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To Study the Plantar Response in Newborns and Determine Type of Response & Latency of Initiation, Optimal Response and Total Duration of Plantar Response

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Abstract:

Background: The plantar response in normal newborns is variably reported by numerous investigators. Much of the difference between studies depends upon methodology used. So the present study has been conducted to recognize the exact type of plantar response in newborn; the qualitative response, especially in consideration to gestational age, fetal growth, age after birth and gender, as well as quantitative aspect of plantar response, latency of initiation of response, duration of optimal response and total duration for completion of response

Method: The present study is cross sectional, observational study conducted in Newborn stabilization cum screening unit of Department of Pediatrics. The plantar response was elicited in 1000 normal healthy newborns, born after 34 completed weeks of gestation and who had weight of at least 1.8 kg and who had an uncomplicated transition from intrauterine to extra uterine life and remained healthy till the time of examination from 6 hrs to within 7 days of life. A firm mild nociceptive stimulation was employed utilizing thumbnail drag along the lateral aspect of the sole from the heel to the base of the 4th and the 5th toes.
The Examination was video graphed on a 12-megapixel camera and the captured videos were visualized on the monitor of laptop. Using time extension on VLC media player with accuracy of 1/60 of a second, the latency of onset, duration of optimization and total duration for plantar reflex were calculated.

Result: Extensor response was predominant response in 70.6% (1412 responses), followed by flexor 24.15% (483 responses) and equivocal response was minimum 5.25 % (105 responses). On comparing bilateral response, bilateral extensor response is predominant response 58.8%, followed by asymmetrical response25.3%, followed by bilateral flexor response12.2% and lastly bilateral equivocal response 3.7%.

ISSN: 0975-3583,0976-2833 VOL12,ISSUE05,2021

Male newborns demonstrated a little higher percentage of flexor response (26.2%) compared to females (22.6%). Preterm and post term babies had a lower frequency of extensor response (64.4% and 62% respectively) as compared to term babies (71.4%), while frequency of equivocal and flexor response was higher in preterm and post term babies**.** Small for gestational age babies had higher percentage of extensor response (72%) as compared to appropriate for gestational age babies (65.7%).

Latency of initiation of plantar response was found to be 0.492-0.5 second with a mean value of 0.496 seconds. Duration of optimization was found to be 0.847-0.857 seconds and mean value was 0.852 seconds. Total duration of plantar reflex was observed as 1.663-1.679 seconds and mean value was 1.671 seconds. Latency of flexor response was found to be higher than extensor response. This can be attributed to short latency of early and long latency of late reflexes.

Conclusion Extensor response was predominant response in 70.6%, followed by flexor 24.15% and equivocal response was minimum 5.25 %. On comparing bilateral response, bilateral extensor response is predominant response 58.8%, followed by asymmetrical response 25.3%, followed by bilateral flexor response 12.2% and lastly bilateral equivocal response 3.7%.

Further studies with larger number of observations can help to determine the normal range of values for plantar response and it can be used as reference value to assess sick newborns and to identify how these reflexes behave in different clinical conditions.

Keywords: Plantar Response, Newborns, Latency.
Study Design: Cross Sectional Observational Study.

1. INTRODUCTION

The primitive reflexes constitute one of the earliest, simplest, and most frequently used tools to assess the central nervous system integrity of infants and young children.[1]

Primitive reflexes are stereotypic motor responses to various stimuli that develop before birth and disappear during early infancy in a predictable pattern.

Primitive reflexes are brainstem-mediated, complex, automatic movement patterns that commence as early as the twenty-fifth week of gestation, are fully present at birth in term infants, and with central nervous system maturation become more and more difficult to elicit after the first half of the first year of life, when voluntary motor activity and thus cortical inhibition emerges and takes over.[2-4]

The major primitive motor reflexes or patterns that have been described include Moro, palmar and plantar grasp, plantar reflex, rooting, sucking, placing, Moro, Galant (or truncalincurvation), asymmetric tonic neck reflex, crossed extensor, tonic labyrinthine reflex, and others.[5]

As per Landau[6], special emphasis should be placed on the plantar response of the infant, which is a polysynaptic response elicited by stroking along the lateral aspect of the foot from heel to toe.

