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Development of A Device Constantly Stimulating Tuning Fork and Variability of Its Vibration Perception Time

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= 국문초록 =

음차를 일정하게 자극하는 장치의 개발 및 이 장치로 측정한 진동 감지 시간의 변이

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진동감각의 이상을 검사하는데 음차를 이용한 진동 감지 시간을 측정하는 방법이 임상에서 널리 이용되고 있으나 이 방법은 동일 피검자에 대해서도 검사자에 따라 많은 차이가 있다. 이는 주로 음차에 가해지는 자극이 표준화되어 있지 못하고 경험에 의해 이루어 지고 있기 때문이다. 검사자간의 오차를 제거하기 위해 음차에 일정한 자극을 줄 수 있는 장치(그림 1)를 전자석의 원리를 이용하여 개발하였다. 본 장비를 이용하여 28명의 건강한 의예과 남학생을 대상으로 그들의 오른손 집게손가락에서 측정된 진동 감지시간은 평균 12.44 초 였고, 9.47 에서 17.25 초 사이에 분포되었다. 그 변이 계수는 16.89 % 였다. 30 분 후 재검사 한 결과와 첫 검사 사이의 상관계수는 0.957 이었다($p < 0.01$). 본 검사법은 비침입적이며, 비염오적이고 간단하다. 이를 실시함에 있어 숙련이 요하지 않으며, 현장에서 쉽게 이루어질 수 있다. 검사 시간은 1 분 정도 밖에 걸리지 않으며 추적 조사도 가능하다. 또한 본 장비는 휴대에 간편하다.

진동감각의 장애가 말초신경 질환의 초기 징후일 수 있으며, 진동 지각 역치를 측정하는 방법들이 말초신경 질환의 조기발견에 이용되고 있음에 비추어 볼 때, 본 장치에 의해 진동 감지 시간을 측정하는 방법이 직업성 말초신경 질환의 조기발견을 위한 집단검진에 널리 사용될 수 있을 것으로 생각된다.

I. INTRODUCTION

Occupational peripheral neuropathy is often the result of long-term, low-level exposure to various chemical substance, heavy metals or physical factors in workplace. Although it is unknown how many cases of occupational peripheral neuropathy occur in United State each year (Gerr et al, 1990) and reported that the neurotoxicity is the third most prevalent type of occupational disease in Finland (Seppalainen, 1975), it is likely that the reported cases of neuropathy represent only a fraction of those that occur in the workers. Occupational neurologic disease is both subtle and insidious in onset (O'Donoghue, 1985) and involves large groups of people (Aaserud et al, 1990). Designing a valid and reliable monitoring program sensitive to the onset of neuropathy is becoming of paramount concern for the occupational physician and industrial toxicologist (O'Donoghue, 1985) as increasing numbers of neurotoxic substances are used in industry or deployed in environment (Arezzo and Schaumburg, 1980).

After Trietel (1987) studied patient with tabes and alcoholic polyneuritis and found that vibratory loss occured early, disturbance of vibratory sense had been described in a wide variety of neurologic disorders (Egger, 1899 ; Rydel and Seiffer, 1903 ; Williamson, 1922 ; Fox and Klemperer, 1942). Impairment of vibratory sensibility, starting distally in limbs, may be an early sign of peripheral neuropathy (Williamson, 1922 ; Nielsen, 1972 ; Bergstrom et al, 1975), and measurement of vibration perception has attaracted considerable interest in early detection of workers at risk for occupational peripheral neuropathy. It has resulted in effort to develope instruments which can employ sensitive and precisely defined quantifiable stimuli, as well as the best available methods of testing and scoring, to assess senation accurately and objectively. Several portable electromagnetic devices testing the vibration perception threshold have been introduced for use in screening occupational and environmental neurologic disorders (Gerr et al, 1990 ; Arezzo and Schaumburg, 1980 ; Bergstrom et al, 1975 ; Bloom et al, 1984 ; Katims et al, 1986).

Tuning fork introduced by Rumpf (1899) was to prove a most useful adjunt to the armmentarium of clinical neurologist (Calne and Pallis, 1966) and is used at present by physicians not as a first-line screening, but as means of creating a case definition, or as part of the definitive diagnostic process. Although traditional method of the time honoured tuning fork is widely available for examining vibration sensation, and quick and simple for gross assessment, there exists great interobserver variation and a lack of standardization in its administration and interpretation (Bleecker, 1986). The perception time of vibration from tuning fork has been supplemented by threshold determinations by means of electromagnetic devices (Bleecker, 1986 ; Goldberg and Lindblom, 1979).

Authors intend to develope the electromagnetic device constantly stimulating the tuning fork to eliminate the interobserver variation and evaluate variability of vibration perception times of this device.

II. METHOD

The instrument shown in figure 1 consists of tuning fork (256 Hz), electric magnet (3 Kw) and relay, timer, and three buttons (start, stop and reset). Test procedure is as follows ; 1) By pushing start-button, impactor of magnet stimulates once tuning fork to vibrate, at the same time the timer is started. 2) End of tuning fork is instantly held in firm contact but with minimal pressure on testing site. 3) When the vibration from

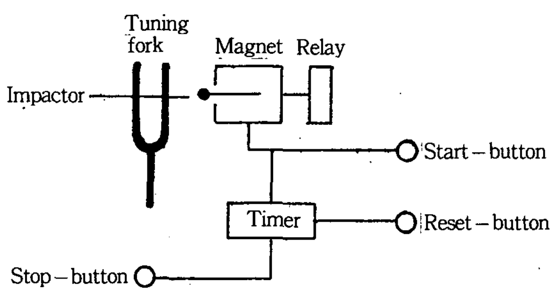

Figure 1. Schematic representation of a device testing the perception time of vibration from tuning fork by constant stimulus.

tuning fork can not be felt, subject pushes stop-button to stop timer. 4) Time shown in the timer expresses the duration subject can feel vibration from tuning fork and is called vibration perception time using as indicator of vibration sensibility. 5) For next test timer is reset to zero by pushing reset-button.

