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Management of Gait Changes and Fall Risk in MCI and Dementia

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Opinion statement

Gait disorders and falls are very prevalent in aging, especially in older adults with cognitive impairment: older adults with dementia are 2–3 times more likely to fall than their non-demented counterparts. The management of gait disorders and falls in older adults with mild cognitive impairment (MCI) or dementia begins by their identification with the use of specific screening tools, such as measuring gait speed, use of dual-task gait tests, or diagnosing motoric cognitive risk syndrome, a newly described pre-dementia syndrome. This clinical approach is useful to reveal subtle gait changes that may lead to an increased risk of falls in older adults. Various non-pharmacological interventions have been tested in older adults with MCI or dementia to reduce risk of falls. Physical activity interventions are feasible in older adults with cognitive impairments, and may improve gait, and thereby decrease risk of falls. Besides non-pharmacological interventions, identification and removal of potentially inappropriate medications (i.e., psychotropic drugs) is part of a comprehensive falls management strategy in older patients. The use of anti-dementia drugs, such as cholinesterase inhibitors or memantine, may help to improve gait in demented older adults. Adopting a multidisciplinary care strategy that integrates general practitioners, geriatricians, neurologists, cardiologists, physical therapists, and occupational therapists to identify older adults at increased risk of falling or with subtle gait changes, prior to applying individualized non-pharmacological and/or pharmacological interventions, is essential to reduce the burden of gait disorders and falls in older adults with cognitive impairment.

Introduction

Gait changes are common in older adults with mild cognitive impairment (MCI) and dementia and may be related to neurodegenerative or vascular mechanisms. The prevalence of gait disorders in non-demented community-dwelling older adults is estimated to be 36%: among them, a predominance of non-neurological gait disorders (48%) has been reported, while 41% present with pure neurological gait disorders and 11% with a combination of non-neurological and neurological gait disorders [1]. In patients with MCI, the prevalence of slow gait or neurological gait abnormalities reaches 46%, almost threefold higher than healthy older adults without MCI [2]. More than 50% of demented older adults present with clinical gait abnormalities, with an increased prevalence seen in non-Alzheimer's disease dementias. A clinic-based study reported that 93% of patients with Parkinson's disease with dementia, 79% with vascular dementia, 75% with dementia with Lewy bodies (DLB), and 25% of patients with Alzheimer's disease (AD) had clinical gait disorders [3]. Although amyloid deposition has been associated with slow gait in older adults [4•], gait abnormalities are more severe in non-AD dementias and in the more advanced stages of dementia [5•].

Both motor and cognitive deficits explain the increased prevalence of gait disorders in dementia: the presence of mild parkinsonian signs or parkinsonism [6–8] and poor executive functioning or memory [9–13] are the major contributors to gait disorders. Similar to mild parkinsonian signs [8], cognitive impairment may precede the emergence of gait disorders [14]. The reverse longitudinal association between gait disorders and incident dementia has been also demonstrated [13, 15–18], including in the oldest old population [19•]. In community-dwelling older adults without dementia, the presence of clinical neurological gait abnormalities predicts the future development of dementia, especially non-AD dementias [18, 20]. Quantitative gait parameters are also good predictors of cognitive impairment [13, 21] and dementia [13, 15, 17]. The presence of gait disorders in older adults is not only associated with poor cognition but also with falls that consecutively leads to institutionalization, disability, and death [1, 22–25].

Falls affect around 30% of community-dwelling older adults [26], while older adults with dementia are 2 to 3 times more likely to fall than non-demented older adults [27]. In USA, 24,190 older adults were reported to have died from an unintentional fall in 2012, while an estimated 3.2 million Americans experienced non-fatal fall injuries in the same year [28••]. Fatal falls were estimated in 2015 to cost $637.2 million in USA, and the treatment of non-fatal fall injury was estimated to cost $31.3 billion [28••]. The presence of dementia is an independent risk factor for falls in older adults [29, 30]. Similar to non-demented older adults [31], the occurrence of a fall in older adults with dementia rarely results from a single risk factor, but from the interaction of different contributors. Functional status [32, 33], daytime sleepiness [34], polypharmacy [33], white matter lesions [33], presence of depression [35], orthostatic hypotension [35], autonomic symptoms [35], and low physical activity profile [35] are all major risk factors associated with falls in older adults with dementia. Among institutionalized older residents with dementia, a meta-analysis of eight studies revealed that age, the use of psychoactive drugs, general health status, and presence of gait disorders were associated with an increased risk of falling [36].

