Age and Ageing 2009; **38:** 435–440
doi: 10.1093/ageing/afp066
Published electronically 18 May 2009

The influence of fear of falling on gait and balance in older people

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Abstract

Background: fear of falling (FoF) has great impact on functioning and quality of life of older people, but its effects on gait and balance are largely unknown.
Methods: we examined FoF in 100 participants aged ≥75 years, using the Activities-specific Balance Confidence scale. Participants with a mean score <67% were assigned to the FoF group. We quantified gait and balance during walking at the preferred velocity with and without a cognitive dual task (arithmetic task and verbal fluency), using an electronic walkway (Gaitrite®) and a trunk accelerometer (SwayStar®). Primary outcome measures were gait velocity, stride-length and stride-time variability, as well as mediolateral angular displacement and velocity.
Results: gait velocity was significantly lower ($P < 0.05$) and stride-length and stride-time variability were significantly higher ($P < 0.05$) in the FoF group. However, after standardisation for gait velocity, differences became non-significant. Mediolateral angular displacement and velocity were not associated with FoF. We found no difference between the FoF and no-FoF group with respect to the dual-task effect on gait and balance variables.
Conclusions: the lower gait velocity in the FoF group may be a useful adaptation to optimise balance, rather than a sign of decreased balance control. The ability to attend to a secondary task during walking is not influenced by FoF.

Keywords: *older people, fear of falling, gait, balance, dual task, elderly*

Introduction

Fear of Falling (FoF) refers to the lack of self-confidence that normal activities can be performed without falling [1]. The prevalence varies between 21 and 85% and is higher in women and increases with age [2, 3]. FoF may be associated with a history of falls, but is also present in older people without previous falls [3, 4]. In addition, FoF is associated with anxiety, depressive symptoms, decreased mobility, gait and balance abnormalities and the use of a walking aid, restricting everyday functioning and reduced quality of life [5, 6]. This activity restriction may reflect a useful adaptation to physical limitations, but FoF may also lead to unnecessary avoidance of activities that the person is capable of doing [7, 8]. Inactivity could be the start of a downward spiral leading to social isolation, deconditioning, heightened risk of falling and a further increase of FoF [9, 10]. Some older people with FoF adapt their gait, often described as 'cautious gait' or 'fearful gait' [11]. FoF thus may influence balance during walking. In contrast to static balance, however, little is known about the dynamic balance in older people with FoF. Since most falls occur during movement, dynamic balance may be more important and directly related to falls and FoF [12].

Dual-tasking requires participants to divide their attention, which may interfere with gait and balance control [13]. Following Gage's study on the influence of anxiety on attentional demands during walking, FoF may reduce the amount of cognitive resources available for gait and balance control [14]. The effect of FoF on gait and balance may therefore be more apparent when people perform a second task during walking, as happens often in daily life.

The purpose of this study was to examine the association between FoF and gait and balance in older people during walking with and without dual-tasking. We expected a slower gait velocity, higher gait variability and more sway in the FoF group compared to the group without FoF. In addition, we hypothesised that people in the FoF group would have more difficulty performing dual tasks, resulting in a more pronounced dual-task effect on gait and balance parameters and/or the secondary task.

Methods

Participants

Participants were randomly recruited from an existing community-based longitudinal study (the Nijmegen Biomedical Study), which included a large sample ($N = 22{,}451$) of the inhabitants of Nijmegen. Inclusion criteria were age $\geq$ 75 years, ability to independently walk 10 m for at least five times (use of a walking aid was allowed) and ability to understand short instructions. People were excluded if their (aided) vision was insufficient to read a newspaper. The study was approved by the institutional review board and written informed consents were obtained.

