PAPERS AND SHORT REPORTS

Use of a biothesiometer to measure individual vibration thresholds and their variation in 519 non-diabetic subjects

STUART BLOOM, SEBASTIAN TILL, PETER SÖNKSEN, SHIRLEY SMITH

Abstract

A series of 519 non-diabetic subjects had vibration thresholds at three points measured using a biothesiometer. Thresholds appeared to be log normally distributed and increased with age. Centile charts of this relation were derived from the data giving a range for normal thresholds.

The biothesiometer provides a quick and reliable assessment of vibration thresholds, which when related to the centile charts gives an objective measure of the progress of diabetic peripheral neuropathy.

Introduction

The only method at present widely available for examining vibration sensation is the time honoured tuning fork. Although quick and simple for gross assessment, it is unsatisfactory for measuring the amplitude threshold at which vibration becomes perceptible. This threshold is raised in some diseases, including diabetic peripheral neuropathy.[1] To examine the normal range of vibration thresholds and see how they varied with age, thresholds in 348 non-diabetic people in this hospital were measured using a biothesiometer. This machine has existed for at least 45 years[2] but is not well known in Britain. The aim was to help the clinician decide whether a patient's threshold is within normal limits and to give an objective method of monitoring one aspect of peripheral neuropathy.

Departments of Medicine and Pharmacology, St Thomas's Hospital Medical School, London SE1 7EH
STUART BLOOM, BA, medical student
SEBASTIAN TILL, BSC, research assistant
PETER SÖNKSEN, MD, FRCP, professor of endocrinology
SHIRLEY SMITH, MA, PHD, lecturer in pharmacology

Correspondence to: Professor Peter Sönksen.

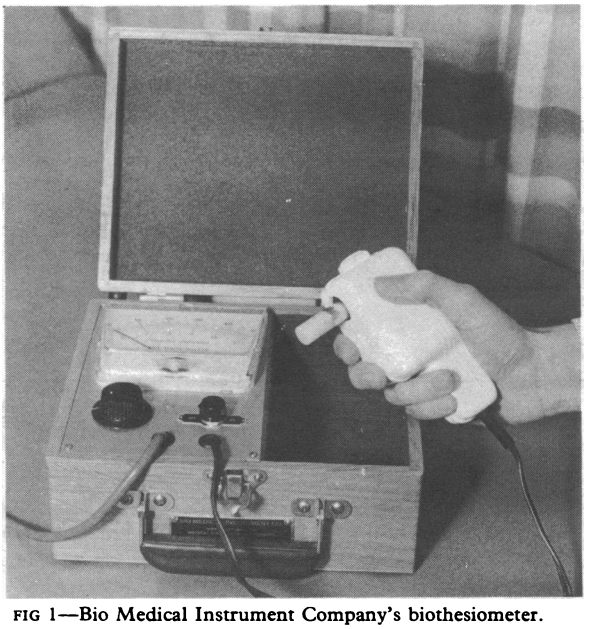

FIG 1—Bio Medical Instrument Company's biothesiometer.

Subjects, materials, and methods

Twelve students in their first clinical year used six biothesiometers to measure the thresholds of 348 people—namely, patients (less than a quarter of the sample), visitors, and staff selected at random within the hospital (group 1). Subjects with conditions known to affect peripheral sensation were not included.

The instrument used (Bio-thesiometer; Bio Medical Instrument Co, Ohio, USA) was a handheld mains operated unit with a rubber tactor which vibrates at 100 Hz when operating from 50 Hz mains (fig 1). The linear scale shows the applied voltage, which is proportional to the square root of the amplitude of vibration.

Subjects were measured (either sitting or lying) at thumbs, great toes, and medial malleoli; 80 were measured on one side only, and 268 on both sides of the body. There were no restrictions on the testing environment, most subjects being measured on the wards during daytime. Testing was standardised so that the tactor was held in firm contact but with minimal pressure against the skin. For the

thumb the site was the palmar aspect of the terminal phalanx opposite the nail bed. Similarly, the plantar aspect of the great toe opposite the nail bed was used. Stockings or thin socks did not alter the threshold, so subjects were asked only to remove thick socks. Subjects were familiarised with the sensation by turning the amplitude to maximum and then tested by gradually increasing the amplitude from zero and saying when they felt it. The lowest of two readings was recorded along with age, sex, diagnosis (if any), drugs taken, and smoking habit.

