



## Neonatal neurological examination of late preterm babies

Domenico M. Romeo <sup>a</sup>, Rita Luciano <sup>b</sup>, Mirta Corsello <sup>b</sup>, Daniela Ricci <sup>a</sup>, Claudia Brogna <sup>a</sup>, Antonio Zuppa <sup>b</sup>, Costantino Romagnoli <sup>b</sup>, Eugenio Mercuri <sup>a,\*</sup>

<sup>a</sup> Paediatric Neurology Unit, Catholic University, Rome, Italy

<sup>b</sup> Neonatal Unit, Catholic University, Rome, Italy

### ARTICLE INFO

#### Article history:

Received 8 August 2012

Received in revised form 25 December 2012

Accepted 7 January 2013

#### Keywords:

Late-preterm

Neurological assessment

Newborn

### ABSTRACT

**Backgrounds:** Healthy late-preterm (LP) infants examined at term equivalent age showed wider median and range of neurological scores than full-term infants; differences between infants born at 34 and those born at 35–36 weeks were also observed.

**Aims:** The aim of this study is to establish the range and frequency distribution of neonatal neurological scores in a cohort of low risk LP infants assessed during the first 3 days from birth.

**Study design and subjects:** 118 low-risk infants born between 34 and 36 weeks of gestational age (GA) were assessed between 48 and 72 h from birth.

**Outcome measures:** The full version of the Hammersmith Neonatal Neurologic Assessment and the screening proforma were used to assess all the infants. The raw scores obtained were compared to those of full-term infants using the same examination.

**Results:** The distribution of neurological scores was similar among the 3 GAs for 26 items, with different median scores among LP infants born at 36 weeks and those born at 34 and 35 in only 2 items.

LP infants showed a wider range of findings for each item than that of full term infants assessed soon after birth. Using the screening proforma, in our cohort, for each item the findings falling outside the 90% level were identical to those found in term-born and very preterm infants assessed at term age.

**Conclusions:** The neurological scores obtained in our cohort could help as reference data when examining LP infants at birth compared to age matched low risk infants.

© 2013 Elsevier Ireland Ltd. All rights reserved.

### 1. Introduction

The interest for late-preterm (LP) infants, thus infants born at 34.0 to 36.6 weeks of gestational age (GA), has increased in the last ten years with several studies published [1–8]. This population has increased progressively and it actually represents about 70% of the whole preterm population. They are generally considered at relatively low risk of developing neurological abnormalities compared to infants born at lower gestational age, but higher compared to term born infants [1–8]. In recent studies, LP infants showed slight but significant differences in neurological performances at term age compared to both term born and very preterm infants [2,7,8].

So far most of the studies, including our recent work on a screening proforma [9], report the spectrum of neurological findings of preterm infants assessed at term age. This screening proforma consists of 12 items, selected from the original proforma designed for the neurologic screening of full-term infants, and was adapted for preterm infants; the findings identified as ‘warning signs’ in preterm infants

were identical to those found in full-term infants, suggesting that this screening tool could also be used in preterm infants at term age [9]. In clinical practice however low risk late-preterm newborns are often discharged on the third or fourth day after birth and are not seen at term age and it would therefore be important to define the spectrum of neurological findings at the time of discharge.

Therefore the aims of the present study were: a) to establish the range and frequency distribution of neonatal neurological scores in a cohort of low risk late-preterm infants assessed during the first 3 days from birth using the full version of the Dubowitz neurological assessment; b) to assess whether the screening proforma designed for the neurologic screening of term born and preterm infants assessed at term age could be suitable for early assessment of late preterm infants.

### 2. Subjects and methods

Infants were recruited from the Neonatal Unit of the Gemelli Hospital (Rome, Italy) from October 2011 to June 2012.

Infants were consecutively enrolled when

1. they were born between 34.0 and 36.6 weeks of GA according to the first trimester ultrasound scans or, when not available, to the last

\* Corresponding author at: Paediatric Neurology Unit, Catholic University, Largo Gemelli 8, 00168 Rome, Italy. Tel.: +39 0630155340; fax: +39 0630154363.