Measurements

We recorded relevant biological and demographic variables: the number of drugs used, level of anxiety [Hospital Anxiety and Depression Scale—Anxiety subscale (HADS-A)], handgrip strength (HGS) as a measure for frailty, physical activity (Voorrips questionnaire; sports subscale) and executive function (susceptibility to interference: Stroop Color-Word Test, interference score). We also described activities of daily living (ADL) with the Groningen Activity Restriction Scale (GARS), general mobility with the Timed Up and Go test (TUG), co-morbidity with the Cumulative Illness Rating Scale—Geriatric (CIRS-G), Parkinsonism with the Unified Parkinson's Disease Rating Scale (UPDRS, motor section) and economical status (ISEI-92 code).

We assessed FoF indirectly using the Activity-specific Balance Confidence scale (ABC-NL) [15], a reliable 23-item scale scoring the confidence a person has in maintaining balance when performing specific activities such as climbing stairs. Each item is scored 0–100% (higher percentages represent higher confidence levels). A cut-off score of 67% was used; participants with a mean score lower than 67% were assigned to the FoF group [16]. The ABC-NL was chosen over the Falls Efficacy Scale (FES), since the FES has a ceiling effect in relatively healthy older people [17]. In addition, we assessed FoF by asking the single yes or no question 'Are you afraid of falling?', which has a high test–retest reliability.

Gait and balance

Participants walked 10 m at a preferred velocity with and without performing a cognitive dual task. Both an arithmetic (continuously subtracting 7, starting from 100) and a verbal fluency task (naming as much animal species as possible) were performed. For both cognitive tasks, the answers were recorded. Additionally, the participants walked at a slow, quick and as quick as safely possible speed, to collect the data necessary to standardise the gait and balance variables for gait velocity (see reference [18] for a more detailed description).

During these walking tasks, we performed a quantitative gait and balance assessment. The exact timing and foot placement were recorded with a 5.6 m long and 0.89 m wide electronic walkway (GaitRite®). Balance during walking was measured with a wireless device attached to the trunk at the level of the lumbar spine (SwayStar®). This device measures the upper-body movements at the centre of mass as angles and angular velocities. Primary outcome measures were gait velocity, stride-length and stride-time variability, angular displacements and velocities in a mediolateral direction of the point of gravity, since these measures are known to be strongly related to falls [12, 19–21].

Statistical analysis

The baseline characteristics for each group were summarised as mean ± standard deviation and both groups were compared using independent-sample *t*-tests. If necessary, logarithmical transformations were performed to normalise the data.

Stride-length and stride-time variability were expressed in coefficients of variation [CV; (standard deviation/mean) × 100%]. Changes in gait and balance variables within and between groups were compared using paired and independent-sample *t*-tests, respectively. Finally, we performed a multiple linear regression analysis to describe the association between FoF as measured with the ABC-NL scale (independent variable) and the gait and balance variables (dependent variables), corrected for confounders if necessary. Possible confounders were the number of falls in the past 12 months, number of drugs used, anxiety level (HADS-A), executive function (Stroop interference score), frailty (HGS) and activity level (Voorrips Sports scale). A confounding variable was included in the model if it changed the β-coefficient for the relation between FoF and the gait and balance variables more than 10%. The best-fit model was created for walking at a preferred speed, which was then also used for the two dual-task conditions.

As a secondary analysis, we standardised the gait and balance variables for the gait velocity to study the influence of FoF on the variables independent of the gait velocity.

Results

Of the 300 invited, 100 people participated in this study. Six people had an incomplete ABC-NL scale due to the lack of understanding of the scale and were excluded from further analysis.

Baseline characteristics

Based on the ABC cut-off score, 65 participants were assigned to the no-FoF group and 29 to the FoF group. Baseline characteristics for both groups are summarised in Table 1. The FoF group consisted of less males, had more co-morbidity, a higher number of drugs used, a higher GARS score, a lower Voorrips Sports score, a higher HADS-A score, a higher UPDRS score, a longer TUG time and less HGS ($P < 0.05$). Because of the unequal sex distribution across both groups, we performed a secondary analysis comparing baseline characteristics in both groups for both sexes separately. Males in the FoF group had significantly more co-morbidity and used a higher number of drugs than males in the no-FoF group.