Among the dementia subtypes, non-AD dementias are associated with a higher risk of falls than AD [37]. Patients with DLB had a higher incidence of fall-related injuries (10.7%) than patients with AD (1.1%); this increased incidence was not attributed to parkinsonism seen in DLB [38]. Similarly, the incidence of multiple falls (>5) was more in DLB patients (37%) than in patients with AD (6%) [39]. Vascular lesions are also major contributor to increased risk of falls in non-AD dementias. Higher volume of white matter lesions, an index of cerebrovascular disease, was associated with incident falls in older adults [40]. The increased progression of white matter hyperintensities was also associated with incident multiple falls in older adults [41].

While falls are more frequent in the later clinical stages of dementia [37], the association between cognitive domains and falls is similar in healthy older adults, MCI, and demented patients [42–45] and involves impairment of executive functions. Executive functions—mainly supported by the frontal lobe—refer to a set of cognitive processes that include mental flexibility, judgment, planning, decision making, prioritization, or cognitive inhibition [46, 47]. In non-demented older adults, the presence of executive function deficits predicts the occurrence of future falls [43, 45]. Falls risk was associated with non-amnestic MCI, and this association was mainly explained by poor executive functioning [42]. In patients with mild to moderate dementia, poor executive functions were associated with 1.5 times increased risk of multiple falls, whereas the level of global cognitive function was not associated with risk of falls [44]. These observations indicate specificity in the relationship between cognitive processes and falls in aging.

In this narrative review, we will focus on the importance of the identification of gait disorders and falls in older adults with MCI and dementia, before exploring their management. We will include a summary of non-pharmacological interventions aiming to improve gait and to diminish the risk of falls in older adults with MCI and dementia. Then, we will explore how pharmacological treatments may target gait disturbances and improve current falls management strategy. This article is not a systematic review of the literature, but a comprehensive approach that aims to describe the current practice of the management of gait disorders and falls in older adults with MCI and dementia.

Identification of gait disorders and falls in MCI and dementia

Common clinical predictors have been associated with poor gait and falls [48] and can be separated into different categories such as mobility issues, cognition, behavior, abnormalities on the neurological examination (i.e., poor vision or mild parkinsonian signs), history of single or recurrent falls, polypharmacy or use of specific drugs such as psychotropic or anti-epileptic drugs, or comorbid illnesses (i.e., cardiovascular, osteoarticular) (Table 1). However, the identification of subtle gait abnormalities or fall risk may be challenging and could rely on the approaches presented below.

1. *Gait assessment: a tri-modal approach*

Gait disorders are easily diagnosed in non-AD dementias [5•]; however, in MCI or in early stages of AD, subtle gait changes need a more sensitive clinical approach. Self-report of walking difficulties, clinical observation of gait abnormalities, and quantification of gait parameters by a stopwatch or more advanced instrumented devices constitute the three main clinical methods used to assess gait in clinical or research settings. Self-reported mobility difficulties was reported to improve fall risk assessments [49] and predict functional impairment [50], while observable deficits in walking abilities may precede the self-report of walking difficulty [51]. However, intrinsic factors, such as poor vision [52] or cognitive impairments [53], may limit patients' perceptions of walking difficulties. Furthermore, older adults are often poor judges of overall risk of falling and may underestimate their own risk of falling [54]. Clinical gait abnormalities have been identified as a good predictor for falls in aging [1, 24], especially when older adults present with neurological gait abnormalities such as neuropathic and unsteady gait disorders [24]. Quantification of gait represents a more reliable approach than clinical examination [55] and is recommended by national organizations, such as the American Geriatrics Society or the British Geriatrics Society, as a good screening measure for falls [48]. Besides new instrumented devices, the use of quantifiable clinical tests, such as the Timed up and go test [56, 57], the Berg Balance Scale [58] or the Performance-Oriented Mobility Assessment [59] has also been demonstrated to have good reliability for predicting risk of falls in aging. Combining all three approaches (self-reported walking difficulties, clinical gait examination and quantification of gait parameters) improves the