E-mail address: [mercuri@rm.unicatt.it](mailto:mercuri@rm.unicatt.it) (E. Mercuri).

POSTURE	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) opisthotonus
ARM RECOIL	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
ARM TRACTION	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° & maintained as shoulder lifts	flexion of arms <100°; maintained when body lifts up
LEG RECOIL	No flexion ← →	incomplete or variable flexion	complete but slow flexion	complete fast flexion	legs difficult to extend; snap back forcefully
LEG TRACTION	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
POPLITEAL ANGLE	180°	≈ 150°	≈ 110°	≈ 90°	< 90°
HEAD CONTROL (1)	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 CONTROL (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
HEAD LAG	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
VENTRAL SUSPENSION	back curved, head & limbs hang straight	back curved, head ↓, limbs slightly flexed	back slightly curved, limbs flexed	back straight, head in line, limbs flexed	back straight, limbs above body

1	.5	2	.5	3	.5	4	.5	5	
4	0	22	0	56	7	11	0	0	34w
2	0	20	0	59	0	19	0	0	35w
2	0	17	2	64	2	13	0	0	36w
0	0	0	1	20	5	73	0	<1	LP at term*
0	0	0	0	6	3	90	1	0	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	30	0	37	0	33	0	0	34w
0	0	18	2	52	0	27	0	0	35w
0	0	10	0	72	0	18	0	0	36w
0	0	0	2	24	10	63	1	0	LP at term*
0	0	5	2	22	3	67	1	0	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	33	0	48	0	19	0	0	34w
0	0	14	2	50	0	34	0	0	35w
0	0	15	2	60	0	23	0	0	36w
<1	<1	6	2	38	7	46	0	0	LP at term*
0	0	1	0	22	8	69	0	0	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	11	0	41	0	48	0	0	34w
0	0	11	0	53	0	36	0	0	35w
0	0	4	2	43	0	51	0	0	36w
0	0	4	1	34	5	55	<1	<1	LP at term*
0	0	3	1	4	1	91	0	0	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	11	0	48	0	41	0	0	34w
0	0	12	0	50	0	36	0	2	35w
0	0	2	2	53	2	40	0	0	36w
0	0	3	3	29	1	64	0	0	LP at term*
0	0	0	1	12	12	72	0	3	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	22	0	63	4	11	0	0	34w
2	0	23	5	43	0	25	2	0	35w
0	0	13	0	72	2	13	0	0	36w
0	0	12	2	47	3	36	0	0	LP at term*
0	0	5	5	19	20	51	0	0	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	22	0	52	0	26	0	0	34w
0	0	14	7	57	0	23	0	0	35w
0	0	23	2	57	2	15	0	0	36w
0	0	5	1	45	10	39	0	0	LP at term*
0	0	0	6	26	12	56	0	0	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	11	0	59	0	30	0	0	34w
0	0	11	2	59	0	27	0	0	35w
0	0	17	2	62	0	19	0	0	36w
0	0	3	3	49	7	38	0	0	LP at term*
0	0	0	4	29	15	52	0	0	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	19	0	78	0	4	0	0	34w
0	0	20	7	55	2	16	0	0	35w
0	0	13	2	70	0	15	0	0	36w
1	0	10	3	53	10	23	0	0	LP at term*
0	0	9	4	44	12	31	0	0	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	15	0	85	0	0	0	0	34w
0	0	14	2	75	0	9	0	0	35w
0	0	13	4	74	0	9	0	0	36w
<1	0	7	4	53	15	20	0	0	LP at term
0	0	4	5	47	16	28	0	0	Full term

FLEXOR TONE		arm flexion less than leg flexion	arm flexion equal to leg flexion	arm flexion more than leg flexion but difference 1 column or less	arm flexion more than leg flexion but difference more than 1 column

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

menstrual period confirmed by Ballard's evaluation of GA [10]; neonates where excluded from the study in case of uncertain GA.