The three main sources of error—namely, differences among observers and machines and repeatability—were controlled for by a separate trial in which four people tested each other with the six machines on three different occasions. The four people were aged 22 to 32 years, and in this respect represented only part of the experimental group.

Measurements from a further 171 non-diabetics were obtained in the department of pharmacology using one machine (group 2). Subjects in this second group were either staff and visitors or people who worked near to the hospital. All were free of factors that might have influenced vibration threshold (see below). Analysis by unpaired *t* tests yielded no significant difference between the two sets of figures.

Results

We excluded from analysis all subjects with neurological disorders, trauma to limbs, peripheral oedema, vitamin B_{12} deficiency, hypothyroidism, malignant neoplasms, febrile disorders, malabsorption, alcoholism, claudication, osteoarthritis, and those taking psychotropic or sedative drugs. Unpaired *t* tests between groups 1 and 2 showed no significant difference ($p > 0.05$) within each age decade. Although this does not prove that the two populations were exactly comparable, the two sets of data were nevertheless combined in order to increase the number of observations in each decade.

A total of 486 subjects were included in the analysis, and table I shows their distribution among the various decades of age.

Normality was assessed by skewness and kurtosis tests and probit plots of the readings grouped by age and location on the body. Both tests showed that while distribution was not normal, log distribution was.

Sources of error—Paired *t* tests on the 268 subjects who had both sides of their bodies measured showed no significant difference between the two ($p > 0.6$), and readings from two sides of the same body were therefore averaged. Two way analyses of variance on the readings from the small control trial showed no significant observer, machine, or repeatability error ($p > 0.25$ in every case).

Variation of threshold with age—The threshold at which vibration became perceptible increased with age (table II), and the readings for thumbs had the lowest mean and variance. Estimates of centiles in relation to age were calculated after log transformation of the threshold readings (which eliminated any tendency to skewness, kurtosis, and heteroscedasticity and resulted in a normal distribution of the data). The relation between log vibration threshold and age appeared to be linear, and in order to define the population limits most accurately linear regression analysis was carried out for the logarithmically transformed readings against age. The parameters of the normal distribution were then used to calculate the mean and centiles of the normal limits. From the regressions the intercept "a" and the slope "b" were obtained together with residual standard deviation "s." Hence the predicted value of the $_i$th centile was: antilog $[a + (b \times \text{age}) + c_i \times s]$, where c_i was the normal equivalent deviate for the $_i$th centile. Figure 2 shows the results. The 2·5 and 97·5 centiles thus calculated represented the 95% range. There was a close and highly significant ($p < 0.001$) correlation between the log threshold and age.

TABLE I—*Age distribution of subjects remaining for analysis after exclusions for conditions that might have affected results*

	Decade of age									
	≤10	−20	−30	−40	−50	−60	−70	−80	−90	Total
No of subjects	18	65	106	59	65	64	57	41	11	486

TABLE II—*Mean and range of vibration threshold with age (2·5 and 97·5 centiles enclose 95% range)*

Age (years)	Thumbs			Great toes			Medial malleoli		
	2·5	50	97·5	2·5	50	97·5	2·5	50	97·5
10	2·3	4·7	9·6	2·1	4·9	11·3	2·9	6·6	15·0
20	2·6	5·3	10·7	2·7	6·1	14·2	3·6	8·1	18·4
30	2·9	5·9	11·9	3·3	7·7	17·8	4·4	9·9	22·5
40	3·2	6·5	13·2	4·2	9·6	22·3	5·4	12·2	27·7
50	3·6	7·2	14·7	5·2	12·1	28·0	6·6	14·9	33·9
60	4·0	8·1	16·3	6·6	15·2	35·1	8·1	18·3	41·7
70	4·4	9·0	18·1	8·3	19·1	44·0	9·9	22·5	>50
80	4·9	10·0	20·1	10·4	23·9	>50	12·2	27·6	>50
90	5·5	11·1	22·4	13·0	30·0	>50	14·9	33·9	>50