Table 1. Common clinical predictors associated with poor gait and falls classified by cognitive status

	Normal aging	Mild cognitive impairment	Dementia
Mobility	Self-reported walking difficulty Abnormal gait examination (i.e., neurological gait abnormalities) Slow gait	Self-reported walking difficulty Abnormal gait examination (i.e., neurological gait abnormalities) Slow gait	Self-reported walking difficulty Abnormal gait examination (i.e., neurological gait abnormalities) Slow gait
Cognition	Cognitive complaint Impaired executive function Motoric cognitive risk syndrome	Non-amnestic MCI Motoric cognitive risk syndrome	Non-Alzheimer disease Severe dementia
Behavior	Fear of falling Depression Apathy Anxiety	Fear of falling Depression Apathy Anxiety	Fear of falling Depression Apathy Anxiety
Neurological examination	Sensory deficits (i.e., poor vision, unilateral or bilateral vestibular failure, neuropathy) Mild parkinsonian signs; Focal neurological deficits	Sensory deficits (i.e., poor vision, unilateral or bilateral vestibular failure, neuropathy) Mild parkinsonian signs; Focal neurological deficits	Sensory deficits (i.e., poor vision, unilateral or bilateral vestibular failure, neuropathy) Mild parkinsonian signs; Focal neurological deficits
History of falls	Recurrent > single event	Recurrent > single event	Recurrent > single event
Medication	Number and at risk classes (i.e., psychotropic drugs; antiepileptic, opioid, diuretics)	Number and at risk classes (i.e., psychotropic drugs; antiepileptic, opioid, diuretics)	Number and at risk classes (i.e., psychotropic drugs; antiepileptic, opioid, diuretics)
Comorbid illnesses (i.e., cardiovascular, osteoarticular)	+	+	+

identification of future falls compared to using any one individual approach [23].

2. *Dual task*

The dual task paradigm consists of walking while simultaneously performing a secondary task (i.e., cognitive or motor) and tests the ability to correctly allocate attention to both tasks. In comparison to young adults, healthy older adults slow down while walking while counting backward, suggesting an age-related effect of the dual task [60]. The dual-task paradigm has been extensively studied in older adults with MCI [61, 62] and dementia [12, 63–67]. Using different dual-task protocols, previous studies have reported decreased gait performance during dual-tasking and an increased dual task cost among MCI and demented older adults in comparison to healthy older adults. Dual-task studies have been conducted in various dementia subtypes (i.e., AD [12, 66, 67], vascular dementia [63, 65], DLB [68], frontotemporal dementia [64], or normal pressure hydrocephalus [69]). When comparing demented older adults with and without impaired attention and executive functions, those with impaired attention and executive functions presented poorer dual-task gait performances [63]. Similar observations were reported in non-demented older adults [70]. Several studies have used the functional near-infrared spectroscopy technology to quantify age-related prefrontal activation during dual-tasking. These studies showed an increased level of prefrontal activation in healthy older adults while dual-tasking compared to young adults [71]. In a cohort of 348 non-demented community-residing older adults, prolonged prefrontal activation throughout the dual task was observed in contrast to the single walking task, where an initial prefrontal activation was seen at the beginning of the walking task [72]. In older adults with MCI, a similar increased prefrontal activation has been observed during walking while performing a verbal letter fluency task; the extent of the prefrontal activation has been correlated to performance on executive function tests [73]. The use of dual task-related gait changes may represent an appropriate method to identify subtle gait disorders and impaired attentional mechanisms related to gait control in older adults with early signs of gait impairment.

