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Falls in the Elderly: The Development of a Risk Questionnaire and Posturographic Findings

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Abstract: In elderly people, owing to a perturbation at several levels, including the motor, sensory and cognitive levels, a condition of dizziness and unsteadiness complicated by frequent falls often appears. In this article, we review the most recent information about clinical and instrumental tools available for preventing mobility-related accidents and report the results of a comparative study of postural control, carried out through tetraataxiometry (by Tetrax, Tel Aviv, Israel), in two samples of elderly women belonging to two different populations: 24 Italian women (11 reporting falls and 13 without falls) having a mean age of 73.1 years, and 37 Israeli women (12 with falls and 25 without falls) having a mean age of 72.5 years. The posturographic findings show that the falling subjects, to maintain postural control, are highly dependent on somatosensory inputs and have a weaker "*systeme postural fin*" (fine postural system), according to Gagey. They also show that an elderly subpopulation exists that, for unknown reasons, is immune to destabilization and falls.

Key Words: elderly; falling risk inventory; falls; tetraataxiometry

Dizziness and unsteadiness are frequent symptoms of aging. They are particularly important because they impair the social autonomy of the aged and often are the cause of falls. The causes of falls differ widely. There is evidence that aging affects multiple sensory inputs as well as the muscles', joints', and central nervous system's ability to perform sensorimotor integration [1, 2]. The elderly are characterized by a perturbation at several levels, including the sensorimotor (decreases in muscle mass, increases in the threshold of vibratory sensations) and the cognitive levels (memory processes, attention span) [3]. Gait stability, especially in women, may be compromised in the elderly by the combination of increased body weight and decreased muscle strength [4].

Generally speaking, falls in the elderly typically are caused by multiple deficits that can add up to produce disability disproportionate to their individual contributions [5, 6]. In this article, we aim to present clinical and instrumental tools connected with accidental falls.

MATERIALS AND METHODS

Falling Risk Inventory Questionnaire

An initial period was dedicated to developing a specific questionnaire aimed at identifying aged subjects with increased risk of mobility-related accidents. An earlier-version falling risk inventory questionnaire (FRI) consisting of 87 items was administered to 57 randomly selected subjects (29 women and 28 men) distinguished only on the basis of age (older than 65 and younger than 80 years). Some subjects had a history of falls,

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whereas others did not. Questionnaire items were based on the most frequent causes of falls.

The questionnaires were evaluated by means of Rasch analysis [7], a statistical model based on item response theory. It assumes that the probability of a given subject-item interaction is governed only by the item's difficulty and the subject's ability. Starting from the matrix of raw scores, difficulty and ability are both estimated in true interval units along the shared continuum made up by the underlying variable (in this case, the risk of falling). Once item measures are known, their spreading and redundancy can be easily assessed. According to a logistical model, the more a subject's ability overcomes the item's difficulty, the higher the probability is for the subject to achieve a pass rather than a fail score in that item. Once a subject's overall ability and the item difficulty are known, individual missing responses can also be estimated (an otherwise arbitrary procedure with raw scores). The improbability of the response of a subject to the various items accumulates, thus providing a measure of improbability of the whole response set. The same holds true for the improbability of the response achieved by a given item from various subjects. Rasch analysis of the first release of the FRI allowed us to prepare a definitive version of the FRI (Table 1).

The revised FRI was proposed to general practice doctors (GPs) for use in select subjects with a high risk of falls. The questionnaire is self-administered, and it comprises 32 items, 8 of which assess lifestyle (e.g., number of hours the patient spends at home), 4 the social and affective situation (e.g., amount of time the patient spends alone during a day), 4 general mobility (e.g., whether a patient experiences difficulty in climbing stairs), 8 the patient's general state of health (e.g., whether hypertension is present), 4 daily activities (e.g., whether having a bath is difficult), and 4 medications (e.g., use of hypotensive drugs or benzodiazepines).

Table 1. Falling Risk Inventory Questionnaire

1. Do you (happen to) stumble on staircases?
2. Do loud noises make you start?
3. Do you spend more than 6 hours daily watching television?
4. Do you usually need a companion (to be able) to walk?
5. Do open spaces make you feel uneasy?
6. Does your head spin when you urinate in the morning after waking up?
7. Do your feet hurt when you put them down?
8. When you walk, is it an effort/strain to watch where you are going? The ground? To look down?
9. Do you suffer from blood pressure problems?
10. Do crowded places make you feel uneasy?
11. When you walk, do you feel pains in your leg joints?
12. Do you usually stay at home in the afternoon after lunch?
13. Do you suffer from sudden headaches?
14. Do you experience chewing problems?
15. Do you have a restricted social life, limited largely to your family, so that social contacts and stimuli are few?
16. Do you happen to upset objects casually?
17. Are you in trouble or afraid when taking a bath?
18. Do you have a heart condition?
19. Is it an effort for you to go down stairs?
20. Do your hands shake?
21. Do your wear shoes with rubber soles?
22. Do you use diuretics?
23. Does your head spin when you evacuate?
24. When you get up in the morning, do you need to remain seated on the bed for a few minutes before standing up?
25. When you look about yourself, do you need to move your head slowly?
26. Do you spend most of your time at home remaining seated?
27. Do you feel faint when you stand for a while?
28. In the morning, do you need to sit up and stand up slowly?
29. Do you experience problems in lacing your shoes while standing?
30. Do you experience problems in getting dressed while standing?
31. When you walk, do your legs hurt?
32. When you're at home, do you wear slippers?