2. their cranial ultrasound scans were normal or showed only minimal abnormalities (transient flares or germinal layer haemorrhages) during the first postnatal week [11].
3. their clinical condition was stable during the first days after birth.

We excluded infants with major congenital anomalies, genetic or chromosomal abnormalities, metabolic disorders, congenital or neonatal infection or any sign of encephalopathy or seizures during their neonatal course, jaundice requiring phototherapy or respiratory distress. Informed consent was obtained for all infants.

### 3. Clinical examination

Neurological examination was performed and recorded using our standardised proforma [12], consisting of 34 items. Items were

grouped in six categories (tone, tone patterns, reflexes, movements, abnormal signs and behaviour).

The infants were examined undressed on an open bed or in their cot in a warm quiet room. Behavioural state, graded according to Brazelton criteria [13], 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 of sleep.

The proforma consists of numbered columns, between 3 and 5 for each item. If an item fell between 2 columns, it is 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 [12].

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 and preterm data [7,14], the distribution of the raw scores (the column circled) for the cohort of low risk infants was plotted for each item and the 10th centile taken as cut-off point.

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 birth subdivided according to their gestational age and those of full-term infants examined in the first 48 h after birth, as previously published [15]. 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.

The results of the preterm cohort were analysed according to their GA at birth: 34 weeks, 35 weeks, and 36 weeks.

All the infants were further assessed by using the screening proforma designed for the neurologic screening of term born and preterm infants assessed at term age [9].

The screening proforma consists of 12 items (Appendix A). With the exception of the last item which includes a number of neurologic abnormal signs scored using a choice of yes/no, all items are set out in 5 columns, with the two lateral columns reporting the findings that were considered “warning signs”, that is out of the reference range (90%).

Each infant was assessed between 48 and 72 h from birth.

All the infants included in this study had a similar level of care.

The study protocol was previously approved by the Ethics Committee of our institution.


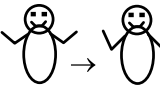
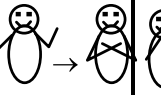


### 3.1. Statistical analysis

Comparison between the distribution of infants born at the 3 different GAs in the two groups subdivided according to neurological assessment (48 and 72 h) was done by a non-parametric test (Kruskal–Wallis test followed by Dunn's post test).

Comparison between cUS scan findings (normal vs minor abnormalities), neurological assessment (48 and 72 h) and genders for scores of each item was done by using the non-parametric test of Mann–Whitney U. The level of significance was set at  $p < 0.05$ .

## 4. Results

A total of 118 low-risk LP infants fulfilled the inclusion criteria. The infants were subdivided into 3 subgroups according to their

TENDON REFLEX	absent	felt, not seen	seen	'exaggerated'	clonus
SUCK / GAG	no gag / no suck	weak irregular suck only: No stripping	weak regular suck Some stripping	strong suck: (a)irregular (b)regular Good stripping	no suck but strong clenching
PALMAR GRASP	no response  R L	short, weak flexion of fingers  R L	strong flexion of fingers  R L	strong finger flexion, shoulder ↑  R L	very strong grasp; infant can be lifted off couch  R L
PLANTAR GRASP	no response  R L	partial plantar flexion of toes  R L	toes curve around the examiner's finger  R L		
PLACING	No response  R L	dorsiflexion of ankle only  R L	full placing response with flexion of hip, knee & placing sole on surface  R L		
MORO	no response or opening of hands only	full abduction at shoulder and extension of the arms; no adduction 	full abduction but only delayed or partial adduction 	partial abduction at shoulder and extension of arms followed by smooth adduction 	<ul style="list-style-type: none"> <li>no abduction or adduction;</li> <li>only forward extension of arms from the shoulders</li> <li>marked adduction only</li> </ul>  or 