3. *Motor imagery of gait*

Motor imagery has been studied in older adults with and without cognitive impairment [74–76]. Motor imagery of gait represents a mental representation of body movement without its actual execution [77] and may help access higher level of gait disorders. Poor mental imagery of gait has been reported in older adults with cognitive impairment [75]. Mental imagery performance was correlated with cortical volumes in key brain regions for motor control such as the prefrontal cortex [74]. An adapted imagined version of the timed up and go (TUG) test [57] has been validated in older adults with and without cognitive impairment in order to easily access motor imagery of gait and by consequence to higher level of gait control [75]. After performing the TUG, the subjects are instructed to imagine redoing the TUG task while keeping eyes open or closed; no specific indications are provided regarding the modality of the mental imagery (i.e., kinesthetic versus visual). An increased gap between the time required to complete actual performance of the TUG and the time required to complete the imagined TUG version indicates a disturbed higher level of gait control [75]. Impaired lower limb proprioception has been also associated with decreased performance in the imagined version of the TUG [76]. Including a rapid assessment of motor imagery of gait may help to identify quickly impaired performances in higher level of gait control, which may be a cognitive link to risk of falls.

4. *Motoric cognitive risk syndrome*

The motoric cognitive risk (MCR) syndrome that combines cognitive and motor impairments has been recently proposed to identify non-demented older adults at higher risk for developing future dementia. The MCR syndrome is defined by the presence of cognitive complaint and slow gait in older adults without dementia, slow gait being defined as gait speed 1 standard deviation below age and gender norms (for norms in different populations see [78•]). Among 26,802 non-demented older adults from 17 countries, the worldwide prevalence of MCR syndrome was reported to be 9.7%, increasing with older age, but without gender predominance [78•]. The presence of MCR is associated with an increased risk of developing dementia [78•, 79]; however, the subtype of dementia that MCR predicts has not yet been established: some studies suggested an increased risk for AD [78•], while others reported an increased risk of non-Alzheimer's dementias [79]. The profile of cognitive decline may change if the construct of gait speed in defining MCR is substituted by other gait parameters: MCR syndrome based on the original gait speed construct predicts the development of incident impairment in global cognition, while using swing time variability instead of gait speed predicts incident memory impairment [80]. These findings highlight overlapping brain circuitry in cognitive and motor control. Besides its predictive value for dementia, the MCR syndrome has been also studied for evaluating falls risk: the presence of MCR syndrome was associated with an increased relative risk for falls of 1.44 in five longitudinal aging studies from three countries including 6204 older adults [81]. Hence, the MCR syndrome represents a novel pre-dementia stage that integrates motor and cognitive dimensions (both may be disturbed in older individuals at risk of dementia) and does not rely on an expansive neuropsychological assessment or complicated biomarkers, such as MRI or CSF proteins. Finally, it has demonstrated its validating value for not only predicting dementia but also assessing risk for falls.

5. *Identification of older fallers with cognitive impairment*

Guidelines to prevent falls from various national organizations or expert committees present convergent recommendations for assessing risks of falls in older adults (Table 2) [48, 82, 83]. Guidelines for assessing risk of falls in older adults with impaired cognitive function are not available, although some practical recommendations have been proposed [84]. Individual phenotypes influences risk factor for falls in older adults; falls predictors differ between older adults with and without postural impairment and gait difficulties (PIGD): fear of falling, presence of previous falls, and comorbid medical illness predict falls in older adults with PIGD, while advancing age and female gender were predictors of falls in older adults without PIGD [85].

