

Dynamic stabilometric findings in equilibrium disorders of the elderly

Rilievi stabilometrici dinamici nelle turbe dell'equilibrio dell'età senile

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Key words

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Parole chiave

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Summary

Equilibrium disorders are frequent symptoms of aging, both on account of the so-called “multisensorial decay” and age-related diseases. Aim of the study was to evaluate the functional integrity of static-dynamic postural control related subsystems (visual, somatosensorial, vestibular), the fundamental postural strategies effected and adaptation to destabilizing inputs, in elderly subjects with otoneurological disorders. From January to November 2003, 40 elderly patients (19 male, 21 female, mean age \pm SD: 69.5 \pm 4.3 years; range: 65-83), with balance disorders, consisting in dizziness or vertigo, have been observed. Otoneurologic and internal case history was collected in all patients, all of whom were submitted to otoscopy, otoneurologic examination, pure-tone audiometry, as well as a specific examination called Equi test. The sensorial analysis, as often occurs in elderly subjects without unbalance, revealed marked impairment of the somatosensorial (85%), compared to vestibular (60%) and visual (40%), subsystems. Longer latencies of motor responses to forward platform translations than to backward translations were observed, even if the symmetry of movements was more evident in the former. Postural adaptation was more frequently impaired during raising of the support (70%) than during lowering. Therefore, in elderly people, somatosensorial impairment, combined with flexor muscle dysfunction, exists. Indeed, extensor responses, although slower than flexor responses, are more correctly performed.

Riassunto

Le turbe dell'equilibrio sono molto frequenti in età senile, sia per via del cosiddetto “declino multisensoriale” che a causa delle patologie legate all'invecchiamento. Lo scopo del lavoro è stato quello di valutare, attraverso apposite metodiche di indagine, l'integrità funzionale dei sottosistemi che presiedono al controllo posturale statico-dinamico del soma (visivo, propriocettivo e labirintico), le principali strategie posturali adottate nonché la capacità di adattamento ad impulsi destabilizzanti, nei soggetti anziani con problemi otoneurologici. Dal mese di Gennaio al mese di Novembre 2003 sono stati osservati 40 pazienti anziani (età media \pm DS: 69,5 \pm 4,3 anni range: 65-83 anni; 19 uomini, 21 donne), affetti da turbe dell'equilibrio consistenti in vertigini o vertigini propriamente dette. Ciascun paziente è stato sottoposto alla raccolta dell'anamnesi otoneurologica ed internistica, ad esame obiettivo otologico, alla visita otoneurologica, ad esame audiometrico ed infine ad uno specifico esame noto come Equi test. L'analisi sensoriale ha evidenziato, come spesso accade anche nei soggetti in età geriatrica senza spiccati problemi otoneurologici, una prevalente compromissione del sistema propriocettivo (85%) rispetto a quello vestibolare (60%) e visivo (40%). È stata inoltre palesata una maggiore latenza delle risposte nelle traslazioni della pedana in avanti piuttosto che nelle traslazioni della stessa indietro, anche se la simmetria dei movimenti era più facilmente mantenuta nella prima evenienza. L'adattamento posturale era più spesso alterato in caso di sollevamento della pedana (70%) che non in seguito al suo abbassamento. Pertanto, nell'anziano è evidente una condizione di netto deficit propriocettivo, il quale si associa ad una disfunzione prevalente dei muscoli flessori. Infatti, le reazioni posturali di tipo estensorio, pur essendo più lente di quelle di tipo flessorio, vengono attuate in maniera più precisa.

Introduction

Equilibrium disorders, consisting of vertigo or dizziness, are one of the most important causes of disability and morbidity in the elderly¹⁻³.

It has been reported that sudden falls on the ground, frequent motor inability and some conditions of discomfort, limiting the self-sufficiency of elderly peo-

ple, are due to otoneurologic diseases or to an anatomic-functional decay of the equilibrium system⁴.