The plantar reflex is a nociceptive segmental spinal reflex that serves the purpose of protecting the sole of the foot. Joseph Francois Felix Babinski, in 1896, first described the plantar response in lesions of the corticospinal tract in adults.[7] Stimulation of the outer edge

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of the sole of the foot produced extension of the great toe in such patients, contrary to the flexor response observed in healthy adults.

Illingworth[8] described the plantar response in healthy term newborn to be flexor. He examined the babies at 6 week of age and found that reflex to be almost invariably flexor unless the child has cerebral palsy of the spastic type.

Hutchison's Clinical Methods describes the traditional extensor response to be a normal response in early infancy and that the flexor response appears in the subsequent 6–12 months as myelination of the corticospinal tract is completed. [9]

Volpe, in his *Neurology of the Newborn*, mentions that the plantar reflex is usually stated to be extensor.[10]

Conclusions of previous investigations of the plantar response in normal newborns are conflicting. So the present study has been conducted to recognize the exact type of plantar response in newborn.

Many studies in past have been conducted for assessment of qualitative aspect of plantar reflex but a few studies have been done to assess the quantitative aspect of the reflex. The present study has been done to determine the plantar response in newborns; the qualitative response, especially in consideration to gestational age, fetal growth, age after birth and gender, as well as quantitative aspect of plantar response, latency of initiation of response, duration of optimal response and total duration for completion of response

Aims and Objectives:

To study the plantar response in newborns and determine:

a) Type of response
b) Latency of initiation of response
c) Duration of optimal response.
d) Total duration for completion of response

2. MATERIAL & METHODS:

The present study is a cross sectional, observational study conducted in "Newborn stabilization cum screening unit" of Department of Pediatrics, S.S. Medical College, Rewa, M.P. during period of 01 year from June 2015 to May 2016. Institutional Ethical Committee approval was taken. The sample size of 1000 newborns fulfilling the inclusion criteria were enrolled for the study after parental consent.

Inclusion criteria were normal healthy newborns who had an uncomplicated transition from intrauterine to extra uterine life and remained healthy till the time of examination. Baby born after 34 completed weeks of gestation and who had weight of at least 1.8 kg were included in study. The gestational age was assessed by maternal last menstrual period, by first trimester ultrasound scan and New Ballard Score after birth. Both vaginally delivered (normal and assisted) and those born through LSCS are included in study. Babies of both primi and multiparous mothers are included.

Detailed antenatal and intrapartum history with complete general physical and systemic examination with particular attention to maternal nutritional status, hemoglobin, clinical examination, body weight and general appearance of mother was carried out prior to the enrolment.

ISSN: 0975-3583,0976-2833 VOL12,ISSUE05,2021

Weight of baby was taken and assessed with modified Fenton's intrauterine growth charts46 provided in neonatal case sheet of department. Babies were categorized in 3 groups.

- SGA (Small for gestational age): weight less than 10th centile for gestation.
- LGA (Large for gestational age): weight more than 90th centile for gestation.
- AGA (Appropriate for gestational age): weight between 10th-90th centile for gestation.

Exclusion criteria were newborn who required admission in NICU, newborn born to mother with long term major antenatal complications leading to fetal compromise, newborn with any abnormality in vital parameter, newborn with any abnormality in head to toe examination or having any sign of illness.

Neonates having pathological jaundice, perinatal risk factors, infections, asphyxia, respiratory distress, congenital heart disease, congenital anomalies, facial dysmorphism, evidence of external injury such as fracture of the clavicle, spinal cord injury, Erb's paralysis, or any other neurological abnormality including neural tube defects and hydrocephalus were excluded from the study.

The examination of newborn is highly dependent on his state of alertness, as it powerfully influences the way infants respond at any given time.

Brazelton[47] described 6 stages for alertness of baby based on the Characteristic behaviors seen in individual states including Body activity, Eye movement, Facial movements, Breathing pattern, Level of response to external and internal stimuli. Stage 4 is state of quiet alertness; during this infants are most attentive to their environment, focusing their attention on any stimuli that are present: nipple, voice, face, or moving objects. Stage 5 is state of active alertness, during this infant's eyes are open, but their eyes and faces are not as bright as in quiet alert. Infants have more body activity in active alert than they do in quiet alert.

It was ensured that babies were examined in state 4 or state 5 of alertness.