In older adults with cognitive impairment residing in a nursing home, the presence of moderate cognitive impairment was associated with increased risk of falls, while severe cognitive impairment was not associated with new falls [86] likely from lower functional ability among those with severe cognitive impairment. In older adults residing in dementia care facilities, use of neuroleptics and sedatives were associated with falls, while the use of wheelchairs, bed rails, and belts were protective for falls [87]. Physical restraints are considered unethical and are associated with increased risk of injuries and death [88, 89]. In a systematic review conducted in long-term older residents with dementia, the use of physical restraints was associated with increased risk of falls [36]. Based on these observations, clinical algorithms have been proposed for systematically assessing fall risk in long-term residency facilities: a system that includes a flowchart with a form that advises on falls characteristics, fall risk factor identification, and appropriate referral has demonstrated its performance for improving the fall prevention strategy [90].

With the implementation of advanced technologies in the clinical practice (also in term of falls risk management), new tools, such as the use of accelerometers during everyday activities [91] or electronic clinical reminders [92], will contribute to improve fall management strategies in older adults with dementia. If some indicators, such as the use of psychotropic drugs or impaired mobility, are associated with increased risk of falls in older adults with

Table 2. Fall risk assessment

Global assessment
History of falls
Presence of fear of falling
Incontinence
Medications
Psychotropic drugs (i.e., benzodiazepine, neuroleptics, antidepressants)
Antiepileptics
Anti-parkinsonian drugs (high dosage)
Opioids
Non-steroidal anti-inflammatory drugs
Diuretics
Anti-arrhythmic drugs (i.e., type 1a anti-arrhythmic drugs, digoxin)
Neurological assessment
Type and severity of cognitive impairment: AD versus non-AD dementia
Gait and balance disorders
Other neurological impairment (i.e., seizure, peripheral neuropathy, cerebellar syndrome)
Cardiovascular assessment
Heart rate and rhythm
Postural hypotension
Osteoarticular assessment
Feet and footwear
Muscle strength
Osteoporosis risk
Environmental hazards

dementia; specific dementia-related conditions (i.e., behavioral symptoms) may also represent specific contributors for falls that need to be further investigated. Multicenter large surveys including demented older adults residing in the community and in long-term facilities are required to better identify risk factors for falls in older adults with dementia.

Non-pharmacological interventions for gait disorders and falls in older adults with MCI and dementia

Non-pharmacological interventions, such as physical therapy, dance therapy, or Tai-chi, are demonstrated to improve gait disorders and fall prevention in older adults with intact cognition [93, 94••, 95]. Although cognitive impairment does not represent a major limitation to participation in physical activities, other factors associated with dementia may prevent the participation of older adults with cognitive impairment:

reduced activities of daily living, autonomic disturbances, delirium, excessive daytime sleepiness, or history of falls [96••]. Due to the increased prevalence of falls and gait disorders in older adults with dementia and their respective consequences on morbidity and mortality, older adults with cognitive impairment represent a main target for interventions to reduce falls and improve gait disturbances. Encouragingly, the feasibility of exercise interventions has been demonstrated in people with dementia, even in the more advanced stages [97].

A growing number of exercise interventions have been tested in older adults with MCI and dementia (Table 3) [98–113]. The majority of exercise interventions targeted older adults with mild or moderate stages of dementia and mainly older adults with AD, while non-AD dementias have been associated with increased risk of falls and with more gait disturbances in comparison to AD, especially in the latest stages of dementia [5•, 37]. Previously reported interventions incorporate a variety of physical activities (i.e., balance or walking exercises, Yoga) as well as cognitive training provided at home or in day care centers. These interventions have been studied in both community dwellers and older adults residing in nursing home. The duration and frequencies of the interventions are quite variable, ranging from two sessions per week for 6 weeks to daily sessions for 12 months. In general, the duration of the sessions ranged from 30 to 90 min. Various study outcomes have been investigated in these trials: balance, gait, muscle strength, falls, behavior (i.e., fear of falling or depression), cognition, and care burden. Though many of these studies lacked control groups, the majority reported a short-term improvement (if any) among these various outcomes. In conclusion, physical activity interventions are feasible in older adults with cognitive impairments and may improve motor and cognitive disability in patients with MCI and dementia. However, there is a need for randomized controlled trials that include not only participants with dementia of mild severity but also demented older adults in the more advanced stages.