Table 1. Baseline characteristics in the fear of falling and no fear of falling group

	Fear of falling Mean ± SD ($N = 29$)	No fear of falling Mean ± SD ($N = 65$)	P-value
Age (years)	80.6 ± 4.2	80.5 ± 3.7	0.842
Sex, male (%)	48.3	73.8	0.016
ABC score	53.0 ± 9.6	84.7 ± 10.0	0.000
FoF question (% 'yes')	48.3	13.8	0.000
BMI (kg/m^2)	26.4 ± 4.1	25.3 ± 3.6	0.189
ISEI-92	50.3 ± 15.8	49.6 ± 16.9	0.844
CIRS-G	8.6 ± 3.9	6.3 ± 3.1	0.003
Number of falls in past 12 months	0.8 ± 1.9	0.51 ± 1.4	0.217
Number of medications	4.5 ± 3.4	2.9 ± 2.3	0.027
GARS	32.8 ± 9.2	22.8 ± 5.7	0.000
Voorrips Sports score	4.5 ± 4.2	8.7 ± 4.9	0.000
HADS-A	4.4 ± 3.4	2.9 ± 2.9	0.013
UPDRS motor section	5.0 ± 4.6	2.1 ± 2.9	0.002
Use of an assistive device (%)	13.8	3.1	0.556
TUG (s)	12.8 ± 4.9	8.9 ± 2.6	0.000
HGS (kg)	28.8 ± 8.3	34.6 ± 8.0	0.002
MMSE	28.4 ± 1.3	28.6 ± 1.5	0.407
Stroop interference score	58.9 ± 26.8	60.9 ± 36.1	0.799

ABC score = Activities-specific Balance Confidence scale (23 items, score 0–100, a higher score indicates a higher confidence level); FoF = fear of falling question: Are you afraid of falling?; BMI = body mass index (<18.5 = underweight; 18.5–24.9 = normal weight; 25–29.9 = overweight; BMI of 30 or greater = obese); ISEI-92 = International Socio-Economic Index of occupational status [ranges from 16 (lowest status) to 87 (maximum score; highest status)]; CIRS-G = Cumulative Illness Rating Scale—Geriatric (range 0–52; a higher score indicates a higher level of co-morbidity); GARS = Groningen Activity Restriction Scale, four-point scale (range 18–72; a higher score indicates a higher ADL dependency); HADS-A = Hospital Anxiety and Depression Scale—Anxiety subscale (range 0–21; a score > 8 indicates mild-to-moderate anxiety symptoms); UPDRS = Unified Parkinson's Disease Rating Scale (range 0–56; higher score indicates a higher level of Parkinsonism); TUG = Timed Up and Go (<13.5 is associated with an increased risk of falling); HGS = Handgrip strength; MMSE = Mini-Mental State Examination (range 0–30; a score <24 indicates cognitive impairment).

BMI was significantly higher for women in the FoF group compared to the no-FoF group.

Gait and balance variables

We found a significantly lower gait velocity for walking at the preferred velocity and during the performance of both dual tasks in the FoF group compared to the no-FoF group (Table 2). Stride-length variability was significantly higher in the FoF group during dual-tasking. Stride-time variability was also significantly higher in the FoF group when walking at the preferred gait velocity and while performing the arithmetic task. However, these differences were completely explained by the difference in the gait velocity, since stride-length and stride-time variability were comparable in the two groups after standardisation for gait velocity. We found no significant differences between both groups for lateral angular displacement and lateral angular velocity, even after standardisation for gait velocity.

As a result of the arithmetic and verbal fluency tasks, the gait velocity decreased, stride variability increased and lateral angular displacement increased significantly in both the FoF and the no-FoF group (see Table 2). These changes in balance and gait variables were similar in the FoF and the no-FoF group. Furthermore, accuracy of performing the cognitive task was comparable for both groups as well: for the arithmetic task, the mean number of correct answers was 2.59 (SD 1.59) and 2.96 (SD 2.10) for the no-FoF and the FoF group, respectively ($P = 0.4$). For verbal fluency, these numbers were 6.20 (SD 1.45) for the no-FoF and 7.04 (SD 2.10) for the FoF group ($P = 0.1$).