Twenty eight students in premedical course who had no conditions that affect the peripheral sensation were recruited. They were all male and 20 to 22 years in age. The perception time of vibration was tested on their index finger of dominant right hand and retested after 30 minutes. There were no restrictions on testing environment.

Data were analysed and test-retest correlation coefficient (Pearson) was calculated by using SPSS / PC+ V2. 0.

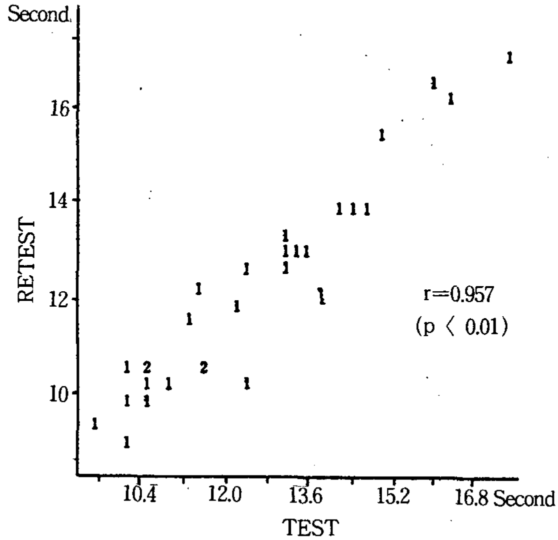

Figure 2. Correlation of vibration perception time between *test and retest after 30 minutes.*

Ⅲ. RESULTS

The perception time of vibration from 256 Hz tuning fork was a mean of 12.44 seconds in the first test and 12.37 seconds in the retest after 30 minutes, and ranged from 9.47 to 17.25 and 9.22 to 17.10, respectively. The difference between test and retest ranged from -1.06 to 2.10 seconds and mean difference was 0.07 and 0. 47 seconds as absolute value. Coefficient of variation for test and retest was 16.89 % and 18.08 %, respectively (Table 1).

The correlation coefficient of vibration perception time between test and retest was 0.957 and statistically highly significant ($p < 0.01$) (Fig. 2).

Ⅳ. DISCUSSION

This study shows that the perception time of vibration from tuning fork assessed only very roughly at present by traditional method, can be measured precisely by the use of this device. The problem of interobserver variability can hardly occur in this procedure.

Coefficient of variation for the perception time of vibration by this method was 16.9 %, and vibration

Table 1. The perception time of vibration from 256 Hz Tuning fork by constant stimulus of 3 Kw magnet on their dominant index finger of twenty eight subjects.

	Mean (seconds)	SD (seconds)	Range (seconds)	C.V. (percent)
Test	12.44	2.101	9.47 - 17.25	16.89
Retest	12.37	2.237	9.22 - 17.10	18.08
Difference between				
test and retest	0.07	0.650	-1.06 - 2.10	-
(Absolute value)	(0.47)	(0.440)	(0.01 - 2.10)	-

SD : standard deviation.
C.V. : coefficent of variation.

threshold by use of Optacon (Bleecker, 1986) 25.5 % and by method of limit and forced choice by menas of Vibration II (Letz, 1988) 30.0 % and 45.1 %, respectively. Also, it was 41.1 % for 30 Hz (Cherniack et al, 1990) tuning fork by traditional method and 26.6 % 128 Hz (Aaserud et al, 1990). It indicates that this method is less variable than methods testing the vibration perception threshold and traditional method with tuning fork.

Test–retest correlation coefficient was 0.957 for vibration perception time by this method and 0.81 for vibration threshold by method of limit (Letz, 1988) and 0.51 forced choice procedure (Letz, 1988). It suggests that this method is more reproducible and reliable than other methods for test of vibration sensibility and intrasubject variation may be less.

This test procedure is noninvasive, nonaversive, simple and rapid. It does not require a highly skilled technician and is readily performed in field. This device is also completely portable. This test can be carried out within one minute. Authors believe that this device is suitable for screening the occupational peripheral neuropathy.

This study is limited in its generalisability by the characteristics of study population. They had a low prevalence, if any, of neurological disease manifesting as peripheral neuropathy, and were highly educated, all male and specific group in age. The reliability of this method in working populations with a lower educational level and at higher risk of peripheral neuropathy may vary from the reliability reported in these subjects.

Further studies are needed to 1) determine the sensitivity and specificity of this method in giving situation, 2) evaluate possible confounding variables such as temperature, skin thickness on testing site and so on, and 3) test the reliability of different frequencies and stimuli by this method.

V. SUMMARY

The time honoured tuning fork at present widely available for examining vibration sensation is brought about the problem of great interobserver variation. To resolve this problem, author developed a divice using electric magnet that stimulates constantly tuning fork. The perception time of vibration from tunung fork by this device was tested on the index finger of dominant hand of twenty eight subjects. It was 12.44 seconds on average and ranged from 9.47 to 17.25. Coefficient of variation of it was 16.89 percent. Correlation coefficient between test and retest after 30 minutes was 0.957 ($p < 0.01$). This device is portable. Test procedure is non–invasive, non–aversive and simple, can be performed within one minute, and does not require the skilled technician. It is felt that this device testing vibration perception time is suitable as screening tool for early detection of occupational peripheral neuropathy.

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