Pharmacological treatments for gait disorders and falls in older adults with MCI and dementia

Careful evaluation of the medication of older fallers is a key component of the falls management strategy. Polypharmacy and certain drug classes have been associated with falls in normal aging. Psychotropic drugs—benzodiazepines, antipsychotics, and antidepressants—are the well-recognized drug classes associated with increased risk of falls in aging [114, 115]. Antiepileptics [116], high dosages of anti-parkinsonian drugs [117], opioids [118], non-steroidal anti-inflammatory drugs [115], diuretics [119], type 1a anti-arrhythmic drugs [119], and digoxin [119] have also been associated with falls in aging. In older adults with cognitive impairment, the studies focusing on medications and falls are more limited: polypharmacy has been associated with falls in patients with dementia [120]. New prescriptions of benzodiazepines in nursing home settings represent an immediate threat to falls in demented residents [121••].

Regarding anti-dementia drugs specifically (i.e., cholinesterase inhibitors and memantine), a meta-analysis revealed no effects of cholinesterase

Table 3. Summary of non-pharmacological interventions conducted in older adults with MCI or dementia to improve gait disorders and/or falls

Study	Population/setting	Type of intervention	Duration of intervention	Study outcomes	Main results
Taylor, 2017 [98]	42 participants with dementia (MMSE: 21.2 ± 4.1)/ community-dweller/no control group	Individually tailored exercise program	6 months home based	Balance (postural sway)/depression (GDS)/concern about falling (iconFES)/planned physical activity (IPEQ)/muscle strength (knee extension)/ Care burden (Zarit Burden Interview)/fall	Immediate post-intervention improvement in balance, concern about falling, and planned physical activity, but decrease in muscle strength (knee extension)
Smith-Ray, 2016 [99]	20 participants with MCI, AD, VD, or other dementia (MMSE 21.4 ± 2.9)/ day care center /no control group	Cognitive training (online brain exercise program)	60 min/twice per week/10 weeks	Balance (4-position balance from BBS), locomotion (TUG), depression (GDS), cognition (MMSE and CSRQ)	Immediate post-intervention improvement in depressive symptoms
Ries, 2015 [100]	30 AD (MMSE: 14.8 ± 6.8)/3-day health centers /no control group	Balance training program	45 min/twice per week/12 weeks	Balance (BBS)/Locomotion (TUG, gait speed, fast gait speed)/cognition (MMSE)	Immediate post-intervention improvement of BBS, TUG and fast gait speed; no improvement of gait speed and MMSE Delayed (3 months post-intervention) improvement of BBS
Arcoverde, 2014 [101]	20 participants with 16 AD and 4 mixed dementia (MMSE: 19.9 ± 3.4)/outpatients from a University Hospital/ control group consisted of no intervention	Treadmill walking	30 min/twice per week/4 months	Cognition (MMSE, CAMCOG, and attentional and executive neuropsychological test)/Locomotion (TUG)/balance (BBS, functional reach)/muscle strength (sit-to-stand)	Immediate post-intervention improvement in the CAMCOG, BBS and TUG in the intervention group in comparison to the control group
McCarffrey, 2014	9 AD (moderate to severe form)/day care center/no control group	Sit 'N' Fit Chair Yoga	45 min/twice per week/8 weeks	Locomotion (6 min walk test, gait speed)/balance (BBS)	Immediate post-intervention improvement in BBS
Cadore, 2014 [102]	18 participants with 10 AD, 1 VD and 7 mixed dementia (MMSE: 15.1 ± 6.3)/nursing home/no control group	Multicomponent exercise program (walking, balance, cognitive exercises)	8 weeks (4 weeks of exercise training +4 weeks of resistance training	Muscle strength (upper and lower limbs muscle strength, raising from a chair)/balance (FICSIT-4 test)/locomotion (gait velocity in single and dual task, TUG)/cognition (MMSE)/autonomy (Barthel)/Falls	Immediate post-intervention improvement in TUG, balance, upper and lower limbs muscle strength, and immediate decreased incidence of fall; no immediate improvement in gait speed and in MMSE No delayed improvement in any outcomes
Wesson, 2013 [103]	22 participants with dementia (MMSE: 23.5 ± 3.7)/community-dwellers/control group consisted of usual care	Home-based physical and balance training exercises and home hazard reduction	12 weeks	Falls/Fear of falling (FES-I, icon-FES)/daily functioning (IDDD)/depression (Cornell Scale for depression in dementia)/behavior (agitated behaviors in dementia scale)/physical activity levels (IPEQ)/carer burden (Zarit)/physical performance (PPA)	Immediate post-intervention assessment showed similar performances in all outcomes
Pitkala, 2013 [104]	210 AD (MMSE: 17.7 ± 6.6)/community-dwellers/home based exercise versus group based exercise versus	Individualized multicomponent exercise	60 min/twice per week/12 months	Falls/functional assessment (FIM, SPPB)/autonomy (ADL)/hospital admissions	Lower decline in functioning (FIM) in both intervention groups than controls More falls were reported in the control group in

