

THE STATOKINESIOMETRY IN EVALUATION OF THE BALANCE SYSTEM IN PERSONS WITH CHRONIC CARBON DISULPHIDE INTOXICATION

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Key words: Statokinesiometric test, Electronystagmography, Balance disorders, Vertigo, Chronic carbon disulphide intoxication

Abstract: In the group of 37 patients with chronic carbon disulphide (CS₂) intoxication manifested by encephalopathy, polyneuropathy or psycho-organic syndrome and complaining for vertigo, a statokinesiometric test was performed with open and closed eyes, and with visual stimulation.

Basic test parameters of stabilograms and statokinesiograms were compared with standard values of the control group.

Results of the test were additionally verified by electronystagmography with the recording of spontaneous, positional, optokinetic and post-rotatory nystagmus as well as the eye-tracking test. The statokinesiometry revealed postural stability disorder in 72.9% of patients. Balance disorders detected by means of this test showed high compatibility with results of electronystagmography which confirmed damage of the central part of vestibular system due to CS₂ intoxication.

INTRODUCTION

Chronic intoxication with carbon disulphide (CS₂) belongs to the most common occupational intoxications in Poland (21.9% of all chemical intoxications).

Diagnosis of the disease is very difficult and complex because of a non-specific clinical picture and quite a number of subjective symptoms. That is why clinicians still look for methods which could make the symptomatology of intoxication more objective. The diagnosis of chronic CS₂ intoxication is usually based on symptoms manifested by the central and peripheral nervous system disorders in the form of psycho-organic syndrome or encephalopathy or polyneuropathy (2, 4, 17).

These symptoms can also be associated with lesions of the cranial nerves, most often acoustic and optic nerves (2, 10, 17).

An ototoxic effect of CS₂ has been known for years and hearing impairments as well as vertigo and balance disorders (the latter identified as vestibular syndromes) are common findings recognized in cases of intoxication (2, 4, 8, 10). Numerous reports confirm that otologic and vestibular tests (audiometry and electronystagmography) are very useful especially in an early diagnosis (2, 4, 14, 17).

It is thought that the evaluation of the vestibular function provides extremely valuable information. It has been indicated that vestibular symptoms are observed much earlier than other intoxication symptoms and that vestibular tests, particularly electronystagmography (ENG), are much more sensitive than electroencephalography (EEG).

The purpose of the present study is to assess the usefulness of the statokinesiometry in evaluation of the balance function in persons with chronic CS₂ intoxication; to compare results obtained with electronystagmographic findings; and to check whether the test can be applied in the diagnosis of intoxication.

MATERIALS AND METHODS

The study was performed on 37 patients with chronic occupational CS₂ intoxication diagnosed at the Clinic of Occupational Diseases, the Nofer Institute of Occupational Medicine, Lodz, during the years 1989-1990.

Most of the subjects were employed in the Chemitex-Wistom Plant of Chemical Fibres in Tomaszow Mazowiecki as operators of viscose fibre production.

The group under study was composed of males (mean age 51.3 ± 6.3) occupationally, exposed to CS₂ for 20.1 years on average (± 4.2).

In 62.2% of patients typical characteristics of encephalopathy were found while the rest manifested symptoms of polyneuropathy or psycho-organic syndrome, 27.9% and 8.1%, respectively.

Each patient was subjected to otologic examination supplemented with audiometry and electronystagmography and then the statokinesiometric test was performed by means of a PE 60 set Model 03.

The set comprised: post-urographic mobile platform (a rectangle 40 × 40 cm), information processing block linked with IBM computer, and additionally, feed-back block. A simplified scheme of the set is shown in Fig. 1.

On the platform, a body oscillation was assessed with open eyes (O-E test), closed eyes (C-E test) and visual stimulation (V-S test) based on the feed-back, in the latter, location of the body gravity centre was displayed on a computer screen as a light spot. A patient watching the light spot and making small moves of his body might displace and correct the body gravity centre. Thus, the examined person was put on a rectangular platform near a geometric centre in a motionless position. When the subject's sight was fixed on a marked spot and the body posture became stable, then the testing (lasting 30 sec) was started.