Multiple regression analysis showed that FoF was significantly associated with the gait velocity for each of the three tasks (Table 3). FoF was also associated with the stride-time variability during walking at the preferred velocity and stride-time and stride-length variability when performing the arithmetic task. No significant association with the gait variables was found for verbal fluency, except for the gait velocity. The trunk sway measures were not associated with FoF for either of the tasks. We added HGS and the Voorrips score as confounders to the models for gait velocity, stride-length variability and lateral angular velocity.

Discussion

Our findings show that FoF is significantly associated with the gait velocity when walking at the preferred velocity with and without a cognitive dual task. Stride-time variability and stride-length variability were also associated with FoF, but this association was explained by the change in gait velocity. After correction of the stride variability for gait velocity, the association with FoF was no longer significant. Surprisingly, we found the mediolateral angular displacement and mediolateral angular velocity to be comparable in both groups and found no difference in the dual-task effect between the FoF and no-FoF group, for both standardised and raw data.

Table 2. Gait and balance parameters for walking at preferred speed and while performing a dual task

	Group	No dual task Mean ± SD	Arithmetic task Mean ± SD	Verbal fluency Mean ± SD
Gait velocity (cm/s)	No FoF	106.1 ± 19.3*	99.7 ± 26.3*,^	99.6 ± 25.6*
	FoF	80.9 ± 16.4	75.4 ± 21.0^	78.8 ± 23.4
Stride-length variability (% CV)	No FoF	2.6 ±1.8	3.5 ± 3.5*,^	4.0 ± 4.9*,^
	FoF	2.8 ± 1.8	4.6 ± 2.6^	4.6 ± 2.5^
Stride-time variability (% CV)	No FoF	1.9 ± 1.0*	3.4 ± 3.6*,^	4.6 ± 8.8^
	FoF	3.0 ± 1.7	4.0 ± 2.4	5.7 ± 8.5
Mediolateral angular displacement (deg.)	No FoF	5.2 ± 1.4	6.6 ± 3.2^	6.7 ± 3.8^
	FoF	5.7 ± 1.7	7.2 ± 2.5^	7.0 ± 2.5^
Mediolateral angular velocity (deg./s)	No FoF	50.1 ± 15.0	51.0 ± 16.6	52.0 ± 20.4
	FoF	46.1 ± 13.3	47.3 ± 15.1	50.2 ± 15.9

FoF = fear of falling; CV = coefficient of variation [(standard deviation/mean)×100%]; comparing the change in variables as a result of the dual task in the FoF group to the no-FoF group showed no significant difference for any of the variables.
*$P < 0.05$, comparing the results for the no-FoF group to the FoF group within the performed task; ^$P < 0.05$, for the change in variables when performing an additional task (dual task – preferred speed) within the FoF or the no-FoF group;

Table 3. The association between gait and balance variables and fear of falling: results of multiple linear regression analysis

Dependent variable	Independent variables	Task	R^2	β coeff. ABC	P-value ABC
Gait velocity	ABC, HGS, Voorrips	1	0.454	0.483	0.000
		2	0.334	0.550	0.000
		3	0.271	0.426	0.009
Stride-length variability	ABC, HGS, Voorrips	1	0.116	−0.001	0.805
		2	0.179	−0.012	0.009
		3	0.191	−0.001	0.815
Stride-time variability	ABC	1	0.233	−0.015	0.000
		2	0.008	−0.012	0.007
		3	0.034	−0.011	0.078
Lateral angular displacement	ABC	1	0.022	−0.003	0.091
		2	0.022	−0.004	0.163
		3	0.011	−0.003	0.320
Lateral angular velocity	ABC, Voorrips	1	0.114	0.000	0.922
		2	0.062	0.001	0.755
		3	0.018	0.000	0.978

ABC = Activities-specific Balance Confidence scale, HGS = handgrip strength, Voorrips = Voorrips Sports scale; Task 1 = preferred gait velocity, Task 2 = preferred gait velocity and performing the arithmetic task, Task 3 = preferred gait velocity and performing the verbal fluency task.