Before starting the study, a thorough understanding was obtained about the reflex and method of elicitation and pilot study was conducted in 30 patients by examiner.

The plantar reflex was elicited while the neonate was in brazelton stage 4 (quite wakeful state) or stage 5 (active wakeful state) 1–2 h after the feed, placed supine with head in the midline and legs extended or held in extension at the knee. All responses were elicited and recorded by the same observer to minimize interobserver bias. With the foot perpendicular to the leg and the toes in neutral position, firm but mild nociceptive stimulation (stimuli that are noxious or at least potentially harmful) was employed utilizing drag of the thumbnail along the lateral aspect of the sole from the heel to the base of the 4th and the 5th toes. In order to minimize proprioceptive bias, care was taken not to apply pressure on the subject's lower leg or foot. Any contact on the dorsum of the foot was also avoided. The response was elicited in the right foot first followed by the left foot.

The movement of the great toe was observed. If it moved upwards, the response was graded as extensor; if it moved downwards, it was graded as flexor; and if there was no movement of the great toe, the response was graded as equivocal. All three responses for a single observation were added for each foot separately.

The Examination was video graphed on a 12-megapixel camera (make SONY, model cyber shot) and the captured videos were visualized on the monitor of laptop (13 inch, make APPLE). Using time extension on VLC media player with accuracy of 1/60 of a second, the latency of onset, duration of optimization and total duration for plantar reflex were calculated.

ISSN: 0975-3583,0976-2833 VOL12,ISSUE05,2021

Statistical Analyses

The percentage of extensor, flexor and equivocal responses was calculated for each foot separately and P value calculated using chi square test. P values of <0.05 were considered statistically significant.

The mean value for all the observations in each category (initiation, optimization, completion) is calculated separately and standard deviation from the mean is noted utilizing Anova test.

3. RESULTS

Total 1000 newborns were studied within first 7 days of birth. Plantar response was elicited on both feet.

Most of the newborns 74.6% (n=746) had age of mother between 20-35 yrs of age, 22.9% (n=229) had mother's age <20 yrs whereas 2.5% (n=25) had maternal age >35 yrs.

64% (n=640) mothers were primiparous, while 36 % (n=360) were multiparous.

Table 01: Type of plantar response

Type of response	**Frequency**	**Percentage**
Extensor	1412	70.6
Flexor	483	24.15
Equivocal	105	5.25
Total	**2000**	

Extensor response was predominant response in 70.6% (1412 responses), followed by flexor 24.15% (483 responses) and equivocal response was minimum 5.25 % (105 responses).

Table 02: Type of plantar response according to foot

	Right Foot	**Left Foot**
Type of response	**Frequency**	**Frequency**
Extensor	712(71.2%)	700(70%)
Flexor	228(22.8%)	255(25.5%)
Equivocal	60(6%)	45(4.5%)
P value	**0.15**	

In our study, we first examined right foot, followed by left foot. We found no statistical difference with foot examined first.

Table 03: Description of bilateral response

Type of response	**Frequency**	**Percentage**
B/l extensor	588	58.8
B/l flexor	122	12.2
B/l equivocal	37	3.7
Asymmetrical	253	25.3
Total	**1000**	

ISSN: 0975-3583,0976-2833 VOL12,ISSUE05,2021

Bilateral extensor response was predominant response 58.8%, with high percentage 25.3% of asymmetrical response, bilateral flexor response was noted in 12.2% and bilateral equivocal response in 3.7% observed in the study.

Table 04: Sex wise distribution of plantar response

	Equivocal	**Extensor**	**Flexor**	**Total**
Male	43(4.2%)	720(70.2%)	263(26.2%)	1026
Female	62(6.3%)	692(71.3%)	220(22.6%)	974
P Value	**0.039**			

Male baby demonstrated a little higher percentage of flexor response (26.2%) compared to females (22.6%). While female babies showed a little higher percentage of equivocal response (6.3%) compared to males (4.2%).