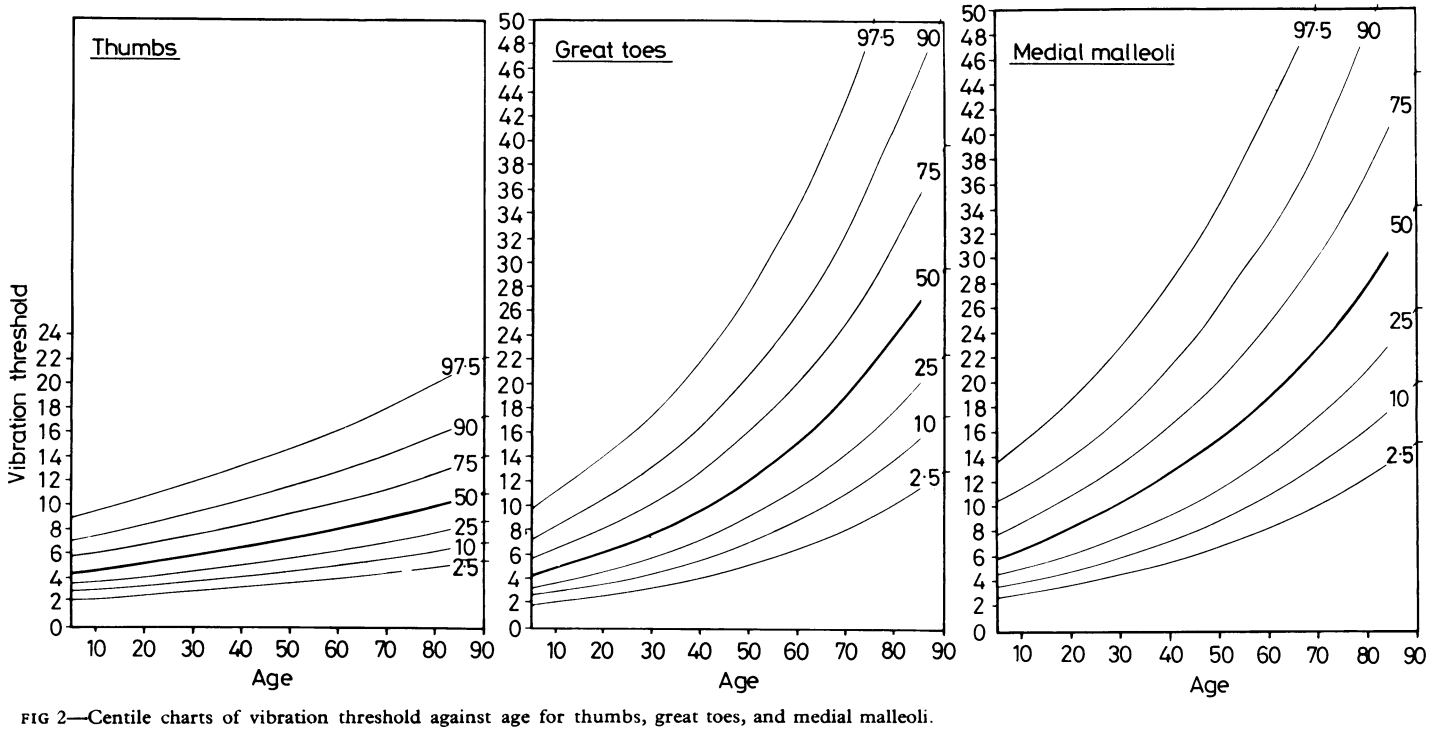

FIG 2—Centile charts of vibration threshold against age for thumbs, great toes, and medial malleoli.

The correlation coefficient for the thumb was lowest on account of the smaller age related changes—thumb: r=0·52 (n=481); great toe: r=0·74 (n=481); medial malleolus: r=0·71 (n=480).

Discussion and conclusions

No other study of biothesiometry[2-4] has investigated how vibration threshold varies with age. Our results quantify the increase of threshold with age and show that within age decades the logarithms of the readings are normally distributed. In order to ensure that the limits of normality that we have defined were based on the maximum possible number of observations we pooled the results from groups 1 and 2. We showed that there were no detectable differences among machines, among observers, and between the two populations and therefore consider that there was a reasonable case for combining the data.

