 88	0 0 0	25 16 20 12	0 0 0	3 4 3 <1	0 0 0 0	2 0 0 <1	35w 36w
TREMOR	even to	no spontaneous	Moro or occasionally when awake  2-3 spontaneous	when awake		0 0 0	0 0 0 0	70 80 77 88	0 0 0 0	25 16 20 12	0 0 0 0	3 4 3 <1	0 0 0 0	2 0 0 <1	35w 36w Full term
TREMOR	even to	no spontaneous	Moro or occasionally when awake  2-3 spontaneous	when awake		0 0 0 0	0 0 0 0	70 80 77 88 2 50	0 0 0 0	25 16 20 12 3 6	0 0 0 0	3 4 3 <1	0 0 0 0	2 0 0 <1 <1	35w 36w Full term
ARTLE TREMOR	even to	no spontaneous	Moro or occasionally when awake  2-3 spontaneous	when awake		0 0 0 0	0 0 0 0	70 80 77 88 88	0 0 0 0	25 16 20 12 3 6 8	0 0 0 0	3 4 3 <1	0 0 0 0	2 0 0 <1 5 0	35w 36w Full term

Fig. 4-a) Spontaneous movements. (b) Abnormal signs. Refer to Fig. 1 for diagram interpretation.

maternal pyrexia, generalized infection or chorioamnionitis), elective cesarean delivery, preterm labor. Thirty infants (8%) were small for gestational age.

Infants were subdivided into 3 subgroups according to their gestational age: 79 (34 female, 45 male) were born at 34, 168 (77 female, 91 male) at 35 and 128 (68 female, 60 male) at 36 weeks gestation.

Of the 375 infants studied, 144 children were tested at 39, 159 at 40 and 72 at 41 weeks PMA, with no statistical difference (p>0.05) in the distribution of infants born at different gestational ages (34, 35, 36 weeks) in the three groups subdivided according to TEA assessment. Three hundred-thirty-

eight infants showed normal cUS, 30 transient flares and 7 IVH I. No statistical differences ( p>0.05) were reported for scores of each item between infants with normal and minimal abnormalities on cUS or for genders.

### 3.1. Tone items

3.1.1. Range of scores and median score in the late-preterm infants reaching term age - comparison of different gestational ages at birth

The range of scores falling within the 90th centile in infants born at 34, 35 and 36 weeks was similar in 3 of the 10 items

	1	2	3	4	5	1	.5	2	.5	3	.5	4	.5	5	
	does not open	_	full conjugate eye	transient	persistent	6	0		0	88	1	5	0	0	34w
ES	eyes		movements	nystagmus	nystagmus	2	0	0	0	94	1	3	0	0	35w
NC				strabismus roving eye	strabismus roving eye	4	0	0	0	91	2	3	0	<1	36w
RA				movements	movements	7	0	0	0	92	0	1	0	<1	Full term
EYE APPEARANCES				sunset sign	abnormal pupils										T un term
	100	929 100000	10.000 TO 100 D	2 1221 201 101		1	.5	2	.5	3	.5	4	.5	5	
	no reaction	auditory startle; brightens and	shifting of eyes, head might turn towards	prolonged head turn to stimulus; search with	turns head and eyes towards noise every	6	0	23	0	58	1	12	0	0	34w
		stills; no true	source	eyes; smooth	time; jerky abrupt	4	0	21	0	64	0	12	0	0	35w
z		orientation				2	0	22	0	67	0	9	0	0	36w
1,2						<1	0	30	0	50	0	20	0	<1	Full term
AUDITORY ORIENTATION						1	.5	2	.5	3	.5	4	.5	5	
z	does not	stills, focuses,	follows horizontally and	follows horizontally and	follows in a circle	0	0	6	0	30	17	47	0	0	24
[0]	follow or	follows briefly to	vertically;	vertically; turns head		0	0	10	0	45	9	36	0	0	34w
TAT	focus on	the side but loses	no head turn						_	10000	100		_	_	35w
EN	stimuli	stimuli				0	0	6	0	42	7	45	0	0	36w
I I I	(079) A49(C)C	9000	100	2000	100	<1	0	7	0	41	0	51	0	1	Full term
VISUAL ORIENTATION	В Т	В Т	В Т	В Т	В Т										
	will not	when awake,	when awake, looks at	keeps interest in stimuli	does not tire	1	.5	2	.5	3	.5	4	.5	5	
	respond to stimuli	looks only briefly	stimuli but loses them		(hyper-reactive)	0	0	8	5	58	4	25	0	0	34w
	Julian					1	0	3	0	54	0	42	0	0	35w
						2	0	2	0	49	0	47	0	0	36w
SS						1	0	2	0	48	0	49	0	<1	Full term
ALERTNESS															Tun term
	quiet all the time, not	awakes, cries sometimes when	cries often when handled	cries always when handled	cries even when not handled	1	.5	2	.5	3	.5	4	.5	5	
	irritable to	handled	when handled	when handled	nandica	14	0	73	0	13	0	0	0	0	34w
	any stimuli					4	0	91	0	4	0	1	0	0	35w
7						8	0	89	0	2	0	<1	0	<1	36w
E						<1	0	93	0	5	0	2	0	<1	Full term
IRRITABILITY									_						ı
	not crying consoling not	cries briefly; consoling not	cries; becomes quiet when talked to	cries; needs picking up to console	cries cannot be consoled	1	.5	2	.5	3	.5		.5	5	
>	needed	needed		TO TOMOTO	James de Comboled	20	0	18	0	33	0	27	0	2	34w
LI I						11	0	32	0	43	0	14	0	0	35w
IBI I						7	0	33	0	31	0	29	0	0	36w
CONSOLABILITY						1	0	41	0	45	0	12	0	<1	Full term
	101000000000000000000000000000000000000		201 00002000 00000			1	.5	2	.5	3	.5	4	.5	5	
	no cry at all	whimpering cry only	cries to stimuli but normal pitch		high pitched cry; often continuous	20	0	8	0	71	1	0	0	0	34w
		only	normal pitch		commuous	4	0	5	0	91	0	0	0	0	35w
						11	0	8	0	81	0	0	0	0	36w
						<1	0	7	0	92	0	0	0	1	Full term
CRY									1						