One might remember that the statokinesiometric set, used by us ensures a graphic recording of spontaneous displacements of the body in an upright position. Displacements were in four directions: in vertical axis — forward and backward as components Y/+ and Y/-, and in horizontal axis — to the right and to the left as components X/+ and X/-. They were recorded in the form of two curves, called stabilograms. Simultaneously, the body gravity centre was recognized and recorded in a coordinate system, called statokinesiogram. Examples of both recordings are drawn in Figs 2 and 3.



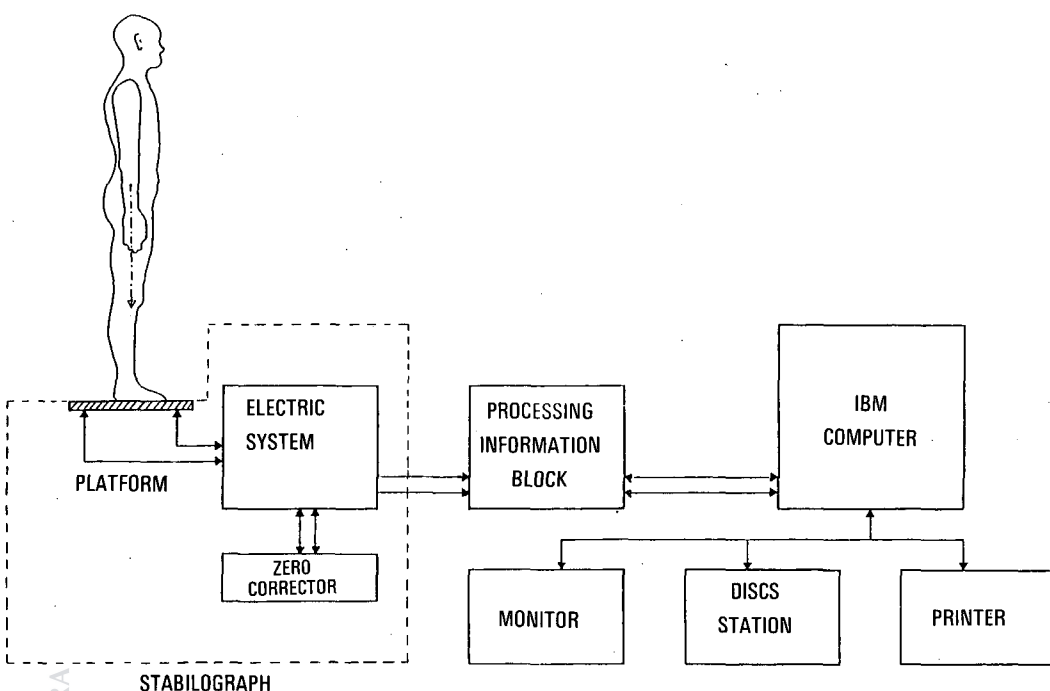


Fig. 1. The scheme of equipment for the statokinesiometric test.

Basic parameters of stabilograms and statokinesiograms, ie, contour area, mean curve radius and length, and proportional frequency of the placement of the body gravity centre in each quarter of a coordinate system were calculated. Next, they were compared with normative values defined in the age-matched control group of healthy persons, examined earlier and considered as reference values (5).

The Wilcoxon test was used in statistical analysis and a significant difference at a level of $p < 0.05$ was accepted.

The obtained results of statokinesiometric test were then additionally verified by electronystagmography. It was performed using the Tönnies ENG equipment (linked with an electronically steered rotatory chair) and movements of eyeballs at rest, gaze and positional nystagmus, eye-tracking test, post-rotatory and optokinetic nystagmus were recorded. The ENG tracings were assessed qualitatively and quantitatively, taking into account the maximum angular velocity of slow phase of nystagmus, average amplitude and duration of reaction.