1	.5	2	.5	3	.5	4	.5	5	
0	0	0	0	89	0	11	0	0	34w
0	0	2	0	84	0	14	0	0	35w
0	0	2	0	89	0	9	0	0	36w
0	0	16	<1	63	2	18	0	<1	LP at term*
<1	0	21	0	78	0	<1	0	<1	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	4	0	37	0	59	0	0	34w
0	0	0	0	35	0	65	0	0	35w
0	0	0	0	36	0	64	0	0	36w
0	0	1	0	11	0	88	0	0	LP at term*
0	0	1	0	5	0	92	0	2	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	4	0	52	0	44	0	0	34w
0	0	2	0	48	0	50	0	0	35w
0	0	4	0	57	0	38	0	0	36w
0	0	6	0	72	1	19	0	2	LP at term*
<1	0	6	0	84	0	9	0	<1	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	4	0	96	0	0	0	0	34w
0	0	2	0	98	0	0	0	0	35w
0	0	4	0	96	0	0	0	0	36w
0	0	3	0	97	0	0	0	0	LP at term*
<1	0	2	0	98	0	0	0	0	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	19	0	81	0	0	0	0	34w
0	0	10	0	90	0	0	0	0	35w
0	0	15	0	85	0	0	0	0	36w
0	0	10	0	90	0	0	0	0	LP at term*
1	0	18	0	81	0	0	0	0	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	7	0	56	0	37	0	0	34w
0	0	9	0	46	0	45	0	0	35w
0	0	2	0	53	0	45	0	0	36w
0	0	9	0	44	0	46	0	0	LP at term*
0	0	1	0	20	0	79	0	0	Full term

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

gestational age: 27 (12 females, 15 males) were born at 34, 44 (22 females, 22 males) at 35 and 47 (20 females, 27 males) at 36 weeks of gestation.

Of the 118 infants studied, 75 children were tested at 48 h from birth and 43 at 72 h, with no statistical difference ( $p>0.05$ ) in the distribution of infants born at different gestational ages (34, 35, and 36 weeks) in the 2 groups subdivided according to the time of the assessment.

No statistical difference was observed between the evaluation performed at 48 h and that at 72 h from birth for each item of the neurological assessment. One-hundred infants showed normal cranial US, 13 transient flares and 5 germinal layer haemorrhages. No statistical differences ( $p>0.05$ ) were reported for scores of each

item between infants with normal and those with minimal abnormalities on cUS or for gender.

#### 4.1. Tone items

##### 4.1.1. Range of scores and median score in the late-preterm infants – comparison of different gestational ages at birth

The range of the scores falling within the 90th centile in the 3 gestational age subgroups was similar in all the 10 items assessing tone, with the exception of leg recoil and traction and head lag. The median scores in the 3 subgroups were similar in all the items but 1 (Fig. 1).

**a**

SPONTANEOUS MOVEMENT (quantity)	no movement	sporadic and short isolated movements	frequent isolated movements	frequent generalised movements	continuous exaggerated movements
SPONTANEOUS MOVEMENT (quality)	only stretches	stretches and random abrupt movements; some smooth movements	fluent movements but monotonous	fluent alternating movements of arms + legs; good variability	<ul style="list-style-type: none"> <li>cramped synchronised ;</li> <li>mouthings</li> <li>jerky or other abn. mov.</li> </ul>
HEAD RAISING PRONE	no response	infant rolls head over, chin not raised	infant raises chin, rolls head over	infant brings head and chin up	infant brings head up and keeps it up

1	.5	2	.5	3	.5	4	.5	5	
0	0	33	0	41	4	19	0	0	34w
0	0	20	0	34	2	43	0	0	35w
0	0	28	0	36	0	36	0	0	36w
0	0	4	0	17	0	78	0	1	LP at term*
<1	0	3	0	5	0	92	0	<1	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	22	0	52	0	26	0	0	34w
0	0	23	0	51	2	23	0	0	35w
0	0	34	2	47	2	13	0	2	36w
1	0	6	0	15	0	77	0	1	LP at term*
2	0	5	0	<1	0	93	0	<1	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	52	0	44	0	4	0	0	34w
2	0	50	0	40	0	8	0	0	35w
0	0	57	0	38	0	4	0	0	36w
0	0	22	0	52	1	24	0	1	LP at term*
<1	0	10	0	50	0	40	0	<1	Full term