Stabilometric Assessment: A Tetraataxiometric Evaluation

Postural control of a standing individual can be partly considered as a dynamic feedback control involving somatosensory, cervical proprioceptive, vestibular, and visual information [8]. The measurement of body movements during stance are used to assess postural control objectively, which has led to the development of posturography. Tetraataxiometry (Tetrax, Tel Aviv, Israel) is the last developed posturographic set, consisting of two pairs of single piezoelectric sensor platforms that record posturographic right and left heel and toe applied forces on the ground. The posturographic findings in falling and nonfalling elderly women belonging to two culturally different populations, Italian and Israeli, have been compared, and the preliminary results are presented here.

Two samples were collected from two groups: 24 Italian women—11 reporting falls and 13 without falls—having a mean age of 71.6 and 73.1 years, respectively, and 37 Israeli women—12 with falls and 25 without

Table 2. Cross-Cultural Comparison of Posturographic Features of Elderly Women Reporting Falls and Those Reporting No Falls

	Women Without History of Falls		Women With History of Falls	
Sample	No. of Subjects	Mean Age (yr)	No. of Subjects	Mean Age (yr)
Italian	11	71.6	13	73.1
Israeli	12	72.9	25	72.5

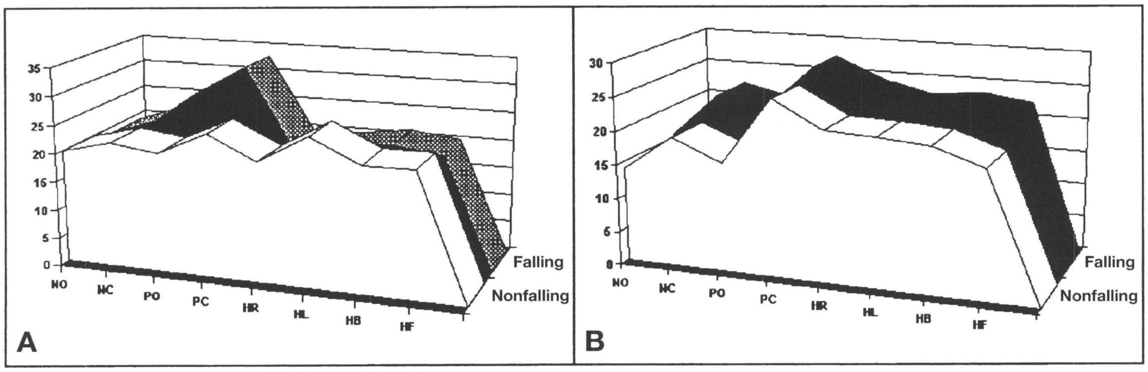

Figure 1. General stability among Italian (A) and Israeli (B) subjects. Falling elderly subjects are less stable than nonfalling elderly subjects during a standing test on pads. Percentage of instability index is displayed on the ordinate axis (low score indicates stable; high score indicates unstable). (*HB* = head bending backward; *HF* = head bending forward; *HL* = head turning leftward; *HR* = head turning rightward; *NC* = normal closed [eyes closed]; *NO* = normal open [eyes open]; *PC* = pads closed [eyes closed, standing on foam pads]; *PO* = pads open [eyes open, standing on foam pads].)

falls—having a mean age of 72.9 and 72.5 years, respectively (Table 2). Patients were evaluated by means of the interactive balance system Tetrax platform, which consists of a pair of sensor platforms subdivided into a heel and a toe part. In this way, a simultaneous recording of right-left and toes-heel sway is possible.

The posturographic examinations were performed under eight conditions:

- Eyes open (normal open [NO]) and eyes closed (normal closed [NC])
- Eyes open and eyes closed while standing on foam pads (pads open [PO] and pads closed [PC], respectively)
- Bending the head forward (HF) and backward (HB)
- Turning the head leftward (HL) and rightward (HR)

Dedicated software calculated different parameters:

- General stability
- Fourier sway frequencies spectral analysis, ranging from 0 to more than 3 Hz and divided into eight ranges (F1: 0–0.10 Hz; F2, 0.10–0.25; F3: 0.25–0.35; F4: 0.35–0.50; F5: 0.50–0.75; F6: 0.75–1.00; F7: 1.00–3.00; F8: > 3 Hz)
- Weight distribution
- Weight distribution index, which is the standard deviation of the four weight distribution scores from an expected mean of 25%
- Left/right forces synchronization
- Toes and heel forces synchronization

