MEDIAN NERVE SOMATOSENSORY EVOKED POTENTIALS

STUDIES ON LATENCY VARIABILITY AS A FUNCTION OF SUBJECT HEIGHT, LIMB LENGTH AND NERVE CONDUCTION VELOCITY

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SUMMARY — Report on the results of regression analysis studies concerning median nerve somatosensory evoked potentials (SEPs) latencies, as dependent variables, and subject height, limb length and nerve conduction velocity (NCV), as independent variables. The tests were performed on 23 normal volunteers. Absolute SEP latencies could be predicted by a linear regression model when the independent variable was arm length; when it was subject height, however, both exponential and polynomial models proved better, the Latter showing the best coefficients of determination, R 2. Multiple linear regression with two independent variables (arm length and NCV) was found to be better than simple linear regression for predicting P/N13 latency. The regression line for EP-P/N13 latency on height was found to be a polynomial curve; although the regression was found to be significant by the «F» test (alpha= 1%), the model had a low R2 value (0.41). The same applies to the P/N13-N19 interpeak latency regression curve, but the regression was significant for alpha =5% in that case. Although interwave latencies are the most useful parameters for clinical interpretation of median SEPs, absolute latencies may occasionally be important, and should be corrected for body size; in unusually tall subjects, it might be useful to double-check EP-P/N13 interwave latency prolongation by estimating the maximum expected P/N13 latency, using a model that takes into account both limb length and NCV.

Potenciais evocadas sômato-sensitivos do nervo mediano: estudos de variabilidade das latências em função da altura, comprimento do membro superior e velocidade de condução nervosa.

RESUMO — Descrição dos resultados de estudos de análise de regressão interessando as latências dos potenciais evocados sômato-sensitivos (PESS) do nervo mediano, como variáveis dependentes, e a altura do indivíduo, o comprimento do membro superior e a velocidade de condução nervosa (VCN), como variáveis independentes. Os testes foram realizados em 23 pessoas normais. As latências absolutas dos PESS podiam ser previstas por um modelo de regressão linear quando a variável independente era o comprimento do braço; quando tal variável era a altura, porém, tanto o modelo exponencial quanto o polinomial mostravam-se melhores, este último apresentando os melhores coeficientes de determinação, R 2. A curva de regressão das latências interpicos (EP-P/N13 e P/N13-N19) em função da altura revelou-se do tipo polinomial, com baixo valor de R 2. Embora as latências interpicos sejam os parâmetros mais úteis para a interpretação clínica dos PESS do nervo mediano, as latências absolutas podem eventualmente ser importantes e devem ser corrigidas para as dimensões corporais do paciente. São ressaltadas as situações em que tais correções poderiam ser potencialmente úteis para aumentar a sensibilidade do teste.

The relationship between absolute somatosensory evoked potential (SEP) latencies and the distance separating stimulus site from waveform generator is obvious: the greater the distance, the longer the latency. The need for correcting absolute and interwave latencies for subject height has long been recognized for lower limb

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SEPs; for upper limb testing, however, the general agreement has been that the effect of differences in body size on the interpeak latencies is small enough that it can be disregarded[2]. Although there can be no doubt as to the fact that interwave latencies are much more influenced by body size after lower limb stimulation than after upper limb testing, we have found evidence indicating care must be taken when interpreting SEPs from a subject whose height is significantly different from the range found in the population from which median nerve SEPs normative values were derived. Our normative studies carried out in a sample of 51 normal Brazilian subjects[1] indicated that the highest acceptable EP-P/N13 interwave latency should be 4.4 msec; this is significantly different ($p<0.005$) from the value found by Chiappa[2] in Americans (5.2 msec). In other words, some of his normal subjects could have an abnormal latency, if tested according to our norms. The most likely explanation for the difference is that our subjects were presumably shorter and had shorter upper limbs than their North American counterparts.

In order to further clarify this problem we have thouroughly studied the relationship between subject height, arm length, nerve conduction velocity and median nerve SEP latencies. We are not aware of any other papers which have tried to address this issue in detail; Kritchevsky and Wiederholt[4] have shown a linear correlation between arm length and PI4, a component which they believed to be of thalamic origin; they did not, however, atempt to study the correlation of other components to body size. Sauer and Schenck **5** pointed out that in hereditary motor and in sensory neuropathy type I the prolonged latency of the SEPs depends exclusively on the decreased conduction velocity of peripheral nerves, with normal afferent conduction within the cord; however, they did not report any method for correcting SEP latencies for decreased nerve conduction velocity. The aim of this study is, therefore, to find the best mathematical models to predict maximum acceptable SEP absolute latencies for a given subject, taking into account his height, arm length and peripheral conduction velocity. We feel this kind of information may be useful when testing unusually tall subjects, to prevent mistaking normal latencies for pathologically prolonged ones; conversely, this approach might be useful to increase diagnostic sensitivity when testing unusually short subjects, since their latencies may be within the normal range, although actually prolonged for their body size.