RESULTS

The ENG data in CS₂ intoxicated patients demonstrated abnormalities of vestibular function in 28 persons (75.5%), including spontaneous or positional direction-changing nystagmus in 6 subjects (16.2%), nystagmoidal movements in 4 (10.8%), optokinetic nystagmus asymmetry in 24 (63.8%), deviations in eye-tracking test recording in 6 (16.2%) and directional preponderance of post-rotatory

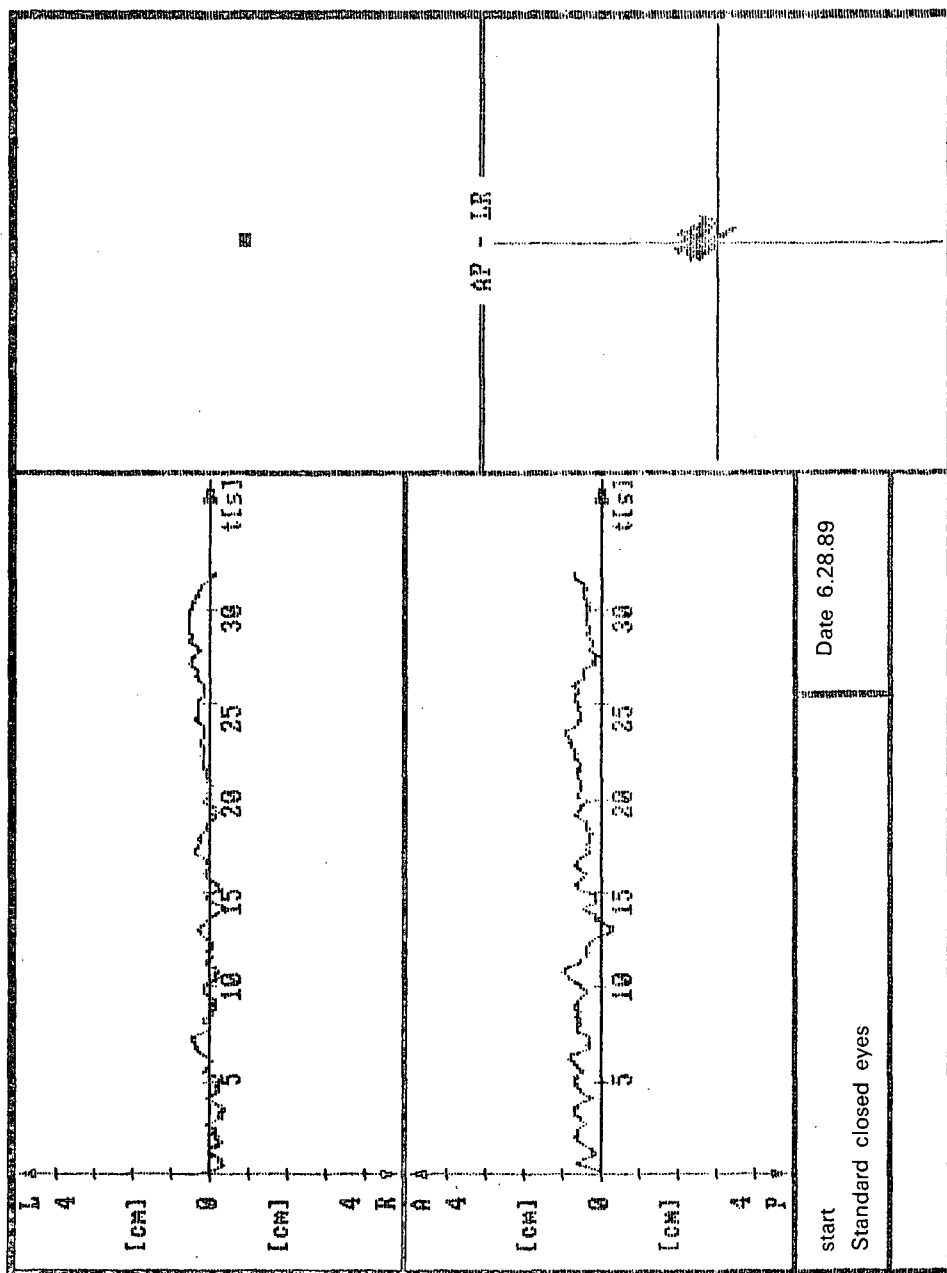


Fig. 2. Normal stabilogram (left diagram) and statokinesiogram (right diagram) in a healthy 25 year old male in C-E test.