Table 05: Gestational age wise distribution of plantar response

	Equivocal	**Extensor**	**Flexor**	**Total**
Preterm	10(7.4%)	87(64.4%)	35(26%)	132
Term	87(4.9%)	1258(71.4%)	415(23.6%)	1760
Post term	8(7.4%)	67(62%)	33(30.6%)	108
P- Value	**0.15**			

Preterm and post term babies had a lower frequency of extensor response as compared to term babies. While frequency of equivocal and flexor response was higher in preterm and post term babies**.**

Table 06: Distribution of plantar response according to fetal growth

	Equivocal	**Extensor**	**Flexor**	**Total**
SGA	30(6.1%)	351(72%)	107(22%)	488
AGA	75(5.8%)	861(65.7%)	376(28.3%)	1312
P Value	**0.016**			

Small for gestational age babies had higher percentage of extensor response (72%) as compared to appropriate for gestational age babies (65.7%). Percentage of flexor response was lower in SGA babies (22%) as compared to AGA babies.

Table 07: Distribution of plantar response according to age at the time of examination

	Equivocal	**Extensor**	**Flexor**	**Total**
6-12 hours	8(2.6%)	226(73.3%)	74(24%)	308
12.1-24 hours	26(2.9%)	640(70.8%)	238(26.3%)	904
24.1-72 hours	68(10%)	466(68.6%)	146(21.4%)	680
72.1- 168 hours	3(2.8%)	80(74%)	25(23.1%)	108
P value	**<.0001**			

ISSN: 0975-3583,0976-2833 VOL12,ISSUE05,2021

Babies who were examined between 12-24 hours had highest percentage of flexor response (26.3%) compared to other groups. While babies examined between 24-72 hours had highest percentage of equivocal response amongst groups. Babies examined after 72 hours after birth had maximum percentage of extensor response (74%).;

Table 08: Latency of initiation, optimization and total duration of plantar reflex

		Initiation	**Optimization**	**Total duration**
Sample size		1895	1895	1895
Mean (Sec)		0.496	0.852	1.671
SD		0.084	0.108	0.175
SE		0.002	0.002	0.004
95% confidence interval (Sec)	Upper limit	0.5	0.857	1.679
	Lower limit	0.492	0.847	1.663

Latency of initiation of plantar response was calculated to be 0.492-0.5 second. Mean value is 0.496 seconds. Duration of optimization was calculated to be 0.847-0.857 seconds and mean value was calculated 0.852 seconds. Total duration of plantar reflex was calculated as 1.663-1.679 seconds and mean value was 1.671 seconds.

Table 09: Latency of initiation of plantar response

		Extensor	**Flexor**
Sample size		1412	483
Mean (Sec)		0.49	0.516
SD		0.084	0.082
SE		0.002	0.004
95% confidence interval (Sec)	Upper limit	0.494	0.52
	Lower limit	0.486	0.505
P Value		**<.0001**	

Latency of extensor plantar response was lower than flexor response. For extensor, latency was calculated to be 0.486-0.494 seconds, whereas while latency of flexor response was calculated to be 0.505-0.52 seconds. The difference was found to be statistically significant.

4. DISCUSSION

Total 1000 newborns were studied within first 7 days of birth. Plantar response was elicited on both feet. Majority of newborns belongs to mother of age 20-35 (74.6%) years. There was also a significant percentage (22.9%) of mothers less than 20 years. Most of the mothers (64%) were primiparous. 34% of mothers did not have adequate antenatal visits. Male to female ratio was approximately 1.05:1. Majority of babies (74.3%) were delivered by normal vaginal delivery while approximately 1/4th (22.8%) were delivered by caesarian section. In the study, 28.8% of mothers had hemoglobin <11gm/dl.

Majority of babies (88%) were full term, while 6.6% were <37 weeks and 5.4% were >42 weeks. Gestational age wise analysis of plantar response was also done. Babies were

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examined from age of 6 hours up to 7 days. Majority of babies (45.2%) were examined between 12-24 hours while 34% between 24 hours to 3 days. Approximately 1/4th of the babies were SGA (24.4%) while 75.6% were AGA.

The overall plantar response was found to be predominantly extensor (70.6%), followed by flexor (24.15%) and, finally, equivocal (5.25%).

Gupta et al [11] in his study using similar methodology found almost similar percentage of extensor response (73.8%) but frequency of flexor response in our study was found to be significantly higher than Gupta et al (8.9%) and frequency of equivocal response was significantly lower than their study (17.3%).

