Falls in Parkinson's disease and Huntington's disease
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Chapter 6.3

The 'posture second' strategy: a review of wrong priorities in Parkinson's disease

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ABSTRACT

Falls are common in Parkinson's disease. It remains difficult to predict these falls, presumably because clinical balance tests assess single components of postural control, whereas everyday fall mechanisms are typically more complicated. A substantial proportionof everyday falls appears to occur while Parkinson patients attempt to perform multiple tasks at the same time. Furthermore, little attention is generally paid to the possible contribution of cognitive impairments to falls. The importance of mental dysfunction is supported by the fact that cognitive loading while walking or balancing can lead to marked deteriorations in postural performance, and there is some evidence to suggest that such "dual tasking" is particularly difficult for elderly persons with dementia or depression. We examined what strategies Parkinson patients used when a basic walking task became increasingly challenging by adding additional tasks (both motor and cognitive). Most patients could perform a simple "dual task" test: simultaneously walking and answering simple questions. However, as the walking task became more complex, patients' performance began to deteriorate. Interestingly, this was reflected not only by failure to answer questions, but also by an increasing number of blocks in motor performance (walking and balancing). This behaviour was different from that of both young and elderly controls, who appeared to sacrifice performance on the cognitive task in order to optimise their gait and balance ("posture first" strategy). Preliminary evidence suggest that impaired multiple task performance is associated with a two-fold increased risk of sustaining falls in daily life. We conclude that Parkinson patients are less inclined than healthy persons to maintain a safe gait. Instead, Parkinson patients use a "posture second" strategy and treat all elements of a complex task with equal priority, which in daily life may go at the expense of maintaining balance and lead to falls.

INTRODUCTION

Life is about priority, evident even in mundane tasks such as driving a car and using a mobile phone at the same time. Most people can achieve this during regular driving, but the conversation is likely to cease temporarily when a busy crossing is approaching. This "secondary task" (or dual task, as it is more commonly termed) interference is at play during everyday tasks, including seemingly simple acts such as walking. In the field of balance and gait research, perhaps one of the most influential publications of the last decade was the description of the "stops walking while talking" (SWWT) test by Lundin-Olsson and colleagues[1]: an inability to walk and talk at the same time had a good predictive value for the occurrence of falls in the next six months. This observation was made in a mixed group of elderly persons, may of whom were depressed, had dementia of both. Apparently, the two concurrent tasks of walking and talking competed within the central nervous system. The inference was that those unable to talk while walking had a restricted central processing capacity, permitting them to do only one task at a time to avoid a system overload. The restricted central processing capacity could also explain the association between ' stops walking when talking' and dementia or depression;whether depression or dementia itself is in any way causally related to dual tasking limitations has never been demonstrated. Another consequence of this finding – with a potentially far-reaching implication – was that gait was not a simple automatic task that is governed solely by subcortical structures, but in fact represents a much more complicated job requiring conscious attention and perhaps some ongoing cognitive processing.

The Lundin-Olsson paper left many questions unanswered. For example, it is theoretically possible that some persons purposely stopped walking while talking, simply because they considered this to be unsafe. If so, then such people who stop walking while talking should perhaps have the lowest risk of falling, not the highest, because they opted for a safe behaviour. Clearly, this was not true for the group as a whole, where the overall riskwas increased, but individual, within the group may have chosen different strategies. In other words, dual tasking difficulties may well be solved in different ways by different populations, depending on such factors as age, disease status, or prior experience. This would set limitations to the generalisation of dual tasking problems. Also, some may have stopped walking while talking out of politeness to face the person you are talking to, which in effect deprives the person of visual feedback of the gait trajectory? This by itself may be enough reason for persons who rely heavily upon visual feedback to stop walking. And what about the nature of the secondary task, which was actually poorly defined in the original description as "maintaining a routine conversation"? Might a more complex and more demanding secondary task be able to predict falls even better? Is the dual task interference restricted to "cognitive" secondary tasks, or is a secondary "motor" task also able to jam the system? And, finally, what about dual task problems in patients with neurodegenerative diseases characterised by cognitive decline, restricted central processing capacities, or frequent falls?