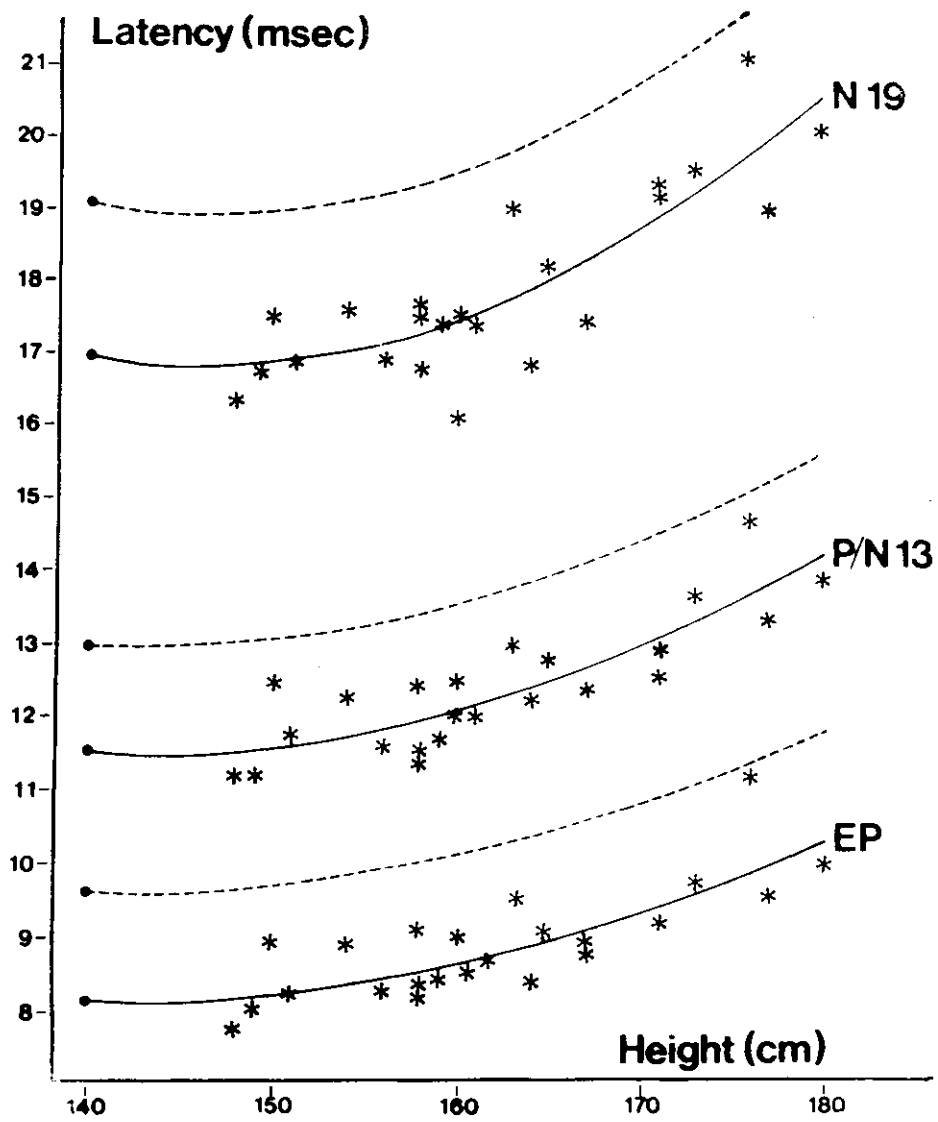

Fig. 1 — Regression of median nerve SEP components on subject height. Each asterisk is the mean latency value of the component in each subject (latency after right side stimulation + latency after left side stimulation /2). The dotted line is at 3 standard errors of estimate above the regression line and is the upper limit of normal. This is the polynomial model (see Table 1 for details).

