

Variability of plantar response in normal population

Ri An Lee *MBBS*, Li Lian Tay *MBBS*, Kheng Seang Lim *MBBS MRCP*, CT Tan *FRCP MD*

Division of Neurology, Faculty of Medicine, University of Malaya, Kuala Lumpur, Malaysia

Abstract

Background: There is lack of normality data in the literature on the plantar response. **Objective:** To determine the variability of plantar response in normal population and factors that might contribute to the variability. **Methods:** We conducted a study of plantar response in healthy subjects aged 19-21 in two phases. First phase was plantar examination with hard strike. Subjects with big toe extension in the first phase were re-examined with light and hard strike in the second phase. **Results:** 100 subjects recruited in first phase, 19 subjects in second phase. Out of 600 attempts (3 attempts for each foot) with hard strike, responses of the big toe were flexion (48.3%), extension (11.3%), no movement (39.8%); other toes were flexion (55.0%), extension (13.0%), no movement (32.0%); ankle was dorsiflexion (30.8%), no movement (59.3%); knee were flexion (15.7%), no movement (84.3%); hip were flexion (15.2%), no movement (84.8%). Of those with big toe extension, significantly less had persistent big toe extension with light strike. More (41%) among those with extensor big toe has withdrawal response (with flexion of the hip and knee) as compared to those with flexor big toe (18.5%, $p < 0.05$). Inter-foot asymmetry was seen in 27% ($\kappa = 0.54$). Plantar responses of sequential strikes were mostly consistent, with only 3.5% inter-attempt variability.

Conclusion: Plantar response with extensor great toe is seen in about 10% of normal adults, less with lighter strike. Withdrawal response can be a partial explanation to the big toe extensor response in normal adults.

INTRODUCTION

Since its introduction to neurology by Joseph Babinski in 1898¹, the Babinski's sign becomes a well-known sign to demonstrate upper motor neuron lesion. However, there is lack of normality data in the literature.

Extensor plantar response can occur in normal population. Study showed that as high as ten percent of patients without history or clinical signs of pyramidal dysfunction had extensor plantar reflex, either unilaterally or bilaterally.² Schüller recorded the presence of Babinski's sign in 6% of healthy men and women. Critchley M commented on the presence of Babinski's sign in healthy elderly patients³, and Kaye reported a prevalence of 5.9% in those aged 65 and 74 years.⁴ Big toe extension in normal individual is usually claimed to be a withdrawal response to nociceptive and ticklish stimulation. Despite its clinical importance, it was only recently that withdrawal response was systemically characterized. A study by our group has shown that withdrawal response can be variable, and is mostly characterized by flexion of toes, dorsiflexion of ankle with knee and hip flexion, but 5% of the subjects has big toe extension.⁵

The reliability and validity of this sign is also a controversy. Three studies, with one blinded to the diagnosis, reported poor inter-rater reliability.⁶⁻⁸ There is only one study, based on assessment of a single unblinded examiner, reporting excellent reliability and validity.⁹

Thus, we performed this study to determine the plantar responses in normal young adults, and the factors that may contribute to the variability.

METHODS

One hundred young medical students in University of Malaya at the age of 19-24 were recruited; 61% were male; 78% ethnic Chinese, 20% Malays and 2% Indian. All subjects had no known neurological problem and clinically no weakness or wasting of the limbs. The study protocol was approved by the Hospital authority. Consent was obtained from all subjects prior to the study. Plantar reflex examination was performed using Babinski's method with orange stick, by striking the lateral sole from the heel towards the base of the big toe. The assessors first went through an intensive training to familiarize themselves with the methods of examination and documentation

of findings, and their skills were evaluated by a neurologist prior to the initiation of the project. All responses were video-taped to be reassessed by the neurologist. For the study proper, a blinded assessment of the plantar response by two independent assessors was performed, to determine inter-assessor variability, on 32 subjects. A blinded rating of the video-recorded plantar response, to determine the inter-rater variability, was performed by two independent raters in 68 subjects.

Each subject was assessed for 3 attempts each foot. Study was conducted in two phases. First phase was plantar examination with hard strike. For those with big toe extension in the first phase, they were re-examined with light strike, followed by hard strike in the second phase. Hard strike is the plantar response performed where the examiner held the stick at the end near the foot; light strike is the plantar response performed with the stick held in the middle. All findings were documented as followed: (1) big toe extension, flexion, or no movement, (2) other toes extension, flexion or no movement, (3) ankle dorsiflexion or plantarflexion, additional movement such as eversion or inversion, or no movement, and (4) knee and hip flexion or no movement. If a subject has sequential responses on a joint, only the first movement was documented (e.g. if the big toe flexed and then extended, the response was documented as flexion).

