

PARADOX EFFECT: A POSTUROGRAPHIC SIGN OF CEREBELLUM FUNCTIONAL INVOLVEMENT IN DIZZY PATIENTS

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ABSTRACT

Kohen–Ratz described in autistic children a particular behaviour of posturographic findings that he named “Paradox Effect” : to be more stable when standing on foam pads with eyes closed as compared to solid surface with eyes open. He correlated this “paradox” phenomenon to the involvement of cerebellar controls.

The aim of this paper is to investigate the incidence of Paradox Effect in a large dizzy population.

Normal values were calculated in 65 normals subjects (43 females and 22 males mean age 43.8 yr). *NORMAL PARADOX INDEX (P. I.)*. It was calculated as $0.8 + SD 0.12$ on the basis of mean surface values. It can be considered pathological when the index is more than 1.1 (mean value+ 3SD). Although PI could be calculated comparing every body sway referred parameter by means of every kind of postutographic equipment, only patients investigated through Tetrax Equipment. 1300 dizzy patients (856 females and 444 males mean age 64,7 yy) were included.

Abnormal P.I. was found in 183 cases (98 females and 85 males mean age 49,5 yy; 14 %). 60 cases (33%) presented dizziness after whiplash. In all cases MRI was performed. MRI showed cerebellar lesions in 3 cases in Traumatic group (5 %) and normal in the others. In no-traumatic group MRI showed cerebellar

lesions in 37 (30 %) and Central Nervous System lesions, in general, in 73 (59.3 %)

Paradoxical behaviour can be easily investigated because it is based on comparison of body sway in two conditions usually performed during routine posturography: standing with eyes open on solid surface and with eyes closed on foam, and expressed by means of Paradox Index.

Thus, even if paradox effect is not frequent to be observe, it can be considered a specific sign suggesting a CNS, in general, and cerebellar, particularly, involvement.

Introduction

The destabilizing effects of reducing visual and /or somatosensory inputs on postural control is well known and has been widely documented by postural research. In 1979 Kohen–Ratz (5) described in autistic children a particular behaviour of posturographic findings that he named “Paradox Effect” : autistic children were more stable when standing on foam pads with eyes closed as compared to solid surface with eyes open. He correlated this “paradox” phenomenon to the involvement of cerebellar controls that are hypotized to be involved in autistic syndrome. (7)

In 2001 Khoen-Ratz et al. (8) described “Paradox Effect” in patients affected with Multiple Sclerosis. They observed a correlation with cerebellar Kurtzke sub-scale and thus confirmed the cerebellar origin of Paradox Effect

The aim of this paper is to investigate the incidence of Paradox Effect in a large dizzy population.

Material and Methods

Paradox effect is evidenced by specific posturographic tests which require the patient to stand on elastic pads with closed eyes. Comparing the results in the two conditions

PARADOX INDEX can be calculated as the ratio between body sway standing with eyes open on solid surface (Fig. 1A) and standing with eyes closed on foam (fig. 1B)

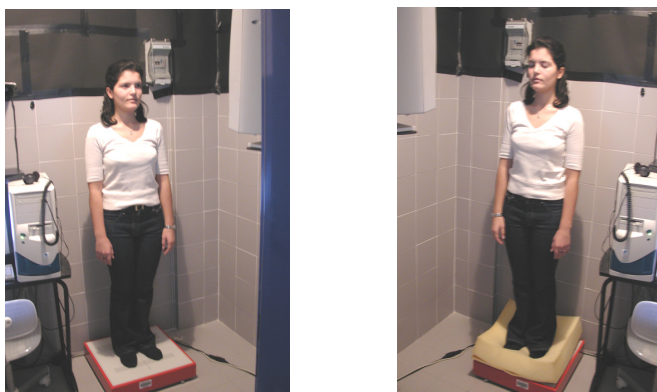


Fig.1: Test is performed in two conditions: standing with eyes open on solid surface (left A) and standing with eyes closed on foam (right B)

Normal values were calculated in 65 normal subjects (43 females and 22 males mean age 43,8 yy). *NORMAL PARADOX INDEX (P. I.)* was calculated as $0.8 + SD 0.12$ on the basis of mean body sway values. It can be considered pathological when the index is more than 1.1 (mean value+ 3SD).