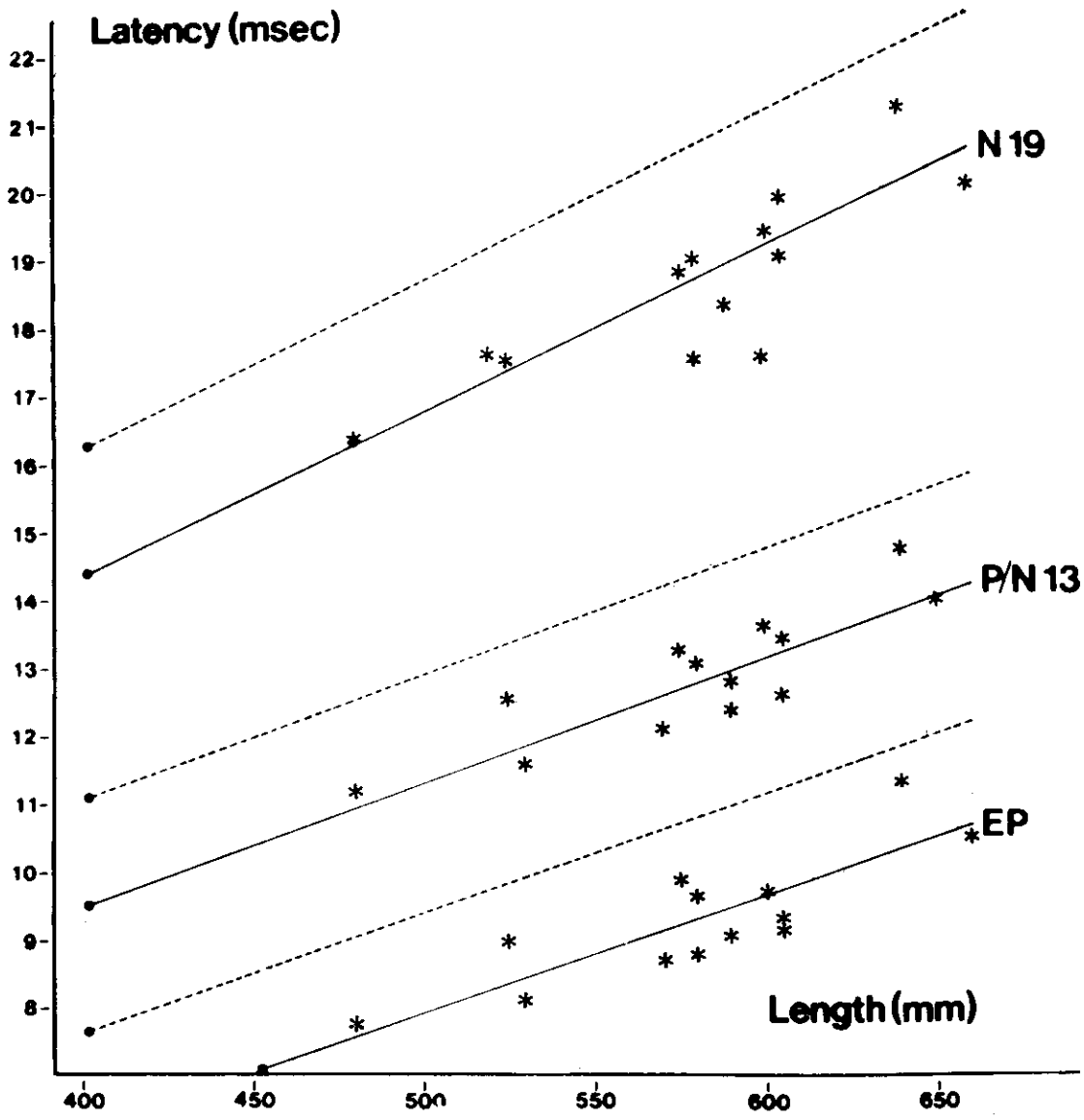

Fig. 2 — Regression of median nerve SEP components on limb length. Each asterisk is the mean latency value of the component in each subject (latency after right side stimulation + latency after left side stimulation /2). The dotted line is at 3 standard errors of estimate above the regression line and is the upper limit of normal. See Table 2 for details.