Because of these many unanswered questions and the potentially important implications, the "SWWT principle" was widely followed and extrapolated to a host of other tasks – including balancing and a range of other secondary or even tertiary tasks – and to a range of pathological conditions, including e.g. Alzheimer's disease,[2,3] Parkinson's disease (PD),[4,5,6] stroke,[7] vestibular disorders[8] and peripheral neuropathy.[9] Adverse effects on balance were noted not only for secondary tasks with cognitive loading, but also for types of secondary tasks that either stressed the motor systems or called for attention. For example, difficulty with carrying a glass of water while walking can also predict falls in the elderly.[10] Here, we will briefly review our own work in this field, which mainly concentrated on patients with PD, with some extensions to the ageing processes. The results provided some new insights into the mechanisms underlying "failure" to execute multiple tasks simultaneously – and in particular on the role of priority processes.

PARKINSON'S DISEASE

Background

Falls are very common in patients with PD. Depending on the duration of follow-up and the method of falls ascertainment, prospective studies identified an incidence of persons with at least one fall from 39 to 68%, and from 25 to 50% for recurrent (twice or more) fallers.[11,12,13,14] The impact of these falls is considerable, due not only to the associated injuries, but also because of the secondary immobilisation caused by a fear of renewed falls.[13,15,16] Prevention of these falls is important. Several strategies may be effective.[17,18] To implement prevention programs, fallers must be identified in an early stage, but this remains difficult in PD patients, presumably because most clinical balance tests merely assess single components of postural control, whereas everyday fall mechanisms are typically complicated. Indeed, in daily life, almost half of all falls occur while PD patients attempt to perform multiple tasks at the same time, for example carrying an object while walking.[19] Furthermore, falls in PD patients are probably the net result of a complex and multifactorial pathophysiology, with contributions of multiple "intrinsic" (patient-related) and "extrinsic" (environmental) factors.[20] Very few tests are specifically designed to measure this multifactorial character of postural instability.

In light of the Lundin-Olsson publication, we reasoned that a simultaneous challenge of posture and cognition might predict falls better than tests of isolated components of postural control. Multiple task performance may be particularly informative in PD patients because studies on arm motor control suggest that they cannot execute simultaneous or sequential tasks adequately.[21] In addition, experienced clinicians noted that PD patients may have difficulty with a second task while walking.[22] Finally, PD patients can improve their motor performance (including balance and gait) by using external cues or by focusing attention on the task at hand, allowing the frontal cortex to compensate for the defective basal ganglia circuitry.[23,24,25] These "conscious" motor strategies could make PD patients vulnerable during performance of secondary tasks that distract their attention.

Dual task impairment

With these ideas in mind, various groups studied the influence of secondary tasks on gait or balance in patients with PD (summarised in Table 1). Although no two studies were the same, the general picture that clearly emerges from this work is that both gait and balance can deteriorate when a secondary task needs to be performed simultaneously. This was true both when the secondary task was cognitively demanding (e.g. mental arithmetic) or when it required a motor skill, such as carrying an empty or a loaded tray. For the "motor" tasks, additional factors may have played a role, including the need to pay attention to the task or – in the case of carrying a tray – visual deprivation of the gait trajectory and the subjects' own feet. As expected, patients appeared to have extra difficulties when the secondary task was more demanding.[4,32] A recent paper drew attention to extra variables that need to be accommodated in the overall equation when interpreting why patients have difficulty performing multiple tasks at the same time.[32] This study not only evaluated the influence of secondary motor and/or cognitive tasks on gait, but also analysed the contribution of common clinical symptoms to the disturbance of gait. The results showed that dual task problems are related not only to cognitive dysfunction and disequilibrium, but also – at least in part – to symptoms such as fatigue and depression.