Fig. 5 - Behaviour. Refer to Fig. 1 for diagram interpretation.

assessing tone and different in the other 7. The median scores in the 3 subgroups were similar in 4 items and differed in the other 6 (Fig. 1). Infants born at 35 and 36 weeks differed only for 3 items for the range of the scores and 1 for median scores.

### 3.1.2. Late-preterm compared to full-term infants

The range of scores in infants born at 34 weeks was similar to that found in full-term infants in 2 items and different in the other 8. The median scores were similar in 3 items and

different in the other 7 (Fig. 1). Infants born at 35 and 36 weeks had similar scores to those found in full-term infants in 6/10 items for the range of scores and 7/10 for median scores.

### 3.2. Tone patterns

# 3.2.1. Range of scores and median score in the late-preterm infants reaching term age

The range of the scores falling within the 90th centile was similar in the 3 gestational age subgroups in 2 of the 5 items

assessing tone patterns and differed in the other 3. The median scores were similar in all subgroups for all the items (Fig. 2). Infants born at 35 and 36 weeks had similar range and median scores in all the items.

### 3.2.2. Late-preterm compared to full-term infants

The range of the scores in infants born at 34 weeks was similar to that found in full-term infants in 1 item and different in the other 4. The median scores were similar in all the items. Infants born at 35 and 36 weeks had similar scores to those found in full-term infants in 2/4 for the range of scores and 4/4 for median scores (Fig. 2).

# 3.3. Reflexes

# 3.3.1. Range of scores and median score in the late-preterm infants reaching term age

The range of scores falling within the 90th centile was similar in the 3 gestational age subgroups in 2 of the 6 items assessing reflexes. The median score was similar in all 3 subgroups in all the items but 1 (Fig. 3). Infants born at 35 and 36 weeks differed only for 2 items for the range of the scores and 1 for median scores.

### 3.3.2. Late-preterm compared to full-term infants

The range of the scores in infants born at 34 weeks was similar to that found in full-term infants in only one item and different in the other 5. The median scores were similar in 5 of 6 items but different for the assessment of the Moro reflex (Fig. 3). Infants born at 35 and 36 weeks had similar scores to those found in full-term infants in 2/6 items for the range of scores and 5/6 for median scores.

# 3.4. Movements

# 3.4.1. Range of scores and median score in the late-preterm infants reaching term age

The range of the scores falling within the 90th centile was similar in the 3 gestational age subgroups in 2 of the 3 items assessing movements. The median score in the 3 subgroups was similar in all the 3 items (Fig. 4a).

### 3.4.2. Late-preterm compared to full-term infants

The range of the scores in infants born at 34 weeks was similar to that found in full-term infants in 1 item and different in the other 2. The median scores were similar in all the items. Infants born at 35 and 36 weeks had similar scores to those found in full-term infants in 1/3 for the range of scores and 3/3 for median scores (Fig. 4a).