In this study were considered patients affected by central vestibular disorder, according well-known diagnostic criteria (3) including electronystagmography, evoked potentials, posturography. Although PI could be calculated comparing every body sway referred parameter by means of every kind of posturographic equipment, only patients investigated through Tetrax Equipment (6) were considered. Subjects for this study were selected out of the data-bases of three Balance Units in Milan regarding patients evaluated because complaining vertigo or dizziness. Patients were evaluated by the same operator for each Unit (R.G; C.A.; M.V). Selected cases were supervised by an independent expert otoneurologist (H.A). In this way 1300 dizzy patients (856 females and 444 males mean age 64,7 yr) were considered.

Results

Abnormal P.I. was found in 183 cases (98 females and 85 males mean age 49,5 yy) out of 1300 patients (14 %)..

PI was more than 2 in 7%, more than 1,6 and less than 2 in 23% and more than 1,5 in 70% of cases. In all cases MRI was performed.

60 cases (33%) presented dizziness after whiplash. In these, MRI showed cerebellar lesions in 3 cases (2 cerebellar haematoma, 1 dissection aneurysm of vertebral artery) (5 %) and was normal in the others. In the NO-Traumatic group Neuroimaging showed Cerebellum involvement in 37 patients (30 % Tab. I); in the other subjects MRI was normal in 13 (10,5%) and showed vascular lesions in 73 (59,3%).

No correlation was noted regarding PI absolute value and diagnosis.

Discussion

A small group (14%) of patients complaining vertigo and dizziness due to central Vestibular system involvement present a paradoxical behaviour regarding stance control. These patients are particularly impaired in integrating multisensorial inputs from the periphery, such as visual and proprioceptive afferences required to control balance, when standing on solid surfaces with eyes open.

Cerebellum is therefore suggested to be the site of this impairment (8). Damage to this structure could impair its ability to integrate sensorial input so that they could find it easier to keep the postural control when inputs are reduced and the cerebellum has less information to elaborate.

Starting from a survey of current ideas on the role of the cerebellum in sensori-motor transformations, recent experiments (2) showed that somatosensory signals modify the spatial organization of the postural reflexes, thus leading to body

stability, and otolith input changes the plane of reflex eye movements, by keeping it perpendicular to the gravito-inertial vector. Evidence will be given that both transformations require the integrity of specific cerebellar regions. These data indicates that the cerebellum allows an optimal input-output coupling in relation to the ultimate behavioural goal of the motor activity.

Cerebellum has at least two related roles, both sub-served by its operation as a 'forward model' of the motor system. First, it provides an internal state estimate or sensory prediction that is used for online control of movements; second, these predictive state estimates are used to coordinate actions by different effectors in the normal coordination of eye and hand, reach and grasp, etc. Preliminary electrophysiological data from cerebellar cortical neurons in the monkey (9-10) supports the hypothesis that a proportion of cells code for the sensory consequences of movement.

Functional imaging of the human cerebellum further supports the hypothesis that the cerebellum is involved in motor control including selection of appropriate cue to maintain both static and dynamic balance.

MRI showed CNS lesions in 89 % and specifically cerebellar in 30 % in patients affected with central vestibular system dysfunction not due to a trauma. MRI was altered only in 5% when vestibular disorder is due to whiplash, thus a dysfunctional and not lesional origin of the paradox effect has to be suspected in normal neuroimaging cases.

Results indicate that Paradox Effect is namely cerebellar but it could be due to a more general CNS involvement both lesional and dysfunctional regarding the appropriate use of proprioceptive and visual cues in maintaining stance. In fact, there is a massive input from cortical and subcortical visual areas to the pontine nuclei. Cells in the pontine nuclei respond vigorously to appropriate visual targets and they distribute their axonal terminals bilaterally in the cerebellar cortex. A cortico-ponto-cerebellar circuit would have remained intact in all cases in the literature in which there was complete disconnection of cortico-cortical fibres between visual and motor cortex. Lesions of the cortical sensory areas that project to the pons or interruption of the fibres within the internal capsule or basis pedunculi, that link cortical sensory areas with the pontine nuclei, can severely impair the sensory postural control. (10)

Conclusions

Paradoxical behaviour can be easily investigated because is based on comparison of body sway in two conditions usually performed during routine posturography: standing with eyes open on solid surface and with eyes closed on foam, as expressed by means of Paradox Index.

Thus, even if paradox effect is not frequent to be observe, it can be considered a specific sign suggesting a CNS, in general, and cerebellar, particularly, involvement.

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