The latter condition derives from a gradual functional depletion of the three balance subsystems (visual, somatosensorial, vestibular), known as “multisensorial decay”^{5,6}.

In the elderly, visual function is impaired by presbyopia, accommodation deficit, down regulation of

retinal receptors; the somatosensorial function by articular and tactile receptors reduction in numbers and, moreover, by functional impairment of muscular and osteoarticular effectors; the vestibular control, at last but not least, by reduction of macular and ampullar cells, otolithic degeneration, involution of ganglionic neurons⁷.

The function of equilibrium subsystems is further weakened both by the delay in conduction of afferent inputs, produced by progressive degeneration of nerve fibres, and by the impaired sensorial decodification of the central nervous system (CNS) related to neuronal dysfunction and encephalic mass reduction⁸. In aging, various cardiovascular, dysmetabolic, neurologic and psychiatric conditions have a negative effect upon the equilibrium of the patient^{9,10}.

On account of the importance of equilibrium disorders in the elderly, a review has been made of the clinical data of all patients over 65 years of age, with otoneurologic disorders, observed from January to November 2003.

The aim of the study was to assess, by means of the results of a specific vestibular investigation method, called Equilibrium test (Equi test), the functional integrity of the three subsystems on which postural control depends, the postural strategies effected and the adaptation to destabilizing inputs in elderly subjects with otoneurologic symptoms.

Materials and methods

From January to November 2003, we observed 40 patients (19 male, 21 female) over 65 years of age (mean \pm SD: 69.5 \pm 4.3 years; range: 65-83), suffering from equilibrium disorders occurring in a period varying between 5 months and 10 years.

Evaluation of each patient included:

- a careful review of internal and otoneurological case history;
- otoscopy;
- otoneurologic examination (Romberg test, Fukuda test, assessment of spontaneous nistagmus during eye movements and after Head Shaking test, research of positioning nistagmus through Dix-Hallpike and McClure manoeuvres);
- pure-tone audiometry;
- equilibrium test.

None of the patients reported whiplash injuries, bone fractures, otologic diseases, habitual use of ototoxic drugs or other harmful substances (alcohol, nicotine). They reported, on the other hand, diseases involving bone metabolism (37.5%; 15/40), blood and haematopoietic organs (5%; 2/40), respiratory apparatus (7.5%; 3/40), thyroid gland (17.5%; 7/40), cardiovascular apparatus (60%; 24/40), glucose and lipid metabolism (35%; 14/40), digestive tract (25%;

10/40), urinary apparatus (2.5%; 1/40) and CNS (17.5%; 7/40).

From the otoneurologic case history, it was possible to identify 3 basic clinical groups:

- Persistent dizziness* (37.5%; 15/40). This was reported as a subcontinuous postural disability, sometimes described as "drunkenness condition", sometimes as a "feeling of falling into space", which induced a sudden stop in walking and a marked impairment of the sense of direction.
- Recurrent dizziness or vertigo episodes* (17.5%; 7/40). In this case, due to persistent instability, some vertiginous attacks occurred.
- Chronic unbalance with recurrent falls to the ground* (45%; 18/40). Subjects belonging to this group described a condition of chronic unbalance that frequently gave rise to sudden falls to the ground.

Otoscopy revealed no significant sign except for modest opacity of the tympanic membranes in 35% (14/40) of patients.

Results of the otoneurologic examination were more useful.

The Romberg test, performed in all subjects, first with eyes open, then with eyes closed, revealed transversal sways (30%; 12/40), sagittal sways (10%; 4/40) or pluridirectional sways (60%; 24/40).

The Fukuda test showed transversal deviations (45° or 90°) in 90% (36/40) of the subjects.

As far as concerns nystagmus, this was evoked during eye movements in 37.5% (15/40) of patients, but in 60% (24/40) following the Head Shaking test. Positioning nystagmus evaluated by means of Dix-Hallpike and McClure manoeuvres was absent in all cases.