Data analysis was performed using SPSS statistical package version 16.0. Chi squared (χ^2)

tests were used in the analysis of proportions. Statistical significance implied p -value < 0.05 unless otherwise stated.

RESULTS

Out of 600 attempts in first phase, the commonest plantar responses in normal young adults were flexion in big toe (48.8%) and other toes flexion (55.0%), no movement in ankle (55.8%), knee and hip (79.4%), as shown in Table 1. Big toe extension was seen in 11.3% of the attempts. Of the 100 subjects, 24 (14 male and 7 female) had big toe extension in one or both feet in at least one attempt. Of those with big toe extension in first phase, 19 subjects agreed to participate in the second phase of study with light and hard strike. Of the 114 attempts, significantly more hard strikes (21.1%) as compared to light strikes (14%) induced big toe extension (Table 2). Only 21.1% of the subjects had reproducible big toe extension with light strike when they were examined on a separate day.

Big toe extension was significantly more likely to be associated with extension of other toes (80.9%), ankle dorsiflexion (86.8%), knee and hip flexion (41.2%), as compared to big toe flexion (3.8%, 31.8% and 18.5% respectively, Table 3). These differences were also seen in the second phase of the study with both hard and light strike.

Plantar response was absent in 29.2% of the attempts. The prevalence of absent plantar

Table 1: Plantar response according to gender in first phase of the study

First phase (Hard strike)		Male, n=378		Female, n=222		<i>p</i>	Total	
		n	%	n	%		n	%
Big toe	Extension	37	9.8	31	14.0	NS	68	11.3
	Flexion	198	52.4	95	42.8		293	48.8
	No movement	143	37.8	96	43.2		239	39.8
Other toes	Extensor	39	10.3	39	17.6	<0.01	78	13.0
	Flexion	229	60.6	101	45.5		330	55.0
	No movement	110	29.1	82	36.9		192	32.0
Ankle	Dorsiflexion	130	34.4	55	24.8	NS	185	30.8
	Plantarflexion	7	1.9	2	0.9		9	1.5
	Others	30	7.9	20	9.0		50	8.3
	No movement	211	55.8	145	65.3		356	59.3
Knee and hip	Flexion	78	20.6	16	7.2	<0.001	94	15.7
	No movement	300	79.4	206	92.8		506	84.3
Absence plantar response		68	18	66	29.7	<0.01	134	22.3

NS, not significant

Table 2: Plantar responses using light strike and hard strike in 19 subjects with big toe extension in first phase of study

		Second phase light strike, n=114		Second phase hard strike, n=114		<i>p</i> (Light vs. hard strike in 2 nd phase)
		n	%	n	%	
Big toe	Extension	16	14.0	24	21.1	<0.0001
	Flexion	57	50.0	77	67.5	
	No movement	41	36.0	13	11.4	
Other toes	Extension	21	18.4	15	13.2	<0.01
	Flexion	60	52.6	82	71.9	
	No movement	33	28.9	17	14.9	
Ankle	Dorsiflexion	25	21.9	48	42.1	<0.01
	Plantarflexion	19	16.7	27	23.7	
	Others	1	0.9	0	0	
	No movement	69	60.5	39	34.2	
Knee and hip	Flexion	23	20.2	30	26.3	NS
	No movement	91	79.8	84	73.7	
Absent plantar response		28	24.6	15	13.2	<0.05

NS, not significant

response was significantly higher in female (29.7% vs 18% in male, $p < 0.01$, Table 1) and with light strike (24.6% vs. 13.2% in hard strike, p -value < 0.05 , Table 2) in second phase.

The consistency of the plantar response in individual foot, in first and second phase of study is listed in Table 4. More than 80% of the subjects have consistent big toe responses in 3 sequential attempts (i.e. 80.5% in first phase, 86.8% in second phase light strike and 84.2% in second phase hard strike). Of those with big toe extension, the responses were consistent in 29 subjects (85.3%) in at least 2 sequential attempts.