We also studied the influence of secondary tasks on gait and balance. We initially began with applying the simple "SWWT" test to patients with PD.[27] In that study, we included 38 patients with idiopathic PD and 35 controls who were all ambulant community residents without depression or cognitive impairment (MMSE ^{3}24). SWWT consisted of a conversation during a standardised 150-meter walk, and we arbitrarily scored a positive result if persons stopped walking for ^{3}3 s. Persons were also followed prospectively for six months, using standardised scoring forms to document all falls. To our initial surprise, SWWT occurred in only four patients, and in none of the controls. More importantly, SWWT did not predict falls in PD, as the SWWT was positive in two patients that were fallers and in two patients who did not fall. These results were confirmed when we extended the original group to 59 patients and 55 controls in a subsequent study.[13] What could be the explanation for this striking discrepancy between our findings and those of Lundin-Olsson and colleagues?[1] Setting aside possible small methodological differences, the key difference resided in the degree of cognitive co-morbidity. Indeed, many persons in the Lundin-Olsson study were demented or depressed, whereas we excluded patients with cognitive impairment. This suggests that impaired dual task performance is perhaps a

Table 1. Summary of published research studies that focused on the influence of secondary tasks on gait or balance in patients with Parkinson's disease.

Reference	Subjects	Primary task	Secondary task	Outcome measures	Results in PD patients
Bond 2000 [4]	12 PD patients 12 controls	walking	1. carry empty tray 2. carry loaded tray	force-sensitive insoles	- problems only in condition 2. - decreased walking speed - reduced stride length
Hausdorff 2003 [6]	10 PD patients	walking	serially subtracting 7's	force-sensitive insoles	- increased stride time - increased stride variability
Ashburn 2001 [5]	48 PD patients (29 fallers)	quiet standing	colour judgment of playing cards	postural sway	- increased sway in fallers
Bloem 2000 [27]	38 PD patients (15 fallers) 35 controls	walking	talking (routine conversation)	stops walking (clinical judgement)	- no difference with controls - no prediction of falls
Camicioli 1998 [26]	19 PD patients (10 with freezing) 19 controls	walking	verbal fluency task	clinical judgement of step number	- increased step number, only in patients with freezing
Rochester 2004 [32]	18 PD patients 15 controls	walking	1. carrying loaded tray 2. answering simple questions 3. combination of 1+2	five accelerometers attached to legs and trunk	- problems greatest for condition 2. and 3. - decreased walking speed - reduced step length - relation to cognition, fatigue and depression
O 'Shea 2002 [30]	15 PD patients 15 controls	walking	1. manual dexterity task 2. serially subtracting 3's	force-sensitive insoles	- effect equal for both conditions - decreased walking cadence
Marchese 2003 [31]	24 PD patients (8 fallers) 20 controls	quiet standing	1. serially subtracting 3's 2. manual dexterity task	static forceplate	- effect equal for both conditions - increased sway amplitude
Bloem 2001 [29]	20 PD patients 20 elderly controls 50 young controls	walking	Multiple tasks, among others: 1.avoiding objects 2. carry empty tray 3. carry loaded tray 4. answering questions	clinical judgment of hesitation or block in performance	- more often motor errors - no "posture first" strategy
Morris 2000 [28]	30 PD patients (15 fallers) 15 controls	1.quiet standing (various foot positions) 2.internal perturbations 3.external perturbations	reciting days of the week backwards	clinical judgment of performance	- deterioration under dual-task conditions comparable to controls

The final column summarises the main effect of the secondary task(s) on the primary task (maintaining balance or walking), as observed within the patient group relative to controls. The effects of secondary tasks on performance within the control group are not indicated separately.

better marker of falls associated with cognitive impairment than (extrapyramidal) motor impairment.