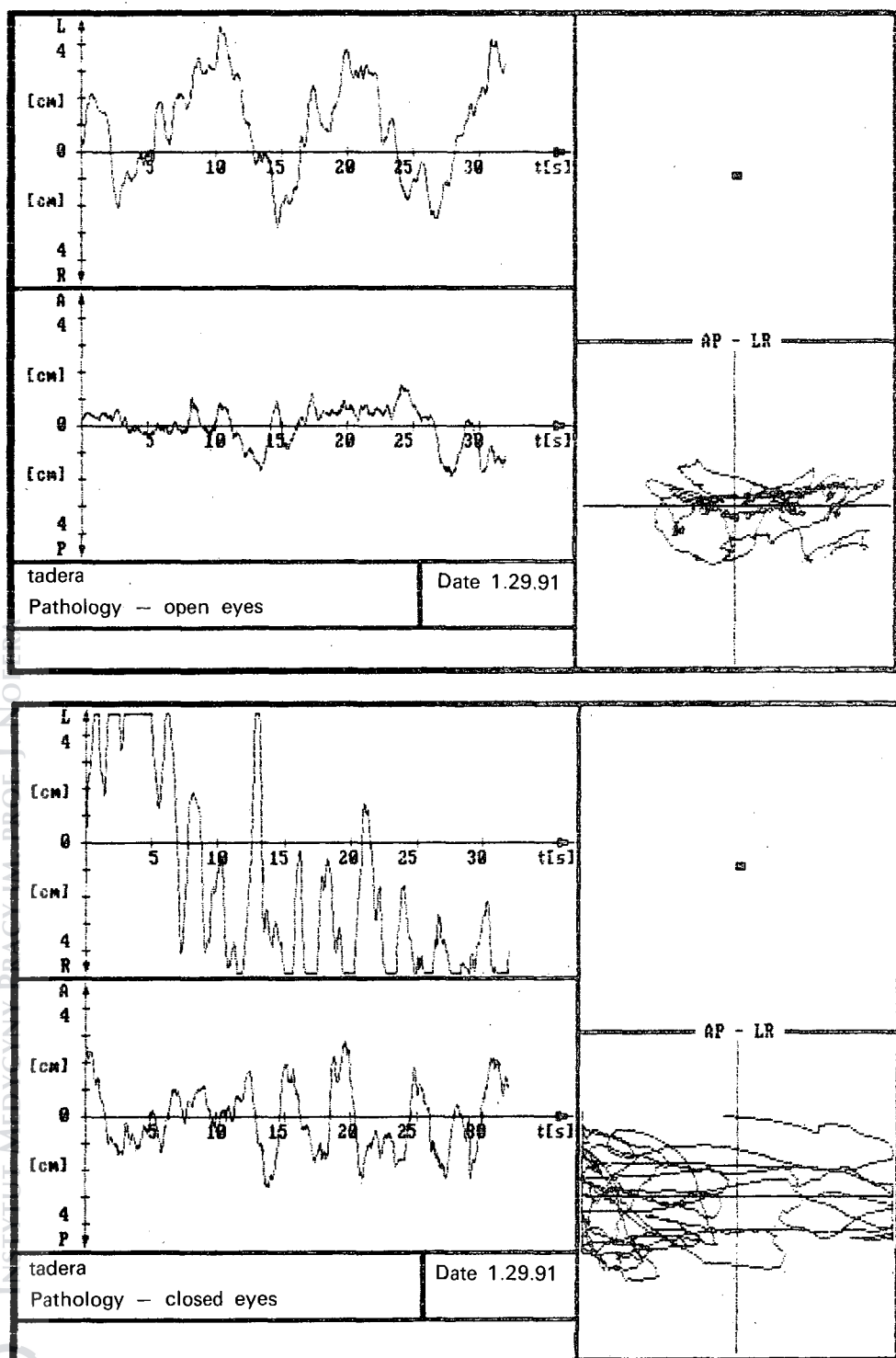


Fig. 3. Pathological stabilogram and statokinesiogram.

nystagmus in 26 subjects (70.3%) (Fig. 4). In the latter group asymmetry above 10% in maximum angular velocity of slow phase in 23 subjects (62.2%), maximum amplitude asymmetry in 22 (59.4%) and nystagmus duration asymmetry in 28 subjects (75.7%) were found. These changes occurred more often ($p < 0.05$) in the group of patients than in the control group of healthy persons, examined earlier and whose examination data was considered as reference values (5).