On comparing bilateral response it was found that bilateral extensor response is predominant response (58.8%), followed by asymmetrical response in 25.3%, followed by bilateral flexor response in 12.2% and lastly bilateral equivocal response in 3.7%.

Gupta et al[11] in his study found that bilateral extensor response was predominant response but the percentage of bilateral extensor response was higher than our study. They observed bilaterally extensor plantar response in 72.5% compared to our study's 58.8%.

In our study, we found high frequency of asymmetrical response (25.3%), which constituted approximately 1/4th of total response. Kumharetetal[12] in his study found almost similar percentage (20.7%) of asymmetrical response. The percentage of asymmetrical flexor response is quite high in our study (12.2 %) compared to Gupta et al[11](5.4%) in Indian neonates.

Landau[13] explained that extensor plantar response in newborns is not same as Babinski sign observed in adults. In healthy newborn infants, this extensor reflex behavior is best understood as evidence that normally functioning cerebral structures are still evolving.

In our study, we first examined right foot, followed by left foot. We found no statistical difference with foot examined first.

In our study, latency of initiation of plantar response was found to be 492-500 milliseconds. Mean value of initiation was calculated as 496 milliseconds (SE- .002). Duration of optimal response was found 847-857 milliseconds. Mean value of duration of optimal response was found 852 milliseconds (SE- .002).Total duration of plantar response was found to be 1663-1679 milliseconds. Mean value of total duration was calculated as 1671 milliseconds (SE-.004).

Our value of 492-500 milliseconds was significantly higher than those obtained by MF Vecchierini-Blineau et al[14]. MF Vecchierini-Blineau studied latency of plantar reflex by using electrical current as stimulus and latency was calculated by recording contraction of tibialis anterior by electromyography. In his study, he found latency of plantar response to be 119±23.5 milliseconds in active wakeful state. In active wakefulness, latencies were 10 to 20 milliseconds shorter than in quiet wakefulness. The variation may be due to difference in state of alertness, difference in strength and type of stimulation, different method of recording plantar response and different method of analysis.

Bijesh[15] in his study found latency of initiation of plantar reflex to be 580-750 milliseconds, duration of optimization to be 920-1070milliseconds and total duration to be 1310-1500milliseconds. The values of initiation and optimization were higher and total duration was lower than our study. Pin drag was used as stimulus. Duration of flexor and extensor response was not separately recorded. Lower sample size and difference in method of elicitation might be the reason for these minor discrepancies in calculated values.

In this study, the latency for flexor and extensor response was separately calculated. Latency of initiation of flexor response was little higher as compared to extensor response. Latency of initiation of extensor response was calculated as 0.486 to 0.492 seconds and mean

ISSN: 0975-3583,0976-2833 VOL12,ISSUE05,2021

value was 0.49 seconds while latency of initiation of flexor response was calculated to be 0.505 to 0.520 seconds and mean value was calculated as 0.516 seconds. The difference in latency of initiation of flexor and extensor response was statistically significant.

5. CONCLUSION

Extensor response was predominant response in 70.6%, followed by flexor 24.15% and equivocal response was minimum 5.25 %. On comparing bilateral response, bilateral extensor response is predominant response 58.8%, followed by asymmetrical response 25.3%, followed by bilateral flexor response 12.2% and lastly bilateral equivocal response 3.7%.

Male newborns demonstrated a little higher percentage of flexor response (26.2%) compared to females (22.6%). Preterm and post term babies had a lower frequency of extensor response(64.4% and 62% respectively) as compared to term babies(71.4%), while frequency of equivocal and flexor response was higher in preterm and post term babies**.** Small for gestational age babies had higher percentage of extensor response (72%) as compared to appropriate for gestational age babies (65.7%).
Latency of initiation of plantar response was found to be 0.492-0.5 second with a mean value of 0.496 seconds. Duration of optimization was found to be 0.847-0.857 seconds and mean value was 0.852 seconds. Total duration of plantar reflex was observed as 1.663-1.679 seconds and mean value was 1.671 seconds. Latency of flexor response was found to be higher than extensor response. This can be attributed to short latency of early and long latency of late reflexes.
Further studies with larger number of observations can help to determine the normal range of values for plantar response and it can be used as reference value to assess sick newborns and to identify how these reflexes behave in different clinical conditions.

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