Some additional insights into dual task performance came from subsequent efforts. In one study, we administered the original SWWT to 17 institutionalised elderly persons (mean age 86.3 years, range 79 to 93 years).[33] In addition, we asked the subjects to walk two trials of 8 m each. During the first 8 m trial, no question was asked (control trial). During the second 8 m trial, subjects had to answer a simple question ("What is your age?") after 2 m of walking. During both trials, we measured not only the simple trial duration, but we also quantified the amplitude of trunk sway and the angular velocity in the forward-backward (pitch) and side-to-side (roll) directions using a trunk sway measuring device – containing two orthogonally mounted and highly sensitive angular velocity sensors[34,35] – that was strapped firmly to the lower back (Swaystar system). Four of the 17 persons (29%) stopped walking while talking during the SWWT as originallydescribed by Lundin-Olsson (i.e. during a routine conversation while walking in the corridor). This percentage quite similar to the 21% reported by Lundin-Olsson et al.[1] However, when subjects were required to answer a simple question during a short (8 m) walking trajectory, eight persons (47%) stopped walking while answering the question. This may have been caused by the greater "urge" to provide the answer because the short trajectory afforded only little time to respond, unlike the SWWT that was applied during a longer walk (several hundred meters). In addition, we suspect that the brief test may also have caused greater problems because we used a sudden question, unlike the more predictable routine conversation during the SWWT. Elderly persons may well have greater problems with such sudden and unexpected events than with more predictable routines. Unexpected interruption of gait by an abrupt question might mimic an event leading to a fall more effectively than a predictable conversation during a longer walk. These results suggest that a shorter and much simpler version of the SWWT (asking a single question during an 8 m walk) may provide a fast and perhaps more effective method of identifying subjects with impaired dual task performance, classified as "stoppers", with less space requirements.

In the same study[33], we also observed that persons who stopped during the 8 m trial with a question had significantly longer walking durations and, more interestingly, a larger trunk roll angular displacement. This was evident not only during the dual task trial, but also during the control trial without a question. This indicates that the "stoppers" had more lateral instability – perhaps an index of a heightened risk to fall sideways – even at a time when they did not come to a full stop. This was not apparent to the naked clinical eye, but was only unveiled by quantitative measurement of trunk movements using the angular velocity sensors. These results suggest that persons with impaired dual task performance have a poorer dynamic control of trunk roll. Other studies also used more sensitive quantitative outcome measures to document the effects of secondary tasks on the quality of gait or balance (see Table 1). For example, Hausdorff et al.[6] used pressure-sensitive insoles to quantify strides, and observed an increase in stride variability in patients with PD who were subjected to a cognitively challenging task. Future studies should clarify whether such quantitative electrophysiological measures of gait or trunk movement also have the ability to predict actual falls in daily life.

In another study we determined the predictive value of dual tasking on falls in the general population of oldest old (a cohort of 509 individuals, all aged 85 years).36 There were no selection criteria on health, and about 30% of subjects were demented (MMSE <24), while some 20% were depressed. In this cohort, we measured the walking time over a 12-meter distance as well as verbal fluency to recite names of animals or professions during a 30 seconds period. In the dual task, we assessed performance when participants combined walking with reciting names. The incidence of prior falls was assessed by interviewing the participants and checking their medical history. We found that no less than 45 percent of our participants stopped walking during talking. The results also showed that dual task performance was related to prior falls, but – again to our surprise – it was in fact not a better predictor for incident falls than single task performance (simple walking time). This difference in results with prior studies[1,10,37] can be explained by differences in methods. Instead of a straightforward walk from one place to another, we asked our participants to walk back and forth along a 3-meter line. Consequently, participants had to make three 180-degree turns, what may have added considerable difficulty to the walking task. This could partially explain why so many persons stopped walking while talking in this study. Increased difficulty of the single walking task could also explain why the dual task provided little additional predictive information.