A comparison of mean values of some important parameters of post-rotatory nystagmus in both groups of subjects (Table 1) also proved a statistically significant difference, which indicated the prevalence of vestibular hypofunction in the CS₂ intoxicated patients.

Table 1. Mean values of nystagmus parameters during 10 s at the peak of the reaction during the rotatory test according to Arslan in the group exposed to CS₂ and in the reference group (R)

	Nystagmus parameters					
	Duration (t)		Mean amplitude (Am)		Mean angular velocity of slow phase (m)	
	R	CS ₂	R	CS ₂	R	CS ₂
Rotation to the right	39.41 ± 9.54	37.44 ± 11.26	5.90 ± 2.59	4.53 ± 2.37	29.05 ± 10.08	19.56 ± 9.10
R	$p > 0.05$		$p < 0.05$		$p < 0.001$	
Rotation to the left	38.50 ± 10.8	32.62 ± 14.38	5.58 ± 2.33	4.24 ± 2.20	22.00 ± 6.74	26.56 ± 14.04
L	$p > 0.05$		$p < 0.05$		$p > 0.05$	
Mean	38.73 ± 9.32	35.03 ± 10.23	5.74 ± 2.36	4.38 ± 2.05	25.52 ± 6.82	23.06 ± 9.94
R + L Z			$p < 0.05$			

Analysis of the statokinesiometric test results, calculated as mean values of the test basic parameters assessed at open eyes, closed eyes and with visual stimulation, again revealed a significant difference between the group under study and the controls, and confirmed the occurrence of various degree balance disturbances in the former (Table 2).

Graphic representation of calculated stabilogram parameters in both groups is illustrated in Figs 5, 6 and 7.

In the group of CS₂ intoxicated patients, the postural balance disturbances, measured by estimating proportional frequency of the placement of the body gravity centre on the quarters of a coordinate system during O-E, C-E and V-S tests, were finally found in 27 subjects (72.9%). The remaining 10 subjects (27.0%) showed no abnormalities.

Comparison of stabilograms with ENG data proved a complete compatibility in the evaluation of the vestibular function in 33 persons (89.0%) while in 4 persons (10.8%) results of both methods were divergent.