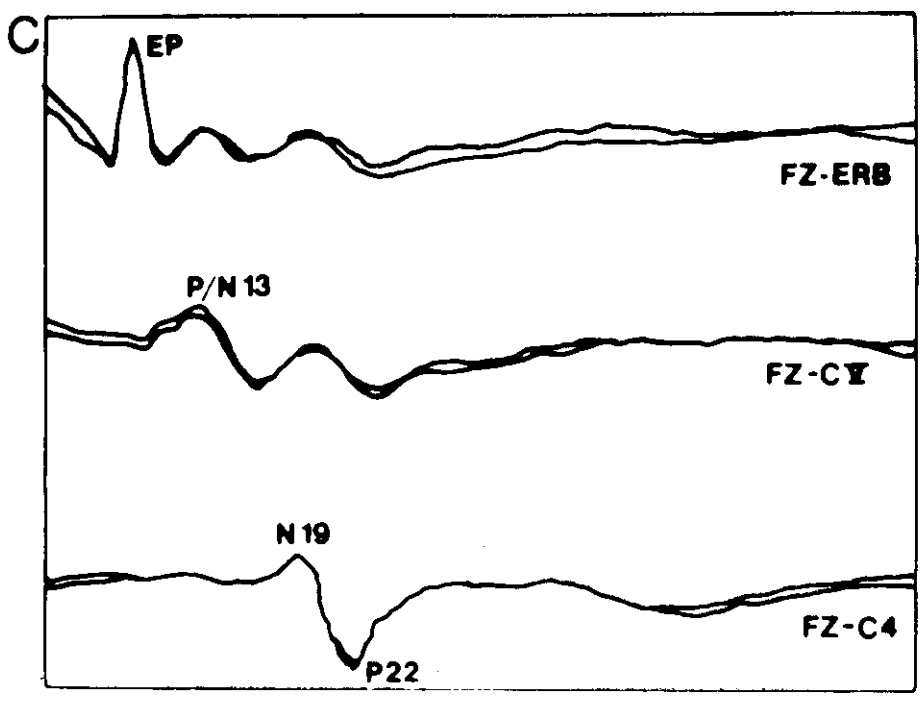

Fig. 3 — Montages and normal median nerve SEP components routinely obtained at our laboratory.

MATERIAL* & METHODS

Median nerve SEPs from 23 normal volunteers were studied. Stimulation of the media* nerve in the wrist was 'accomplished through use of an SC 6 TECA somatic stimulator device, and data were processed by a DAV 62 averager module, both connected to a TE 42 electromyograph. Stimuli were square pulses of 0.2 msec duration, delivered at a frequency of c per second at the minimum intensity required toi produce a visible muscular twitch. Three recording channels were employed: Fz-Erb's point, Fz-CV (fifth cervical vertebra) and Fz-contraliateral cortex (C3' or C4'). Filter setting! was 100-3,000 Hz; analysis time was 50 msec pofet-stimulus delay was 2.0 msec.

Statistical analysis included: assessment of the degree of linear correlation between SEP components and subject height and/or arm length, which was accomplished through calculation of Person's correlation coefficient; calculation of the regression line, the line through the graph of 'all subjects' EP parameters that minimized the sum of the squares of the distances from the points to the line (see Figs. 1 and 2); calculation of the coefficient of determination, R 2, which is the sum of squares explained by the model divided by the total sum of squares 3 and expresses the proportion of variance in Y (latency) explained by the regression equation (e.g., for R 2 = 0.85, 85% of the variance in latency is explained by the model); the standard error of the estimate was also calculated, and the upper limit of normal was set at 3 standard errors of the estimate above the regression line.

Since the linear model yielded low coefficients of determination for the regression of median SEP latencies on height, the exponential and polynomial models were also tested, the latter being chosen as the most suitable one; however, linear correlation of SEP latencies with limb length showed even higher R2 values (see Tables 1 and 2).

The nomenclature used for SEP components throughout this paper is that described by Chiappa (2). Montages and component identification routinely used at our laboratory are shown in Fig. 3.

RESULTS

All the relevant results of the statistical analysis are grouped in Tables 1 and 2; graphs showing the regression lines can be seen in Figs. 1 and 2.

Component	Model	r	R^2	Regression equation
EP	Linear	0.77*	0.52	$L = 0.06\,H - 1.49$
	Exponential	—	0.60	$L = 2.85\,(1.007)^{H}$
	Polynomial	—	0.62	$L = 34.52 - 0.38\,H + 0.0014\,H^{2}$
P/N13	Linear	0.84*	0.67	$L = 0.08\,H - 0.80$
	Exponential	—	0.70	$L = 4.36\,(1.006)^{H}$
	Polynomial	—	0.73	$L = 51.32 - 0.56\,H + 0.0020\,H^{2}$
N19	Linear	0.82*	0.67	$L = 0.11\,H - 0.48$
	Exponential	—	0.67	$L = 6.57\,(1.006)^{H}$
	Polynomial	—	0.72	$L = 87.06 - 0.96\,H + 0.0033\,H^{2}$
EP-P/N13	Linear	0.61*	0.38	$L = 0.02\,H + 0.69$
	Exponential	—	0.36	$L = 1.58\,(1.005)^{H}$
	Polynomial	—	0.41	$L = 16.82 - 0.18\,H + 0.0006\,H^{2}$

Tabie 1 — Regression of median nerve SEP components on height (23 subjects).
*r, Pearson's correlation coefficient; R2, coefficient of determination; L, latency (msec); H, subject height (cm); *, p<0.01.*
Observation — The standard error of the estimate given by the polynomial model was 0.488 msec for EP; 0.479 msec for P/N13; 0.693 msec for N19; and 0.204 msec for EP-P/N13.