Such findings suggest that the very nature of the primary – and likely also the secondary – tasks may affect the overall predictive ability of the combined test. Indeed, such observations led to speculation that combinations of multiple motor tasks (e.g. walking plus carrying an object) may better probe areas of the central nervous system that are involved in motor or, even better, postural control than secondary mental tasks.[10,13] It may also be possible to further increase the sensitivity of detecting balance difficulties by combining more or other simultaneous tasks to enhance overall task complexity. Indeed, strictly dual task designs do not always distinguish well between patients and controls, over and above any baseline differences between these groups.[27,28] As mentioned earlier, evidence is now beginning to emerge that more demanding secondary tasks (or a more unpractised "primary" postural task) may be needed to fully bring out the balance deficits, not only in elderly subjects[38,39,40], but also in patients with PD.[4,32]

Multiple task impairment

We have explored this concept further in two studies in which we developed a true multiple task design. We speculated that combinations of various motor tasks would be particularly useful for patients without cognitive impairment, because their falls are not well predicted by combining a single motor task with a mental task.[27] We further reasoned that falls in daily life would be predicted best by tests that represent complex everyday situations.[41] We also argued that falls would be predicted best by tests that truly challenge postural safety. Finally, we wanted to develop a balance test that would potentially be easy to apply in a consulting room by clinicians. To develop this "multiple task test" (MTT), we first identified relevant risk factors for falls (from a literature review) and actual fall circumstances (from a prospective survey of falls in PD).[42] The factors identified from this review were "translated" into functional tests (or postural "components") that resembled everyday situations. We distinguished a "cognitive" component (answering a series of relatively simple questions regarding everyday situations, in order to provide a continuous and verifiable cognitive load) from largely "motor" components (standing up, sitting down, turning around, walking, avoiding obstacles, and touching the floor). Four additional components included carrying an empty or loaded tray, wearing shoes with slippery soles and reduced illumination. These components were combined to yield eight separate tasks of increasing complexity that had to be executed sequentially. The first and simplest task consisted of standing up, undisturbed walking, turning around and sitting down. For each of the next tasks, a new component was added to the previous and otherwise identical task. All components within each task had to be performed simultaneously. The MTT thus contained all desirable ingredients for an optimal multiple task design: perceptual manipulations (reduced illumination), cognitive manipulations (answering the questions), motor manipulations (e.g. turning) and mechanical manipulations (e.g. avoiding obstacles).[41] Unlike some other studies[43], we urged subjects only once (at the beginning of the experiment) to not purposely prioritise any given component. If this instruction is continuously repeated, one might theoretically obscure any tendency to 'disobey' the initial instruction and to lend priority to what subjects perceive as the primary task (e.g. maintaining balance). The study of such priority strategies was a main goal of our study. Impaired multiple task performance can be reflected by slowing[3,10,37] or a complete stop[1,44] in executing one or more components. Therefore, errors in performance for all tasks were scored as follows: rapid performance of all components within the task ("Normal"); obvious slowing in one or more components within the task ("Hesitation"); complete stop or inability to perform one or more components within the task ("Block"). Hesitations and Blocks were analysed separately, and also combined as Errors. The scoring was simply done through clinical inspection, without complex electrophysiological instrumentation. Errors were scored separately for execution of the motor and cognitive components.

The MTT was first administered to 50 young healthy subjects and 13 elderly subjects.[42] All subjects completed the MTT without falling. In both age groups, 62% of subjects performed all eight tasks without any Errors in the motor components (Figure 1A). Among those making Errors, the proportion of subjects that made motor Errors increased significantly as the tasks became more complex. More elderly subjects produced motor