Bilateral hearing loss was revealed by pure-tone audiometry in all subjects: 75% (30/40) showed a down-sloping hearing loss, 25% (10/40) a flat hearing loss (pure tone mean: 62 \pm 3.4 dB).

Patients were then submitted to balance examinations using a specific dynamic stabilometric tool called Equilibrium test (Equi test) which evaluates:

- the extent to which each balance subsystem influences postural control;
- motor responses to destabilizing movements of the platform on which the patient stands.

The first evaluation is performed by the "Sensorial Organization Test" (SOT), the second by the "Motor Control Test" (MCT).

SOT is composed of 6 different sensorial conditions lasting 30 seconds and repeated 3 times:

- normal vision, fixed support;
 - absent vision, fixed support;
 - sway-referenced vision, fixed support;
 - normal vision, sway-referenced support;
 - absent vision, sway-referenced support;
 - sway-referenced vision, sway-referenced support.
- The test, performed under these conditions, assesses

the patient's ability to make use of visual, vestibular and somatosensory inputs separately and to suppress sense at times when they provide inaccurate information.

The parameters evaluated are:

- equilibrium score, numerical index of the subject's equilibrium which, in normal conditions, ranges from 70 to 100;
- sensory analysis quotients (SOM, VIS, VEST, PREF) that evaluate the functional integrity of the 3 balance subsystems;
- strategy analysis, which indicates whether the patient has used an ankle or a hip movement strategy.

The MCT assesses synchronization and latencies of the motor responses that the patient performs when the support is subjected to destabilizing movements, like backward or forward translations or up/down tilts.

The parameters evaluated consist of:

- latencies of the responses, time delay between onset of perturbation and first active force response against the support surface;
- dynamic symmetry of the responses, distribution of active force response between the two feet;
- amplitude scaling, amplitude of response in relation to amplitude of the stimulus;
- adaptation, which assesses the patient's ability to maintain postural control during raising or lowering of the support through activation of anterior or posterior tibial muscles.

Results

The dynamic stabilometric data were very interesting.

Overall 90% (36/40) of the subjects had an Equilibrium score below 70, whereas in 10% (4/40), this parameter was normal.

The sensory analysis revealed a prevalent somatosensory impairment (85%; 34/40) (Fig. 1).

The strategy analysis did not show a prevalence of the ankle/hip strategy since they were both equally represented in the patients.

As far as concerns the MCT results, elderly subjects were seen to respond faster to backward, than to forward translations, the percentage of pathologic latencies being more evident in the latter condition (72.5% vs. 35%).

Symmetry of the responses, on the contrary, was higher during forward translations (60% vs. 15%).

Amplitude Scaling was abnormal in only 35% (14/40) of cases.

Adaptation was impaired in 70% (28/40) of subjects, especially following raising of the support (Fig. 2).

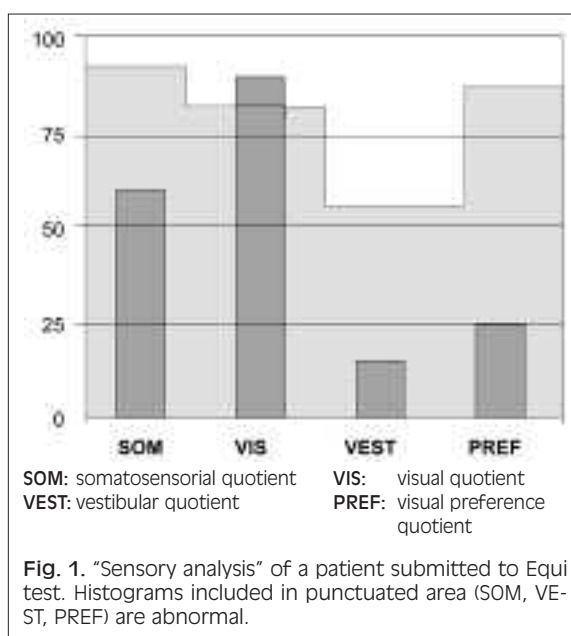


Fig. 1. "Sensory analysis" of a patient submitted to Equi test. Histograms included in punctuated area (SOM, VEST, PREF) are abnormal.