Tabie 1 — Regression of median nerve SEP components on height (23 subjects).
*r, Pearson's correlation coefficient; Rs, coefficient of determination; L, latency (msec); H, subject height (cm); *, p<^0.01.*
Observation — The standard error of the estimate given by the polynomial model was 0.488 msec for EP; 0.479 msec for P/N13; 0.693 msec for N19; and 0.204 msec for EP-P/N13.

COMMENTS

This study shows that there is a significant regression of median nerve SEP latencies both on subject height and limb length. The coefficients of determination are low, however, in the case of interpeak latencies (EP-P/iN13 and P/N13-N19); that is to say, these latencies have just a small proportion of their variability depen-

Parameter	Component		
	EP	P/N13	N19
r	0.86*	0.87*	0.88*
R^2	0.74	0.76	0.78
Regression equation	L=0.017a−0.495	L=0.018a+2.318	L=0.024a+4.771
SEE (msec)	0.495	0.529	0.635
Upper limit of normal latency	= L+1.486	= L+1.586	= L+1.904

Table 2 — Regression of median nerve SEP components on arm length (13 subjects): linear model.

*r, Pearson's correlation coefficient; R^2, coefficient of determination; L, latency (msec); a, arm length (mm); SEE, standard error of estimate; *, $p<0.01$.*

Observations — (1) arm length was measured from the stimulation site in the wrist to the subcutaneous needle electrode at Erb's point; (2) multiple linear regression of P/N13 on arm length and nerve conduction velocity: $L = 11.304 + 18.672\,a - 0.149\,v$; v = nerve conduction velocity in m/sec. Standard error of the estimate = 0.188 msec.

dent on body size. Absolute latencies, however, may easily be corrected for subject height, arm length and nerve conduction velocity. Although in most instances interwave latencies are more useful for clinical interpretation 2 we have already pointed out the potential advantages of correcting absolute values for body size when subjects of unusual height are tested; in the case of an abnormally long EP-P/N13 interpeak latency in an unusually tall subject, for example, one could double-check the abnormality by estimating the maximum acceptable latency for P/N13. If this is also prolonged, the odds are that the long EP-P/N13 interval is really pathological. In predicting P/N13 value, one should use multiple linear regression, which takes into account both arm length and nerve conduction velocity. The latter is an easily obtainable by-product of median SEP testing: all one has to do is divide arm length (in millimeters) by EP absolute latency (in milliseconds); the result is nerve conduction velocity, in meters per second. In our subjects, it ranged from 56.9 to 65.9 m/sec, the mean was 62.3 m/sec, the standard deviation was 3.04. We have set the lower limit of normal as the mean minus 3 SD, which is 53.2 m/sec.

The reason why we do not recommend the use of the EP-P/N13 on height regression equation for estimating that interpeak latency is the low coefficient of determination of the model. The same applies to P/N13-N19 interpeak latency.

In conclusion, this study shows that the effect of body size on median nerve SEP interpeak latencies is small and can be disregarded most of the time. The exception would be in the event of an unusually tall or short subject being tested, or when abnormal SEP latencies coexist with low-normal nerve conduction velocity and it is necessary to check whether there is central slowing in conduction as well. Correction of median nerve SEP latencies for body size (height and/or arm length) and nerve conduction velocity is, therefore, a potentially useful diagnostic tool. Although it is not to be used on a routine basis, as in lower limb SEPs interpretation, its judicious use in selected cases may increase the diagnostic sensitivity of the test.

REFERENCES

1. **Brasil-Neto JP, Kouyoumdjian JA, Kouyoumdjian NCV, Morato-Fernandez RN, Dias Ferreira *JC.* Multimodality evoked potentials: normative studies is 51 subjects of a Brazilian population. Arq Neuro-Psiquiat (Sao Paulo) 1989, 47:423.**
2. **Chiappa KH. Evoked Potentials in Clinical Medicine. New York: Raven Press, 1983.**
3. **Horton RL. The General Linear Model-Data Analysis in the Social and Behavioral Sciences. New York: Mc Graw Hill, 1978.**
4. **Kritchevsky M, Wiederholt WC, Short latency somatosensory evoked potentials. Arch Neurol 1978, 35:706.**
5. **Sauer M, Schenck E. Electrophysiologic investigations in Friedreich's heredoataxia and in hereditary motor and sensory neuropathy. Electroenceph Clin Neurophysiol 1977, 43:623.**