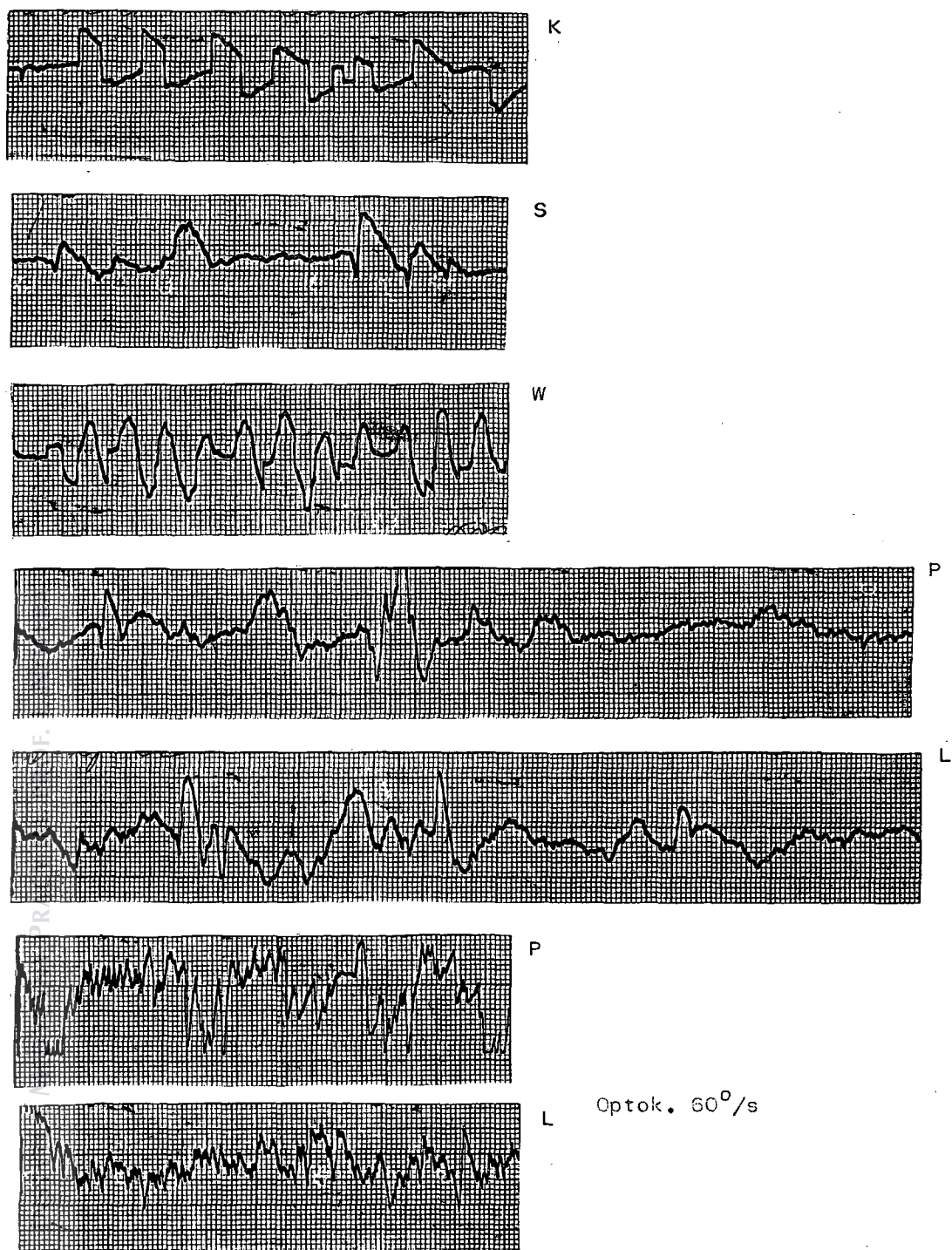
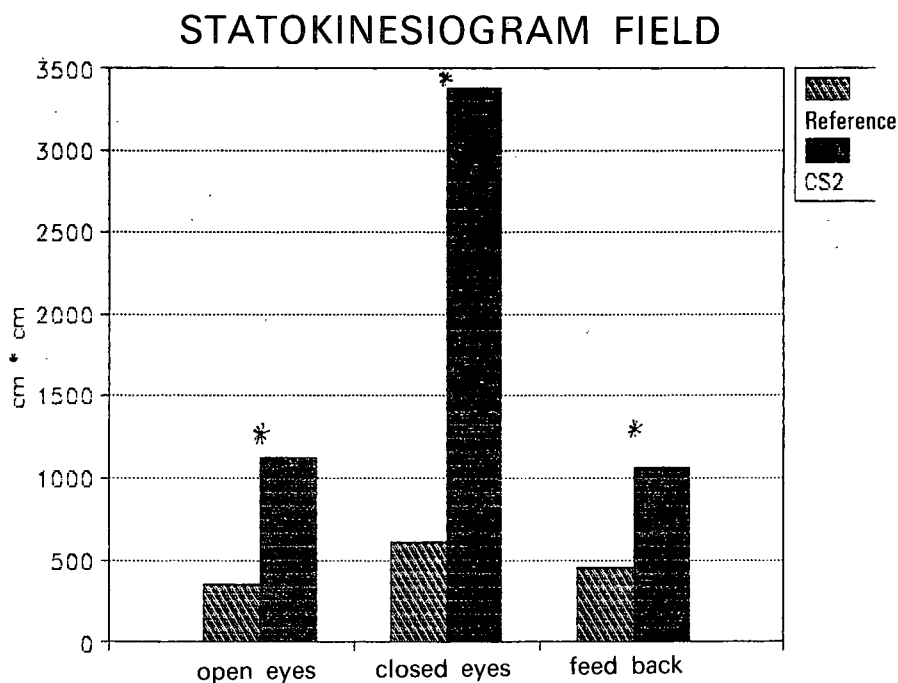


Fig. 4. An example of ENG tracings in a 53 year old male suffering from chronic carbon disulphide intoxication.