**b**

ABNORMAL HAND OR TOE POSTURES	hands open, toes straight most of the time	intermittent fisting or thumb adduction	continuous fisting or thumb adduction; index finger flexion, thumb opposition	continuous big toe extension or flexion of all toes.
TREMOR	no tremor or tremor only when crying	tremor only after Moro or occasionally when awake	frequent tremors when awake	continuous tremors
STARTLE	no startle even to sudden noise	no spontaneous startle but react to sudden noise	2-3 spontaneous startles	more than 3 spontaneous startles

1	.5	2	.5	3	.5	4	.5	5	
0	0	78	0	22	0	0	0	0	34w
0	0	70	0	25	0	5	0	0	35w
0	0	77	0	21	0	0	0	0	36w
0	0	72	0	24	0	4	0	0	LP at term*
0	0	85	0	12	0	3	0	<1	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	33	0	52	0	15	0	0	34w
0	0	28	0	58	2	12	0	0	35w
0	0	30	0	60	4	6	0	0	36w
0	0	77	0	20	0	3	0	<1	LP at term*
0	0	88	0	12	0	<1	0	<1	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	33	0	63	0	4	0	0	34w
0	0	39	0	59	0	2	0	0	35w
2	0	26	2	62	0	9	0	0	36w
18	0	69	0	10	0	3	0	0	LP at term*
<1	0	94	0	6	0	<1	0	<1	Full term

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

## 4.2. Tone patterns

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

The range of the scores falling within the 90th centile and the median scores were similar in the 3 gestational age subgroups in all the items assessing tone patterns (Fig. 2).

## 4.3. Reflexes

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

The range of scores falling within the 90th centile and the median scores were similar in the 3 gestational age subgroups in all the 6 items assessing reflexes (Fig. 3).

EYE APPEARANCES	does not open eyes		full conjugated eye movements	<i>transient</i> <ul style="list-style-type: none"> <li>nystagmus</li> <li>strabismus</li> <li>roving eye movements</li> <li>sunset sign</li> </ul>	<i>persistent</i> <ul style="list-style-type: none"> <li>nystagmus</li> <li>strabismus</li> <li>roving eye movements</li> <li>abnormal pupils</li> </ul>
AUDITORY ORIENTATION	no reaction	auditory startle; brightens and stills; no true orientation	shifting of eyes, head might turn towards source	prolonged head turn to stimulus; search with eyes; smooth	turns head and eyes towards noise every time; jerky abrupt
VISUAL ORIENTATION	does not follow or focus on stimuli	stills, focuses, follows briefly to the side but loses stimuli	follows horizontally and vertically; no head turn	follows horizontally and vertically; turns head	follows in a circle
	B T	B T	B T	B T	B T
ALERTNESS	will not respond to stimuli	when awake, looks only briefly	when awake, looks at stimuli but loses them	keeps interest in stimuli	does not tire (hyper-reactive)
IRRITABILITY	quiet all the time, not irritable to any stimuli	awakes, cries sometimes when handled	cries often when handled	cries always when handled	cries even when not handled
CONSOLABILITY	not crying, consoling not needed	cries briefly; consoling not needed	cries; becomes quiet when talked to	cries; needs picking up to console	cries cannot be consoled
CRY	no cry at all	whimpering cry only	cries to stimuli but normal pitch		High pitched cry; often continuous