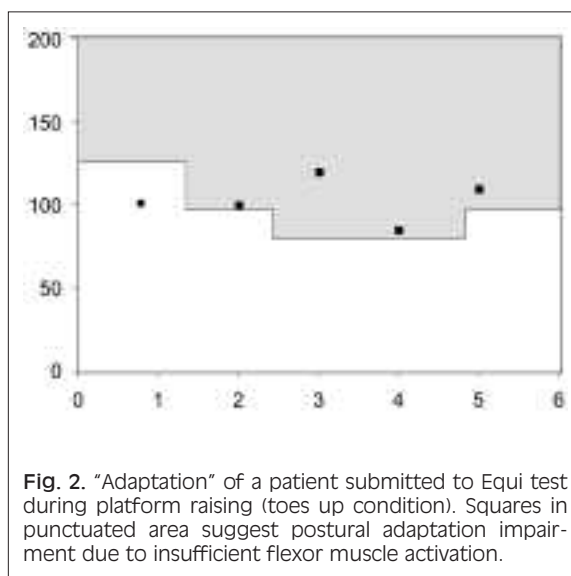


Fig. 2. "Adaptation" of a patient submitted to Equi test during platform raising (toes up condition). Squares in punctuated area suggest postural adaptation impairment due to insufficient flexor muscle activation.

Conclusions

The prevalence of equilibrium disorders in the elderly is considered to be very high.

Otoneurologic symptoms are present in about the 44% of subjects over 65 years of age and in 59% of subjects over 85 years¹¹.

The high prevalence of vertiginous syndromes in the elderly may be due to 3 fundamental factors:

- "multisensory deterioration" related to aging, which induces a downright inputs conduction and decodification delay^{12,13};

- b) aging-related diseases which interfere with vestibular performances of the CNS¹⁴;
 c) muscle tone impairment induced by miotactic reflex deficiency^{15 16}.

Disequilibrium sometimes causes psychiatric disorders or simply insecurity due to the progressive loss of social autonomy.

In the present study population, the otoneurologic symptoms observed were often pure vertiginous attacks but with instability which, sometimes, either spontaneously or following specific body movements, worsened to the extent that an unbalance condition arose. The previous case history associated with results of the otoneurologic examination, suggests a central origin of the equilibrium disorders reported by patients.

The otoneurologic investigation, using the Equi test, provided other important data.

The somatosensorial subsystem would appear to be the most impaired as a consequence of the aging-related multisensorial decay.

Indeed, it is well-known that in elderly subjects, the anatomo-functional decay of muscles, joints and bones coincides with gradual dysfunction of the Golgi and neuromuscular receptors, inducing delayed transmission of somatosensorial information to the cerebellum.

Moreover, the functional deficit of muscles and joints causes a change in the responses to vestibular

outputs conducted by the vestibulo-spinal system.

The impairment not only of afferent, but also of efferent, information could provide a clear explanation of the results of the sensory analysis.

In the elderly, however, there is also a deterioration in skin sensitivity leading to a functional insufficiency of the applied forces of heels and toes on the ground.

The MCT revealed flexor muscle dysfunction during raising of the support.

We also observed longer latencies of motor responses to forward, than to backward platform translations, whereas the symmetry of movements was more evident in the former.

Probably, the elderly, due to a particular postural coordination programme, elaborated by the trunk and cerebellum, develop faster but inaccurate responses to destabilizing tilts coming from forward to backward. Results of this investigation demonstrate that equilibrium disorders are a serious and complex problem of aging, the clinical-diagnostic definition of which requires meticulous otoneurologic investigations.

Sensory analysis together with the observation of postural strategies in aging could be usefully employed to elaborate a specific vestibular rehabilitation programme.

The Equi test is, in our opinion, a dynamic stabilometric tool that provides meaningful information in the otoneurologic assessment of the elderly.

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