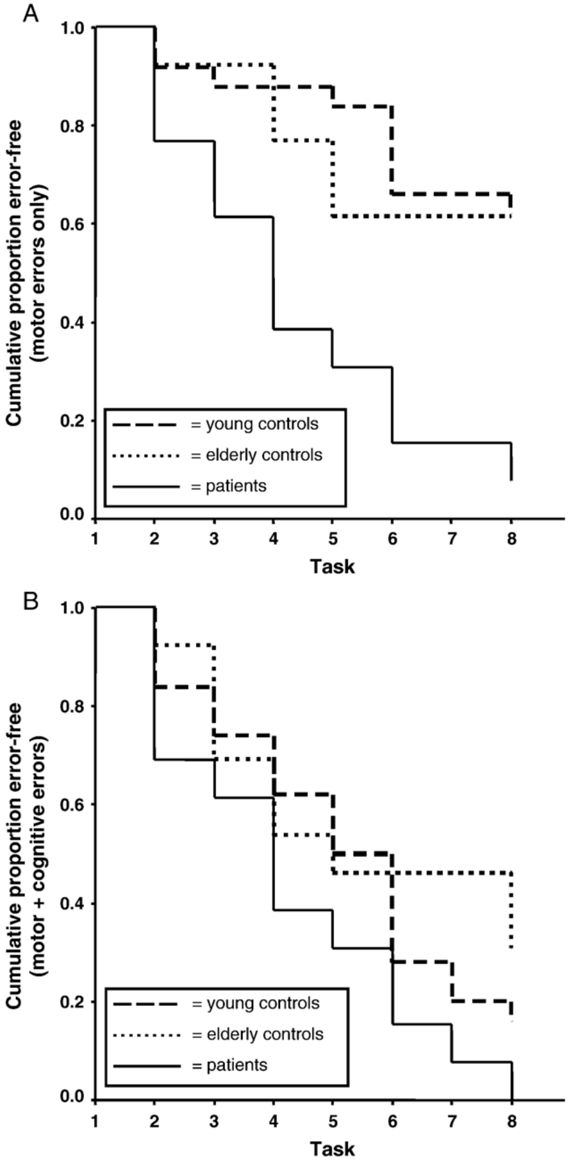

Fig 1 A. Kaplan- Meier curves for the cumulative proportion of subjects with a completely Error-free performance for all motor components within each respective task of the MTT. Subjects who made an Error (Hesitation or Block) for at least one motor component (answering serial questions) were ignored for this analysis. Only 7.7% of the patients had an Error-free performance, as oppposed to 62.0% in both control groups (p< 0.0001). B. Kaplan-Meier curves for the cumulative proportion of subjects with a completely Error-free performance for all component (both motor and cognitive) within each respective task of the MTT. Subjects who made an Error for at least one component of any given task were excluded from the following tasks. 16% of the young controls, 30.8% of the elderly controls and none of the patients completed the test without any Errors (no significant difference).

Errors during the most complex tasks. Cognitive Errors increased even more than motor Errors with task complexity. Interestingly, this increase was most pronounced in young subjects, who apparently postponed answering until the motor components had been completed safely. This suggests that for complex postural tasks, healthy subjects favour execution of motor components over execution of a cognitive component. The results thus provided some interesting insights into normal coping strategies with increasingly complex postural tasks. On the one hand, we found evidence that impaired multiple task performance may reflect a limited processing capacity. Indeed, most of our healthy subjects were able to integrate fairly complex postural tasks without errors, although errors inevitably appeared during the most complex tasks. On the other hand, it also seemed that during extremely complex tasks, healthy subjects lent priority to complete certain task components at the expense of others. In other words, their "blockades" should perhaps not necessarily be regarded as a marker of postural instability or pathologically impaired central processing capacity, but rather as a form of "prudent" behaviour intended to optimise the primary task (maintaining balance). This strategy had been observed previously by others and is termed "posture first".[3,39,41,43,45] It is indeed a safe postural strategy to favour maintaining balance (the "primary" task) over execution of e.g. a manual or mental secondary task. Apparently, young subjects are more inclined than elderly subjects to use this "posture first" strategy, and may therefore be better able to avoid falls.