1	.5	2	.5	3	.5	4	.5	5	
4	0	0	0	79	0	17	0	0	34w
6	0	0	0	68	0	26	0	0	35w
6	0	0	0	76	0	18	0	0	36w
4	0	0	0	91	1	4	0	0	LP at term*
7	0	0	0	92	0	1	0	<1	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	63	0	30	0	7	0	0	34w
2	2	58	0	31	0	5	0	0	35w
9	0	57	0	32	0	2	0	0	36w
3	0	22	0	64	0	11	0	0	LP at term*
<1	0	30	0	50	0	20	0	<1	Full term

1	.5	2	.5	3	.5	4	.5	5	
0	0	13	0	61	0	17	0	9	34w
0	0	8	0	59	0	28	0	5	35w
2	0	4	0	64	0	26	0	2	36w
0	0	8	0	41	10	41	0	0	LP at term*
<1	0	7	0	41	0	51	0	1	Full term

1	.5	2	.5	3	.5	4	.5	5	
11	0	11	0	56	0	22	0	0	34w
0	0	20	0	46	0	34	0	0	35w
9	0	11	0	66	2	11	0	0	36w
1	0	4	1	53	1	40	0	0	LP at term*
1	0	2	0	48	0	49	0	<1	Full term

1	.5	2	.5	3	.5	4	.5	5	
9	0	81	0	10	0	0	0	0	34w
7	0	65	0	28	0	0	0	0	35w
9	0	64	0	27	0	0	0	0	36w
7	0	86	0	5	0	1	0	<1	LP at term*
<1	0	93	0	5	0	2	0	<1	Full term

1	.5	2	.5	3	.5	4	.5	5	
15	0	74	0	11	0	0	0	0	34w
11	0	59	2	23	0	5	0	0	35w
9	0	60	2	22	0	7	0	0	36w
12	0	29	0	37	0	22	0	<1	LP at term*
1	0	41	0	45	0	12	0	<1	Full term

1	.5	2	.5	3	.5	4	.5	5	
11	0	56	0	33	0	0	0	0	34w
7	0	30	0	64	0	0	0	0	35w
9	0	37	0	54	0	0	0	0	36w
9	0	7	0	84	0	0	0	0	LP at term*
<1	0	7	0	92	0	0	0	1	Full term

Fig. 5. Behaviour. Refer to Fig. 1 for diagram interpretation. \*Romeo et al. 2011 [7].



#### 4.4. Movements

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

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

#### 4.5. Abnormal signs

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

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

#### 4.6. Behavioural items

##### 4.6.1. 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 3 gestational age subgroups in all the 7 items assessing behaviour with the exception of visual orientation, alertness, consolability and cry. The median scores were similar in all 3 subgroups for 6 of the 7 items (Fig. 5).

In Figs. 1 to 5, the data of scores of LP infants at term [7] are also included.

#### 4.7. Screening proforma

The findings falling outside the 90th centile were placed in the two lateral columns for all 12 items on the screening proforma (see Appendix A).

In the 118 LP infants, 70% had no warning signs, 13% had 1, 7% had 2 and 10% had > 2 “warning signs”. All the other infants had 0 or only 1 “warning sign”.

### 5. Discussion

This is the first study reporting the frequency distribution of the neonatal neurological findings in a low-risk late-preterm cohort assessed during the first 3 days of life.

The results showed a wide range of findings for each item that was wider than that reported in full term infants assessed soon after birth [12,15]. The differences appeared not to be related to the time of examination and only marginally to gestational age at birth.

As LP infants include infants born between 34 and 36 weeks, we subdivided the cohort into 3 subgroups according to the different GAs. Our findings suggest that in low-risk LP infants there is a

small impact of GA on neurological findings during the first 3 days from birth. The distribution of neurological findings were similar among the 3 GAs for 26 items, with different median scores among LP infants born at 36 weeks and those born at 34 and 35 in only 2 items.