# 3.5. Abnormal signs

# 3.5.1. Range of scores and median score in the late-preterm infants reaching term age

The range of the scores falling within the 90th centile was similar in the 3 gestational age subgroups in 2 of the 3 items assessing abnormal signs. The median scores in the 3 subgroups were similar for all the items (Fig. 4b).

### 3.5.2. Late-preterm compared to full-term infants

The range of the scores in infants born at 34 weeks was similar to that found in full-term infants in 2 items and different in the other 1. The median scores were similar in all the items. Infants born at 35 and 36 weeks had similar scores to those found in full-term infants in 2/3 for the range of scores and 3/3 for median scores (Fig. 4b).

#### 3.6. Behavioural items

# 3.6.1. Range of scores and median score in the late-preterm infants reaching term age

The range of the scores falling within the 90th centile was similar in the three gestational age subgroups in 2 of the 7 items assessing behaviour and differed in the remaining 5. The median scores were similar in all 3 subgroups for 6 of the 7 items (Fig. 5).

### 3.6.2. Late-preterm compared to full-term infants

The range of the scores in infants born at 34 weeks was similar to that found in full-term infants in 2 items and different in the other 5. The median scores were similar for 6 of the 7 items and different for visual orientation. Infants born at 35 and 36 weeks had similar scores to that found in full-term infants in 4/7 items for the range of scores and 6/7 for median scores (Fig. 5).

The 30 infants small for gestational age showed a distribution of results similar to those appropriate for gestational age.

### 4. Discussion

This is the first study reporting the frequency distribution of neonatal neurological findings in a low risk late-preterm population assessed at term age.

When we analyzed the scores according to GA at birth, we found a narrow variability of neurological findings especially in infants born at 35 and 36 weeks GA. Their median scores were similar in 32 of the 34 items. In contrast, infants born at 34 weeks GA showed some differences compared to those born at 35 and 36 weeks, mainly in the tone items, in Moro reflex and visual orientation. This finding is consistent with our previous observation in very preterm infants suggesting that a longer extrauterine exposure to light and different stimuli can facilitate the ability to track a visual target. <sup>5,15</sup>

We were also interested to establish possible differences with full-term infants, by comparing our findings to reported normative data collected by our groups using the same assessment.<sup>2,3</sup> Full-term infants had a narrower range of scores as late-preterm but showed similar median scores in 25/34 item. Not surprisingly the main differences were in the tone items, with marked flexor tone in the limbs and better head control for full-term babies. The number of median scores similar to full-term infants increased to 29/34 if we only considered the infants born at 35 and 36 GA as those born at 34 weeks had a more immature tone than both 35 and 36 and full-term infants.

The pattern of neurological findings observed in infants born at 34 weeks examined at term age was in contrast, more similar to the neurological findings previously reported, using the same assessment, in very preterm infants. <sup>4,5</sup> When examined at term age, very preterm infants also had less flexor tone in the limbs, both on traction and recoil, a lower head control and a higher similar rate of brisk reflexes, stronger palmar grasps, startles and tremors.

Analysing the results subdivided according to GA at birth we were able to observe that not all the late-preterm infants have a similar neurological profile. While infants born at 34 weeks have at term age, a more immature profile, those born at the age of 35 weeks or after have a neurological profile that is more similar to that found in term-born infants. As in our cohort there was an equal distribution of minor US changes and of time at assessment at term age among the 3 subgroups subdivided according to gestational age at birth, we were able to exclude that our findings may be influenced by these variables, In contrast, the changes observed between infants born before and after 35 weeks GA are probably due to the critical period of brain growth and development occurring at this GA, related to the increasing of the volume of both gray and myelinated white matter.9,10

This data can help as reference data when examining latepreterm infants at term age to see where the individual child stands compared to age matched low risk infants and to identify signs that are outside the reported range in infants with lesions or other risk factors.

In a recent study<sup>8</sup> we have previously reported that late-preterm infants, when assessed at 6–12 months corrected age have a lower tone, compared to full-term infants assessed at the same age. Although this cohort is not the same than that assessed at 6–12 months, these results suggest that late-preterm infants may have a persistence of this tone pattern throughout the first year. Further prospective studies are needed to establish the correlation between neonatal and 12 months findings and to establish whether these infants may have minor neurological findings or motor coordination problems at school age.

### **Conflict of interest**

None of the authors have any conflicts of interest to declare.

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