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REVIEW/MISE AU POINT

# Comparison between investigations of induced stepping postural responses and voluntary steps to better detect community-dwelling elderly fallers



*Comparer les analyses des réponses posturales lors des pas de rattrapage et des pas volontaires pour mieux détecter les personnes âgées autonomes à risque de chute*

R. Tisserand<sup>a,b</sup>, T. Robert<sup>a,b,\*</sup>, P. Chabaud<sup>a,c</sup>, P. Livet<sup>d</sup>,  
M. Bonnefoy<sup>e</sup>, L. Chèze<sup>a,b</sup>

<sup>a</sup> Université de Lyon, 69622 Lyon, France

<sup>b</sup> IFSTTAR, UMR\_T9406, LBMC laboratoire de biomécanique et mécanique des chocs, LBMC case 24, 25, avenue François-Mitterrand, 69675 Bron cedex, France

<sup>c</sup> EA 647, CRIS centre de recherche et d'innovation sur le sport, université Claude-Bernard Lyon 1, Lyon, France

<sup>d</sup> Centre régional de prévention, Lyon, France

<sup>e</sup> Service de médecine gériatrique, centre hospitalier Lyon Sud, Pierre-Bénite, France

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**Summary** In this paper, we review a physiological task that is predominant in preventing humans from falling, but that simultaneously also challenges balance: taking a step. In particular, two variants of this task are presented and compared: the voluntary step versus a step induced by an external and unpredictable perturbation. We show that, while these contribute different information, it is interesting to compare these. Indeed, they both are relevant in a global balance assessment and should be included within this, at the same level as tests usually dispensed in the clinical environment such as posturography. We choose to focus on the community-dwelling elderly population, to discuss means of early detection of risk of falls, in order to prescribe an appropriate prevention. An overview of posture-movement coordination and balance recovery strategies is also provided. Finally, a working hypothesis is suggested

\* Corresponding author. IFSTTAR, UMR T9406, LBMC laboratoire de biomécanique et mécanique des chocs, LBMC case 24, 25, avenue François-Mitterrand, 69675 Bron cedex, France.

E-mail address: [thomas.robert@ifsttar.fr](mailto:thomas.robert@ifsttar.fr) (T. Robert).

Compensatory postural adjustments (CPA)

### MOTS CLÉS

Chute ;  
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Faire un pas ;  
Ajustements posturaux anticipés (APA) ;  
Ajustements posturaux compensateurs (APC)

on how “compensatory protective” steps are controlled and how their evaluation could bring additional information to the global balance assessment of risk of fall.

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**Résumé** Dans cet article, nous passons en revue une tâche prédominante dans la capacité des humains à se prémunir de la chute et qui, dans le même temps, met en jeu l'équilibre : faire un pas. Plus particulièrement, deux variantes de cette tâche sont présentées et comparées : le pas volontaire et le pas provoqué par une perturbation à la fois externe et imprévisible. Nous montrons que si les informations qu'elles apportent sont différentes, il est intéressant de les comparer. En effet, ces tâches restent toutes les deux pertinentes au regard d'une évaluation globale de l'équilibre et nécessitent d'en faire partie, au même titre que des tests plus classiques dispensés en clinique comme la posturographie. Nous avons choisi d'orienter notre revue vers une population de personnes âgées autonomes, afin de discuter d'un moyen de détecter au plus tôt le risque de chute pour être en mesure de prescrire une prévention adaptée aux personnes à risque. De rapides rappels sont aussi fournis sur comment se coordonnent la posture et le mouvement ainsi que sur les différentes stratégies de rattrapage de l'équilibre. Enfin, nous proposons une hypothèse de travail sur comment les pas « protectifs compensatoires » sont contrôlés et comment leur évaluation pourrait compléter les informations sur l'évaluation globale du risque de chute.

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## Introduction

### Fall and risk of fall

Falls are a major and concerning health problem for the elderly population, because they are responsible for body injuries (pains, fractures or death), psychological effects (fear of falling, depression) and sociological issues (loneliness, loss of independence, costs of medical care). As normal ageing is responsible for declines in muscular [46,47,6], sensorial [1,37] and neural control [48,44,11,25] systems, 1/3 of people aged 65 years old and more fall at least once per year [100]. Consequently, the elderly suffer from more severe consequences than young [93] and have been identified at an increased risk of falls [89,26]. Fall-related injuries also constitute an increasingly expensive public health concern with a future cost estimated at about 240 billion in 2040 [100,85].

Defining falls is not straightforward. Particularly for community-dwelling elderly adults, the circumstances leading to a fall must be considered. Thus, a definition could be “an event, which results in a person coming to rest inadvertently on the ground or other level regardless of whether an injury was sustained, and not as a result of a major intrinsic or overwhelming hazard” [89]. This definition could be completed with “a fall involves an impact” [31] with the lower level, showing “a failure in recovery responses” [81]. Indeed, during a fall the center of mass (CoM) is transversely and downwardly accelerated. Recovery responses that result in braking the CoM drop are necessary to prevent it. According to these clarifications, current recommendations take into account both the inadvertent character of the fall and the recovery responses [52].

Why do healthy community-dwelling elderly subjects fall? As a fall comes first from an unbalance, the system (i.e. individual's body) has to recover from this unbalance to restore

equilibrium. Interestingly, Granacher et al. [27] distinguish “steady-state” balance (very stereotyped and predictable behaviors like vertical quiet standing or normal gait) from “reactive” balance (recovery from the perturbation of a steady-state involving an unpredictable reaction). This reactive balance corresponds to the automatic responses that allow deceleration of the drop of the CoM, avoiding the fall [34,50]. So, the mechanisms to prevent falls are inseparable from successful reactive recovery responses (see model in Fig. 1). In this way, paying attention to both balance recovery behavior and understanding its underlying mechanisms appear to be determinant in identifying current and future risk of falls [33]. This is particularly true for healthy community-dwelling elderly adults, in whom avoiding a fall could prevent the first event of a negative spiral leading to more complex problems.

### Clinical identification of the risk of falls

The origin of falls is considered to be multifactorial. Many different clinical tests are available in the literature to assess different underlying balance mechanisms. While the topic of this paper is not to review these (see Mancini and Horak [53] for a review), we noticed that none of these assessments involve reactive recovery tasks, relying mostly on steady-state situations that concern known and predictable interactions with the environment. To our knowledge, only one assessment is available to test a balance recovery situation: the BESTest [37]. Likewise, many authors have recently emphasized that current clinical tests are limited in identifying balance capacities or risk of fall [53,64,94,30] and that methods identifying individuals at risk of fall are still needed [49]. In fact, while clinical assessments usually focus on identifying the impairment, it should be remembered that impairments alone do not lead to functional deficits, because subjects may be able

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