As the infants previously reported in the study at term age were not the same infants assessed after birth in the present study [7], we cannot use the results as longitudinal data. Nevertheless, as both cohorts were assessed by the same examiners using the same assessments, we were able to compare the data and to notice some differences in the two cohorts. The two cohorts had a similar range of scores but those examined in the first days after birth had less mature performances in several items. More specifically, there was less axial tone in the majority of infants only holding the head for a few seconds and not maintaining it stably as observed at term age. Similarly leg tone also showed less flexor tone. Spontaneous motility was also slightly different with more brisk movements and stretches and less generalized movements than at term age and generally more signs of jitteriness with more tremors and startles than observed at term age.

Another interesting result of the present study is related to the possibility of using the screening proforma designed for the neurologic screening of term born and preterm infants assessed at term age [9] for LP infants during the first 3 days from birth.

In our cohort, for each item the findings falling outside the 90% level were identical to those found in term-born and very preterm infants assessed at term age, suggesting that the same proforma can be used as a screening tool for LP infants at birth; the 17% of this population showed 2 or more “warning signs”, and in clinical practice, these infants should be assessed using the full structured examination, needed for a detailed diagnostic or prognostic information [9].



































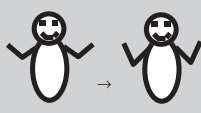
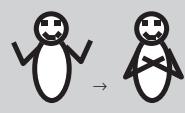


One of the strengths of the present study is that for the first time we assessed a population of preterm infants during the first days of life; these data could help as reference data when examining LP infants at birth to see where the individual child stands compared to age matched low risk infants. The differences in axial and limb tone, in movements and reflexes and in visual behaviour, compared to late preterm at term age suggest that the weeks between birth and term age are important for the maturation of these neurological aspects. This is confirmed by recent studies underlining that the main cortical grey and white matter development occurs during the last 6 weeks of gestation, and a possible immaturity of the brain of LP infants [16,17].

Longitudinal studies assessing preterm infants both at birth and at term age may help to further understand the extent of changes in these weeks.

#### Conflict of interest

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

## Appendix A

Short neurological proforma for newborn term infants and preterm infants at term equivalent age					
	Warning signs				Warning signs
POSTURE	arms & legs extended or very slightly flexed 	legs slightly flexed  For 25 - 27 weekers only	leg well-flexed but not adducted 	leg well flexed & adducted near abdomen 	abnormal posture: a) opisthotonus b) arm flexed, leg extended 
ARM TRACTION	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° & maintained as shoulder lifts 	flexion of arms <100°; maintained when body lifts up 
LEG TRACTION	legs straight - no resistance 	knees flex slightly or some resistance felt 	knees flex well till bottom lifts up 	knees flex and remain flexed when bottom up 	knee flexion stays when back+bottom up 
HEAD CONTROL (1)	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 CONTROL (2)	no attempt to raise head 	infant tries; effort better felt than seen  For 25 -29 weekers only	raises head but drops forward or back 	raises head: remains vertical; it may wobble 	head remains upright or neck extended; cannot be passively flexed
HEAD LAG	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 line of body 
VENTRAL SUSPENSION	back curved, head & limbs hang straight 	back curved, head slightly flexed, limbs slightly flexed 	back slightly curved, limbs flexed 	back straight, head in line with back, limbs flexed 	back straight, head above line of body 
SPONT. MOVEMENT (quality)	only stretches	stretches and random abrupt movements; some smooth movements	fluent movements but monotonous	fluent alternating movements of arms + legs; good variability	<ul style="list-style-type: none"> <li>cramped synchronised;</li> <li>mouthing</li> <li>jerky or other abnormal movement</li> </ul>
TREMOR		no tremor or tremor only when crying	tremor only after Moro or occasionally when awake	frequent tremors when awake	continuous tremors
MORO RESPONSE	no response or opening of hands only	full abduction at shoulder and extension of the arms; no adduction 	full abduction but only delayed or partial adduction 	partial abduction at shoulder and extension of arms followed by smooth adduction 	<ul style="list-style-type: none"> <li>no abduction or adduction</li> <li>only forward extension of arms from the shoulders</li> <li>marked adduction only</li> </ul>  
VISUAL ORIENTATION	does not follow /follows briefly to the side but loses stimuli B T	follows horizontally and vertically; no head turn B T	follows horizontally and vertically; turns head B T	follows in a circle B T	
ABNORMAL SIGNS	Facial Palsy Y N	Abn Eye Movements Y N	Sunset Sign Y N	Fisted hand (s) Y N	Clonus Y N



The central grey column reports the spectrum of neurologic findings within the reference range (90%); the lateral columns include all the warning signs to be considered. The last line “abnormal signs” has to be circled as yes (y) or no (n) for each sign [9].