Whether or not the lower threshold and smaller variance for thumb readings was due to the sensory pathway being longer in the leg was not clear, but our impression is that the threshold in the foot is related to height.

The centile charts may be used in the clinic to help decide whether a patient's vibration threshold is abnormal. Comparing diabetic thresholds with normal ranges will help in quantifying the progress of any peripheral neuropathy. Evidence suggests that vibration sensation may return to normal as control is improved,[1] so possibly we have another method of assessing the benefits of long term diabetic control.

The biothesiometer provides a quick, reliable, and more objective assessment than the time honoured tuning fork.

We thank the 11 student members of the firm who helped collect the data.

References

1 Hockaday TDR, Hilson RM, Smith B. Correlates of deterioration in pedal vibration sensory threshold over 5 years from diagnosis of maturity onset diabetic patients. *Diabetologia* 1982;**23**:174.
2 Laidlaw RW, Hamilton MA. Thresholds of vibratory sensibility as determined by pallesthesiometer: study of 60 normal subjects. *Bulletin of the Neurological Institute of New York* 1937;**6**:494-503.
3 Gregg EC. Absolute measurement of vibration threshold. *Archives of Neurology and Psychiatry* 1951;**66**:403-11.
4 Mirsky IA, Futterman P, Broh-Khan RH. Quantitative measurement of vibratory perception in subjects with and without diabetes. *J Lab Clin Med* 1953;**41**:221-35.

(*Accepted 9 April 1984*)

Oral contraceptives, pregnancy, and endogenous oestrogen in gall stone disease—a case-control study

R K R SCRAGG, A J McMICHAEL, R F SEAMARK

Abstract

A case-control study of gall stone disease in women in relation to use of contraceptives, reproductive history, and concentrations of endogenous hormones was undertaken. The study population comprised 200 hospital patients with newly diagnosed gall stone disease, 182 individually matched controls selected from the community, and 234 controls who were patients in hospital. Use of oral contraceptives was associated with an increased risk of developing gall stones among young subjects but a decreased risk among older subjects. The risk of developing gall stone disease increased in association with increasing parity, particularly among younger women. The risk fell with increasing age at first pregnancy, independent of parity. Mean urinary excretion over 24 hours of oestrone, but not of pregnanediol, was significantly ($p<0.05$) greater for postmenopausal patients than controls.

The age dependence of the relative risk associated with exposure to oral contraceptives and pregnancy suggests that there are subpopulations of women susceptible to early formation of gall stones after exposure to either oral contraceptives or pregnancy.

Division of Human Nutrition, Commonwealth Scientific and Industrial Research Organisation, Adelaide, South Australia 5000, Australia

R K R SCRAGG, MB, PHD, research fellow in epidemiology
A J McMICHAEL, MB, PHD, senior principal research scientist

Department of Obstetrics and Gynaecology, University of Adelaide, Adelaide, South Australia 5000, Australia

R F SEAMARK, BAGSC, PHD, reader in endocrinology

Correspondence and requests for reprints to: Dr R K R Scragg, Department of Community Health, School of Medicine, University of Auckland, Private Bag, Auckland, New Zealand.

Introduction

The greater prevalence of gall stones among women than among men,[1] initially apparent at puberty, is thought to be due to hormonal and reproductive factors such as oral contraception, oestrogens, and pregnancy. Epidemiological studies of living subjects have generally shown a positive association between development of gall stones and prior pregnancy,[2-14] although some studies[15-17] and two series of postmortem examinations did not show any association.[18 19] Exposure to oral contraceptives was initially observed to increase the risk of developing gall bladder disease,[20-22] but subsequent reports have not confirmed this.[13 16 17 23-25] Exogenous oestrogens have also been observed to increase the risk of gall bladder disease developing in women[26] and men,[27] although a study of elderly men showed that oestrogen increased the risk of cholecystectomy but not of gall stones.[28] Urinary excretion of endogenous oestrogen is positively associated with bile cholesterol saturation,[29] but we could find no study that had specifically examined endogenous oestrogens in patients with gall stone disease.

We undertook a case-control study to investigate the role of oral contraceptives, reproductive history, and endogenous hormones in the development of gall stone disease in women of different ages.