Table 3. (Continued)

Study	Population/setting	Type of intervention	Duration of intervention	Study outcomes	Main results
	control group consisting of educational advice on nutrition and exercise				comparison to both intervention groups
Yoon, 2013 [105]	30 demented participants (MMSE: 18.0 ± 1.5)/long-term care facility/cognitive activity with physical exercise versus cognitive activity only	Cognitive activity combined with physical exercise	30 min/3 times per week/12 weeks	Balance (BBS) Wii Balance Board/Fear of falling (Modified Falls Efficacy Scale)/locomotion (TUG)/cognition (Digit Span Forward, Digit Span Backward, MMSE)/autonomy (Kenny Self-Care Evaluation)/depression (Short GDS)	Immediate post-intervention improvement in balance (BBS and Wii Balance Board), Modified Falls Efficacy Scale, Kenny Self-Care Evaluation, the Short Geriatric Depression Scale, Digit Span Forward, Digit Span Backward for the combined cognitive activity with physical exercise group in comparison to the cognitive activity only group
Doi T, 2013 [73]	50 MCI (MMSE: 26.6 ± 1.6)/community-dwellers/control group consisted of educational class about health)	Multicomponent exercise intervention (strength training, aerobic exercise, gait training, balance training)	90 min/twice per week/6 months	Locomotion (quantitative gait parameters measured with an accelerometer)	Immediate post-intervention improvement in gait speed, stride length and trunk smoothness in the intervention group in comparison to the control group
Vreugdenhil, 2012 [106]	40 AD (MMSE: 22)/outpatients/control group consisted of usual care	Muti-component home-based exercise program (strength, balance, brisk walking)	30 min/every day/4 months	Cognition (MMSE, ADAS-Cog)/depression (short-GDS)/balance (functional reach) locomotion (TUG)/muscle strength (sit-to-stand test)/ Autonomy (Barthel, ADL, IADL)/Carer burden (Zarit burden interview)	Immediate post-intervention improvement in MMSE, TUG and IADL
Suttanon, 2012 [107]	40 AD (MMSE: 20.9 ± 4.7)/community-dwellers/control group consisted of educational sessions on dementia and aging)	Multicomponent home-based exercise (balance, strength, walking)	5 per week/6 months	Falls, fall risk (fall risk for older people questionnaire)/balance (sway velocity, functional reach)/locomotion (gait speed, stride length, step width, TUG)/functional score (timed chair stand)	Immediate post-intervention improvement in functional reach and fall risk for older people questionnaire in the intervention group in comparison to control
Ries, 2010 [108]	7 AD (MMSE: 23.2 ± 3.0)/1 day health center/no control group	Functional balance exercise	45 min/twice per week/8 weeks	Balance (BBS)/locomotion (TUG, gait speed, fast gait speed)	Improvement of BBS in 5/5 participants; improvement of TUG in 4/5 participants; improvement of gait speed in 3/5 participants; improvement of fast gait speed in 3/5 participants
Santana-Sosa, 2008 [109]	16 AD (MMSE: 19.9 ± 1.7)/nursing home/control group consisted of no intervention	Physical exercise including resistance while listening music	75 min/3 times per week/12 weeks	Functional capacity (Senior Fitness test)/autonomy (Katz ADL score and Barthel)	Immediate post-intervention improvement in the arm curl test, the chair stand test, the Katz ADL score and the Barthel ADL index for the intervention group