Table 2. Mean values of basic stabilogram parameters in the group exposed to CS₂ and in the reference group (R)

Test	Stabilogram parameters					
	Contour area (mm ²)		Mean radius (mm)		Length (mm)	
	CS ₂	R	CS ₂	R	CS ₂	R
Open eyes	1123 ± 947	350 ± 142	6.6 ± 3.3	2.6 ± 0.7	499 ± 174	402 ± 64
Closed eyes	3374 ± 3455	616 ± 400	10.4 ± 6.7	3.4 ± 1.5	867 ± 417	553 ± 166
Visual stimulation	1062 ± 1114	453 ± 300	6.2 ± 3.8		499 ± 186	507 ± 123

**Fig. 5.** Mean contour area of statokinesiogram in the examined group.

STATOKINESIOGRAM MEAN RADIUS

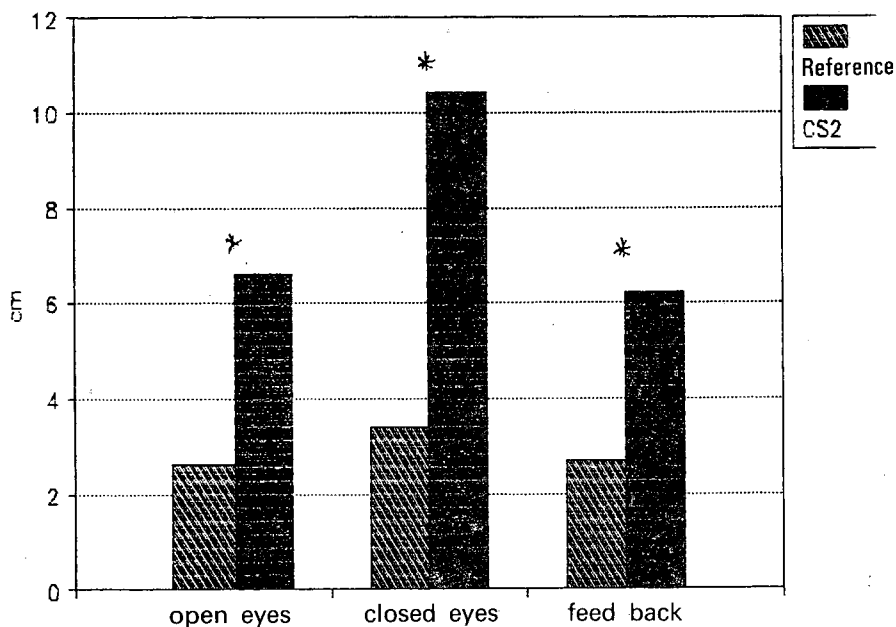


Fig. 6. Mean radius of statokinesiogram in the examined group.

STATOKINESIOGRAM LENGTH

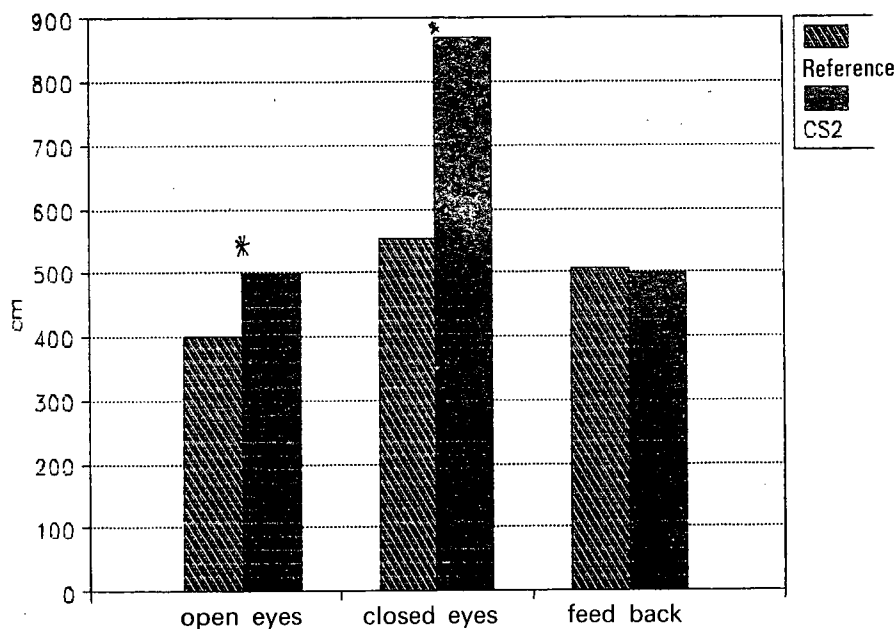


Fig. 7. Mean length of statokinesiogram in the examined group.