Synchronization is the most innovative aspect of

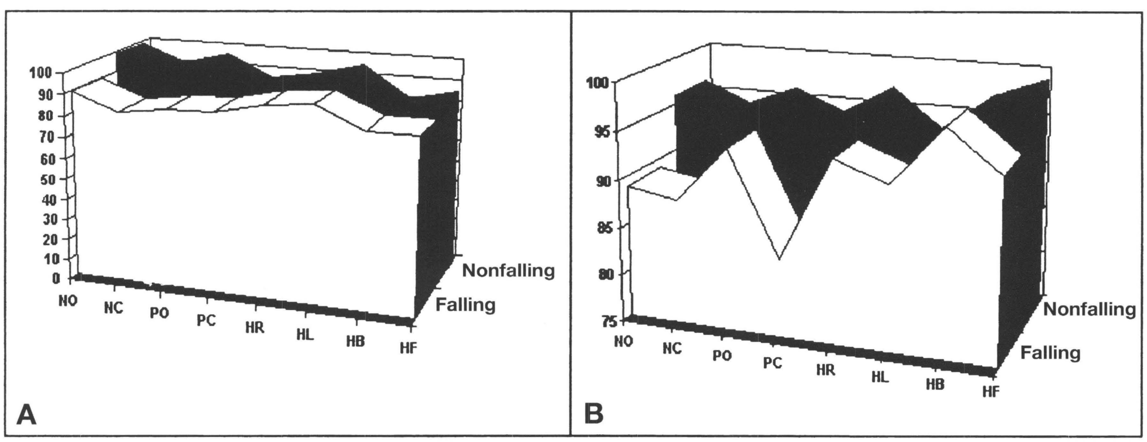

Figure 2. Fourier harmonic index (FHI) among Italian (A) and Israeli (B) subjects. Both Israeli and Italian falling subjects show a decrease of FHI, especially when they are standing on pads (i.e., under conditions of somatosensory deprivation). This is more pronounced in the Israeli sample. Seize of the FHI is displayed on the ordinate axis. (Key is provided in caption for Figure 1.)

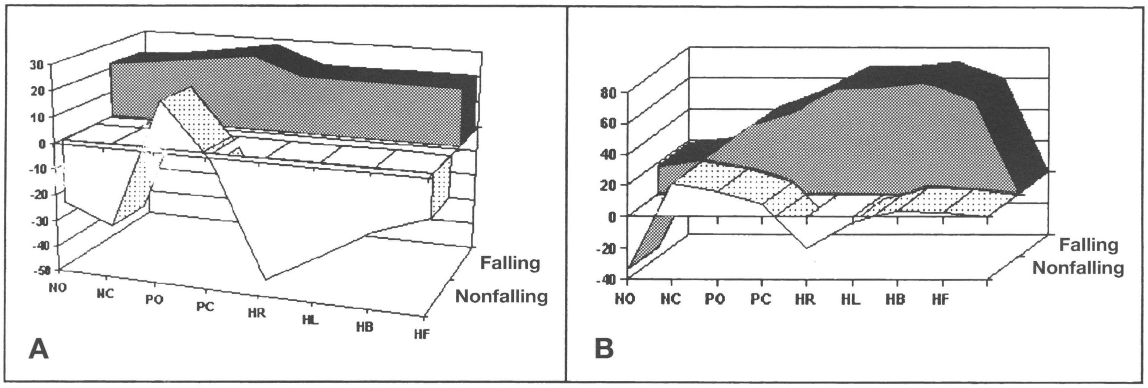

Figure 3. Correlations between chronological age and stability among Italian (A) and Israeli (B) subjects. Age is correlated to instability only in falling subjects, whereas a paradoxical negative correlation is evident in nonfalling subjects, regardless of their nationality. Percentage of instability index is displayed on the ordinate axis (0 = normal stability; 100 = fall). (Key is provided in caption for Figure 1.)

posturography and is peculiar to tetraataxiometry. It reflects the correlation between the oscillations of the left part of the body with respect to the right and the correlation between the oscillations of the anterior part of the body (toes) and the posterior (heels). The oscillations may be in phase and defined as *coactive synchronization* or opposite in phase and defined as *compensatory synchronization.*

RESULTS

The general findings evident in both independent samples were as follows: Falling subjects were less stable only in positions requiring them to stand on pads: That is, subjects proved to be highly dependent on somatosensory inputs and had difficulty compensating through visual or vestibular control (Fig. 1). The Fourier harmonic index is lower in falling subjects (Fig. 2), indicating a weaker "*systeme postural fin*" (fine postural system), according to Gagey [9] and probably a weaker postural feed-forward mechanism, anticipating dangers that threaten the body's equilibrium.

In nonfalling subjects, there was no correlation or a negative correlation between age and instability, whereas in falling subjects, age correlated positively with instability, as might be expected (Fig. 3). This situation seems to indicate that among elderly persons is a subpopulation that, for unknown reasons, is immune from destabilization and, hence, from falls. These findings are interesting and require further investigations.

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