In the second study[29], we studied if performance on the MTT could discriminate between healthy subjects and PD patients. We were particularly interested to study the strategies for increasingly complex postural tasks in PD. Theoretically, patients might reveal various abnormalities. One possibility is that patients use intended "priority processes", much like the young subjects described above. Due to their underlying balance impairment and restricted central processing resources, patients would need to prioritise (and thus make "errors") during less complex tasks than healthy subjects. Patients and controls would thus show a resemblance, albeit at differing task difficulties. This phenomenon indeed occurs in healthy subjects who show Parkinson-like impairments on cognitive tasks if sufficiently distracted by demanding secondary tasks.[46] Alternatively, patients may have lost the ability to lend priority to complete particular components of a complex task. If this were true, performance of the postural task would deteriorate by a challenge to multiple components of postural control. Patients might even be expected to fall, while attempting to continuously perform all components of the task.

We addressed these questions by administering the MTT to 20 non-demented PD patients, and compared their performance to that of the previously tested controls.[29] Significantly more patients produced Errors than young and elderly controls, and only 8% of the patients completed all tasks without any motor Errors (Figure 1A). Patients particularly produced more motor Errors than controls during the most complex tasks. Interestingly, this difference between patients and controls disappeared if the cognitive component was also scored, because more controls made cognitive Errors during complex tasks than patients (Figure 1B). Patients apparently gave less priority to execution of the motor components. Patients thus seemed less able than controls to employ a "posture first" strategy, but instead attempted to perform all tasks simultaneously. However, due to their balance impairment and restricted processing resources, neither motor nor cognitive components were executed very successfully. This might be interpreted as a form of "risky" behaviour that might lead to falls in daily life. In fact, one patient actually had an imminent fall during the eighth task that was prevented by the examiner. The clinical relevance of our findings is further underscored by the fact that more than half of our patients reported difficulties with simultaneous tasks in daily life, including simultaneous motor tasks, such as carrying a tray while walking. Many patients described falls during situations that resembled the most complex tasks of the MTT.

In a subsequent follow-up study, we examined the predictive value of the MTT by asking the 20 PD patients and 20 matched controls to prospectively monitor their falls in daily life for 6 months using standardised diaries (Bloem & Munneke, unpublished observations). Because of the relatively small sample size, we have pooled the data of patients and controls. At least one motor Error was made by 21 of the 40 subjects. Only three out of the 19 subjects who produced no motor Errors during the MTT fell during the 6-month follow-up, while seven out of the 21 subjects with ≥1 motor Error fell during the same time period (Relative Risk [95 % confidence interval] = 2.1 [0.63 – 7.01]). Although the confidence interval was wide due to the small sample size and limited number of incident falls, these preliminary findings do suggest that impaired performance on the MTT was associated with a two-fold increase in the risk of falling. Furthermore, it is interesting to note that only 10 out of the 21 falls in the Lundin-Olsson study[1] were identified by the SWTT, whereas seven out the 10 falls in our study were identified by the MTT. This may reflect a good sensitivity for the MTT, which could be useful for a screening device to pre-select candidates for more detailed evaluations. Larger studies are now underway to fully examine the predictive abilities of the MTT.

GETTING THE PRIORITIES ENTIRELY WRONG

We have suggested that young healthy subjects are well able to cope with complex situations by adopting "safe" strategies (prioritising balance over other concurrent tasks), and that such behaviour is less often seen in elderly persons and, in particular, in patients with PD. Interestingly, however, even young healthy subjects may occasionally get their priorities wrong. In a nicely designed study, Bhateni et al.[47] suddenly perturbed upright standing young persons who held a cane (or, in some trials, merely a useless top handle portion of a cane) in their hand. Instead of optimally using their arms to grab a nearby handrail for support, the subjects tended to cling onto the cane, even when it had no stabilizing value (holding a cane during backward falls) or any intrinsic value whatsoever (carrying a canetop). These findings could have important implications for understanding the mechanisms leading to falls in persons using assistive devices.

There may be subgroups of patients who get their priorities wrong altogether. In PD, many patients are afraid to fall[13,15,16], and this fear of falling may well prevent them from engaging in potentially hazardous activities. The flip side of the coin is that patients with excessive fear may suffer from unnecessary immobilisation.[13] Conversely, patients who are overly confident (possibly due to coexistent cognitive deficits and lack of insight) are at increased risk of sustaining falls and injuries. Some preliminary evidence suggests that this may occur in patients with PD[48], and such patients may be particularly at risk of falls due to their hazardous behaviour.