Table 3. (Continued)

Study	Population/setting	Type of intervention	Duration of intervention	Study outcomes	Main results
					in comparison to the control group
Hageman, 2002 [110]	26 demented participants from various etiologies (MMSE: 18.0 ± 6.2)/2 day care centers/no control group	Resistance-training program	2–3 sessions per week/6 weeks	Locomotion (Gait speed, fast-gait speed, Tinetti-Gait Assessment scale, TUG, Gait Assessment Rating Scale/muscle strength (lower limb muscle strength)	Immediate post-intervention improvement of fast gait speed
Rolland, 2000 [111]	23 AD (MMSE 16.3)/in patients/no control group	Multicomponent exercise program (endurance or resistance exercise, balance)	7 weeks	Autonomy (ADL, IADL)/cognition (MMSE)/Nutritional status (MNA), behavior (NPI)/risk of falls (Tinetti test)	Immediate post-intervention improvement of MNA, MMSE, Tinetti and NPI

AD Alzheimer's disease, *VD* vascular dementia, *BBS* Berg Balance Scale, *TUG* Timed up and go, *MMSE* Mini-Mental State Examination, *ADL* activities of daily living, *IADL* instrumented activities of daily living, *MNA* Mini Nutritional Assessment, *NPI* neuropsychiatric inventory, *iconFES*: short-form Iconographical Falls Efficacy Scale, *GDS* Geriatric Depression Scale, *IPEQ* Incidental and Planned Exercise Questionnaire, *CSRQ* cognitive self-report questionnaire, *CAMCOG* Cambridge Cognitive Examination, *SPPB* Short Physical Performance Battery, *FIM*: Functional Independence Measure, *ADAS-Cog* Alzheimer's Disease Assessment Scale–Cognitive Sub-Scale, *IDDD* Interview for deterioration for daily activities in dementia, *PPA* Physiological Profile Assessment inhibitors on risk of falls, although these medications were associated with an increased risk of syncope. There was also no effect of memantine on falls, but it was associated with decreased risk of fractures [122]. By contrast, for gait disorders, anti-dementia drugs showed an interesting effect of improving gait in AD [123–126]: each individual drug class presenting a specific effect on different components of gait [127•]. Finally, besides the pharmacological and non-pharmacological approaches, reversible causes of cognitive and gait disturbances should be always investigated in older adults with cognitive impairments, such as the use of antiepileptic drugs (i.e., valproic acid [128] or other drugs), or the presence of brain imaging abnormalities (i.e., normal pressure hydrocephalus) [129].

Conclusion

The management of falls and gait disorders in older adults with MCI or dementia relies on a two-step approach: (a) identification and (b) pharmacological and/or non-pharmacological treatment. A multidisciplinary strategy integrating general practitioners, geriatricians, neurologists, cardiologists, physical therapists, and occupational therapists may help to tackle the increasing burden of falls and gait disorders affecting older adults with cognitive impairment.

Compliance with Ethical Standards

Conflict of Interest
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Human and Animal Rights and Informed Consent
This article does not contain any studies with human or animal subjects performed by any of the authors.

References and Recommended Reading

Papers of particular interest, published recently, have been highlighted as:
- • Of importance,
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