Inter-foot variability was determined by comparing the big toe response between left

and right foot. 216/300 (72%) attempts had symmetrical big toe response. However, only 19/43 attempts (44.2%) with big toes extension had symmetrical response (vs. 76.7% in those with other big toe response, $p < 0.0001$). Similar level of inter-foot variability was noted in second phase of the study with light and hard strike. (Table 5)

Independent assessment of big toe response in 32 subjects was consistent in 65.6% (42/64 feet) with a moderate inter-assessor reliability (kappa 0.43). Independent rating of video-recorded big toe response in 68% showed consistent result in 79.4% (108/136 feet), with a substantial kappa of 0.62.

Table 3: Correlation of big toe movement with extension of other toes, ankle dorsiflexion and knee-hip flexion in first phase of the study (n=600)

	Big toe extension	Big toe flexion	<i>p</i>
Extension of other toes	55 (80.9%)	11 (3.8%)	<0.0001
Ankle dorsiflexion	59 (86.8%)	93 (31.7%)	<0.0001
Knee-hip flexion	28 (41.2%)	54 (18.5%)	<0.0001

Table 4: Consistency of the plantar response in individual foot, in first and second phase of the study

	Not consistent in all 3 attempts, n (%)	Consistent for 2 sequential attempts, n (%)	Consistent throughout 3 attempts, n (%)
First phase hard strike, n= 200 feet	7 (3.5%)	32 (16%)	161 (80.5%)
Big toe extension, n= 34 feet	5 (14.7%)	17 (50%)	12 (35.3%)
Second phase light strike, n= 38 feet	0	5 (13.2%)	33 (86.8%)
Second phase hard strike, n= 38 feet	1 (2.6%)	5 (13.2%)	32 (84.2%)

DISCUSSION

This study on plantar response in healthy young adult shows that the plantar stimulation induces variable responses in the lower limbs, the most prevalent being flexion of big toe and other toes flexion, absence of movement in ankle, knee and hip.

We have confirmed that 11.3% of the big toe responses to plantar stimulation were extensor. This is compatible with published data of 5-10%.³⁻⁴ We have also shown that of those with big toe extension, with lighter strike, significantly less had persistent big toe extension. This is consistent with the advice by experienced physicians such as in DeJong, that "It is not true that the stimulus must necessarily be deliberately 'noxious'... The stimulus should be firm enough to elicit a consistent response but as light as will suffice."¹⁰ Our study also support the practice that those with big toe extension, should have the test repeated with lighter strike, as mentioned in DeJong, "When the response is strongly extensor only minimal stimulation is required".¹⁰

Big toe extension in normal individual is usually claimed to be a withdrawal response to nociceptive and ticklish stimulation.¹⁰ We have shown that big toe extension was significantly associated with ankle dorsiflexion, knee flexion

and hip flexion, which are manifestations of withdrawal response.⁵ However, close to 60% of those with big toe extension do not have knee-hip flexion, which are essential features of withdrawal response. Our study thus gives support to withdrawal response as a partial explanation to the big toe extensor response in some of the normal adults. Our previous study also showed an association between fear and ticklish stimulation induced withdrawal response and extension of big toe. It thus emphasizes the importance of making patient comfortable and relaxed during neurological examination.⁵

We have confirmed that absent plantar response is common, close to a third during our first phase of study. We are unable to explain its higher prevalence among females. As we have shown that absent responses is more common with lighter strike, those with absent response should have the plantar response repeated with stronger stimulus.¹⁰

We have also shown that big toe extensor response was reproducible in 2 to 3 sequential attempts in majority (85%) of the subjects. However, when tested on separate day, the reproducibility reduced to 21%. It supports the clinical practice of repeating the examination on a separate day, among those with extension of big toe.

Table 5: Prevalence of symmetrical of big toe response in first and second phase of the study

	First phase hard stroke, % (n/total attempts)	Second phase light stroke, % (n/total attempts)	Second phase hard stroke, % (n/total attempts)
Overall	72 (216/300)	77.2 (44/57)	73.6 (42/57)
Big toe extension	44.2 (19/43)*	45.5 (5/11)	35.3 (6/17)

*The prevalence of symmetrical response was significantly lower in those with big toe extension, as compared to other big toe response (p -value <0.0001).

In our study, plantar response was symmetrical in most subjects. However, asymmetrical plantar response in normal adults is not uncommon, seen in close to 30% of attempts. Inter-assessor reliability was moderate with kappa of 0.62, slightly higher than the published result, probably because it was only single-blinded between assessors but not the subjects' health condition.

In conclusion, 11% of the normal young adults had big toe extension, its prevalence reduced with lighter strike and when examined on a separate day. The big toe extension can be partially explained by physiological withdrawal response.

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