Such apparent lack of insight is encountered more commonly in patients with progressive supranuclear palsy (PSP), characterised by atypical parkinsonism, supranuclear vertical gaze palsy, pseudobulbar palsy and dementia. Development of postural instability and recurrent falls occur early in the course of the disease.[49,59] We recently determined the frequency and characteristics of falls among 117 patients with PSP, using a detailed questionnaire and a 3-month prospective follow-up.[51] At least one fall had occurred since disease onset in 97% of PSP patients, while daily falls were present in 23% of patients who were still mobile. Injuries were also much more common than in PD, not only because postural instability was more severe, but also owing to "motor recklessness": many patients with PSP move abruptly and seem unable to properly judge the risk of their actions. There was no evidence for an overall lack of insight because balance confidence was markedly reduced in PSP patients (mean score of 17.6, on a visual analogue scale of 0-100, with 0 being worst performance). The key problem seems to be impulsiveness, leading patients to respond immediately to external stimuli in a direct "stimulus-response" type behaviour. This impulsiveness or recklessness is presumably related to the pronounced frontal atrophy in PSP.[52] Medical treatment often proves difficult, and strict supervision of activities is typically a mainstay of treatment in this disorder.

Patients with Alzheimer's disease (AD) may be another example of a group who fall because of bad judgement. Their rates of falls and injuries are also high[53,54], despite much less impaired motor function, at least in the early stages of AD. This discrepancy between relatively mild motor problems and frequent falls suggests that falling is possibly related in part to behavioural problems in AD, such as lack of insight or wandering behaviour. A relation with cognitive problems is further suported by studies demonstrating that dual tasking has a profound influence on balance and gait.[2,3,55]

6

IMPLICATIONS FOR TREATMENT

Recognition of dual tasking limitations and their impact on the risk of falls may have treatment implications. It is conceivable that safer dual tasking strategies can be trained by physiotherapists, for example by instructing patients to avoid secondary tasks during complex walking or balancing activities.[56] Another possibility is the use of cognitive rehabilitation.[57] Such treatment possibilities and their effect on everyday performance have thus far not been investigated, and this could be a fruitful subject for future research.

CONCLUSIONS

Evidence is beginning to accumulate that healthy subjects may correctly perceive the difficulty of multiple task performance, and purposely lend priority to execution of one part of a complex task, at the expense of other elements. Which particular type of strategy is chosen may depend on the preference of individual subjects. Some persons will adapt their behaviour by decreasing the walking speed and thus avoid the risk of a fall. Others may lend priority to the walking task at the expense of the other concurrent tasks, an approach referred to as the "posture first" strategy. This strategy is typically implemented by young persons, but less often by elderly persons. Still others may favour the mental task or entirely fail to lend priority to any particular task, but they could pay the price by an increased instability or even a fall. This latter mechanism seems to play a role in patients with PD, and is seen in an extreme form in patients with PSP whose tendency to fall is aggravated by motor recklessness. The opposing effect of these different "strategies" obscures simple interpretation of dual or multiple task performance, and underscores the importance of accommodating the adopted strategy when using dual tasking as a predictor of falls. Another factor that needs to be taken into account is the nature of the secondary tasks. A simple dual task design with a combination of motor and cognitive tasks is perhaps sufficient to detect abnormalities in patients with mainly *cognitive* decline. For these populations, even measurements of simple walking time may suffice, perhaps supplemented with additional quantitative measures of trunk sway or changes in stride. However, more complex tasks such as the MTT (which consists mainly of multiple motor components plus a cognitive component) may be more informative for subjects with mainly *motor* disabilities, such as PD patients. Finally, preliminary evidence suggests that multiple task performance is perhaps best probed using a sudden and unexpected insertion of a secondary task, rather than a more continuous and predictable dual loading.

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