DISCUSSION

In order to gain and keep balance in the upright position, an integrative coordination of organs taking part in the balance maintenance (ie. vestibular system, proprioceptors and vision) is required. The influence of vestibulospinal inputs on human postural control is also important. Such complexity of mechanisms responsible for equilibrium makes it difficult to define criteria for assessing their efficiency (6, 9, 11, 12).

In the study presented, both an oculomotor reaction (ENG record of nystagmus as a reaction essential in the vestibular pathology) and postural balance disorders in the statokinesiometric test were evaluated.

ENG examinations conducted in the group of patients with chronic CS₂ intoxication showed pathological patterns of nystagmus in 75.5% of subjects. Qualitative and quantitative analyses of ENG tracings allowed us to identify sites of lesions in the central part of vestibular system. Such localisation of changes was presumed on the basis of recorded abnormalities such as the presence of spontaneous and direction-changing positional nystagmus found in 16.2% of subjects, nystagmoidal movements in 10.8%, disturbances of optokinetic nystagmus (asymmetry) in 63.8%, pathological pattern of the eye-tracking test tracings in 16.2% and directional preponderance of induced nystagmus in the rotatory test in 70.3% of subjects.

The statokinesiometric test conducted in the same persons revealed considerable difficulties in maintaining postural stability, increased body sway incidence, expressed in much augmented contour area, length and velocity of stabilogram curve.

Perturbations and lateralization were proportional to the level and character of vestibular lesion showing high compatibility (89.2%) with ENG data.

During the E-C test, intensified stability disorders were observed while fixation of eyes on a light spot (V-S test), facilitating correction of the body gravity centre, evidently improved postural stability.

The presented data are, consistent with observations made by other authors (4, 8, 10, 17).

For instance, investigations conducted by De Wit (3) in a patient with an impaired labyrinth due to Meniere's disease and in a patient with an inactive labyrinth, indicated great influence of the vestibular system on statokinesiometric curves course.

Kubiczkowa (7) performed the statokinesiometric test together with nystagmus recording in 45 persons (25 females and 20 males, age range 20-55 years) with postural stability perturbations due to various diseases such as: neuronitis vestibularis, Meniere's disease, commotio cerebri peracta, insufficiency of vertebral and basilar arteries and neurological diseases (sclerosis multiple, pyramid-cerebellar lesion). Comparing the records, she indicated a correlation between oculomotor reaction and balance disorders.

Interpretation of ENG and statokinesiometric data as well as an assessment of compatibility between these two investigations are difficult since limbs are not so strongly linked as eyeballs and they are strongly affected by central nervous centres which modulate these reactions (12, 13, 15, 16, 18).

It should be remembered that there are many other factors which can affect postural stability such as: circulatory disturbances atherosclerosis, neurotoxicity, noise, fatigue, excitement and hypersomnia (18).



In summary, it can be concluded that results of the present study confirm the value of the statokinesiometric test in the diagnosis of vertigo and balance disorders observed in chronic intoxication with carbon disulphide. This method is reliable which has been proved by compatibility obtained in our study with results of the electronystagmographic test, less time consuming and it may become easily available in the clinical practice contrary to elektronystagmography which requires more expensive equipment.

CONCLUSIONS

1. The statokinesiometric test facilitates an objective assessment of reactions of organs involved in balance maintaining.
2. In early intoxication forms, characterized by limited and subjective symptoms, nystagmus reactions and instability can be the only objective manifestations of the disease.
3. In persons with central vestibular lesion, resulting from CS₂ intoxication, strong correlation (89.2%) between ENG data and postural balance disorders, found in statokinesimetry, was confirmed.

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Received for publication: July 16, 1992

Accepted for publication: August 14, 1992