## References

- [1] Harijan P, Boyle EM. Health outcomes in infancy and childhood of moderate and late preterm infants. *Semin Fetal Neonatal Med* 2012;17:159–62.
- [2] Mercuri E, Ricci D, Romeo DM. Neurological and visual assessments in very and late low-risk preterm infants. *Early Hum Dev* 2012;88(Suppl. 1):S31–3.
- [3] Teune MJ, Bakhuizen S, Gyamfi Bannerman C, Opmeer BC, van Kaam AH, van Wassenae AG, et al. A systematic review of severe morbidity in infants born late preterm. *Am J Obstet Gynecol* 2011;205:374.e1–9.
- [4] Samra HA, McGrath JM, Wehbe M. An integrated review of developmental outcomes and late-preterm birth. *J Obstet Gynecol Neonatal Nurs* 2011;40:399–411.
- [5] McGowan JE, Alderdice FA, Holmes VA, Johnston L. Early childhood development of late-preterm infants: a systematic review. *Pediatrics* 2011;127:1111–24.
- [6] Romeo DM, Guzzardi S, Ricci D, Cilauro S, Brogna C, Cowan F, et al. Longitudinal cognitive assessment in healthy late preterm infants. *Eur J Paediatr Neurol* 2012;16:243–7.
- [7] Romeo DM, Ricci D, Brogna C, Cilauro S, Lombardo ME, Romeo MG, et al. Neurological examination of late-preterm infants at term age. *Eur J Paediatr Neurol* 2011;15: 353–60.
- [8] Romeo DM, Ricci D, Serrao F, Gallini F, Olivieri G, Cota F, et al. Visual function assessment in late-preterm newborns. *Early Hum Dev* 2012;88:301–5.
- [9] Romeo DM, Ricci D, van Haastert IC, de Vries LS, Haataja L, Brogna C, et al. A screening neurological assessment tool for screening preterm infants at term age. *J Pediatr* 2012;161:1166–8.
- [10] Ballard JL, Khoury JC, Wedig K, Wang L, Eilers-Walsman BL, Lipp R. New Ballard Score, expanded to include extremely premature infants. *J Pediatr* 1991;119: 417–23.
- [11] Govaert P, De Vries L. An atlas of neonatal brain sonography. 2nd ed. Mac Keith Press; 2010.
- [12] Dubowitz LMS, Dubowitz V, Mercuri E. The neurological assessment of the preterm and full-term newborn infant. 2nd ed. Mc Keith Press; 1999.
- [13] Brazelton TB. Neonatal Behavioural Assessment Scale. Clinics in Developmental Medicine No. 50. London: Spastics International Medical Publications/William Heinemann Medical Books; Philadelphia: JB Lippincott Co. 1973.
- [14] Ricci D, Romeo DM, Haataja L, van Haastert IC, Cesarini L, Maunu J, et al. Neurological examination of preterm infants at term equivalent age. *Early Hum Dev* 2008;84: 751–61.
- [15] Dubowitz L, Mercuri E, Dubowitz V. An optimality score for the neurologic examination of the term newborn. *J Pediatr* 1998;133:406–16.
- [16] Adams-Chapman I. Neurodevelopmental outcome of the late preterm infant. *Clin Perinatol* 2006;33:947–64.
- [17] Kinney HC. The near-term (late preterm) human brain and risk for periventricular leukomalacia: a review. *Semin Perinatol* 2006;30:81–8 [Review].