Previous studies, in contrast to our results, have found decreased balance abilities and postural control reflected in increased postural sway in groups with FoF or an increased postural stiffness because of this fear [22–24]. However, these studies evaluated static balance and not balance during walking, and most studies were not performed in older people. Other studies looking at postural sway in older people found increased postural sway in fallers compared to non-fallers, but they did not study the effect of FoF on postural sway [21]. The higher percentage of walking aid use in the FoF group, although non-significant, might have caused an underestimation of the effect of FoF on trunk sway. We therefore performed a *post hoc* analysis only including participants who did not use a walking aid. This did not significantly change the results with respect to the relation of FoF with the gait and balance parameters, even after standardisation for gait velocity. It seems that FoF does not influence trunk sway, but the gait velocity was influenced. Older people in the FoF group walked slower, comparable to results found in elderly fallers [25, 26]. It is possible that the gait velocity is a more sensitive measure, reflecting both gait and balance differences between the two groups. On the other hand, it is also possible that the decrease in the gait velocity as found in the FoF group is an adaptation to stabilise postural sway, since the expected increase in the sway was not found even after standardisation for gait velocity. Previous studies support this conclusion [12, 27].

In accordance with previous findings, dual-tasking resulted in a decrease in the gait velocity and an increase in stride variability [28]. However, FoF did not influence dual-task performance, neither the motor task nor the cognitive task was affected. Since the performance on the cognitive tasks was comparable, it is not likely that the FoF group focused more on the walking task than on the cognitive dual task (i.e. the posture-first strategy). These results are in agreement with results of Hauer *et al.* [29]. In contrast to the arithmetic task, the verbal fluency task had no effect on the gait velocity, in line with previous findings [30]. One explanation could be that the two cognitive tasks rely on different cognitive processes. Verbal fluency mainly relies on the semantic memory function, whereas arithmetic tasks predominantly require working memory.

HGS and the Voorrips Sports scale score were associated with the gait and balance variables, indicating that physical fitness is also related to the variables characterising the walking pattern. Melzer *et al.* showed that walking as an exercise can improve stability [31] and Cesari showed an association between a lower HGS and lower gait velocity [32]. Unexpectedly, the number of falls did not significantly contribute to the model. We recorded an unexpected low number of falls in our sample. Sixty to seventy per cent did not recall any fall and 25% reported one fall in the past 12 months, leaving a small number with multiple falls. This is possibly because we studied a relatively healthy sample and used a less reliable retrospective collection of fall data. The anxiety level did not contribute to the model either. It is possible that the association between gait variables and anxiety found by Gagnon *et al.* [5] is not present in less severe levels of anxiety. In our study, <5% had a HADS-A score >8, indicating that only in a few people in our population, mild-to-moderate anxiety was present [33].

This study investigated the relation between several gait and balance variables with several independent variables. These multiple comparisons are clearly a limitation of this study, although our results allow clear conclusions with regard to our hypotheses on the effect of FoF on the gait velocity and sway during walking. Furthermore, it is the first study to quantify trunk sway during walking and performing a dual task accurately in a large group of older people with and without FoF. We showed that although an effect was found on gait variables, FoF did not affect the upper-body movement. It may be, however, that our sample was not fearful enough. In turn, FoF is often not easily admitted, but trivialised. We classified 29 people with FoF using the ABC-NL score, only half of whom admitted being afraid of falling when asked directly. Thus, we believe that using the ABC-NL score has been successful in describing FoF without neglecting people who will not easily admit about being afraid. Still, it may be that walking and balance are only affected by higher levels of FoF than we report here. Future studies should examine the difference between different levels of FoF and their influence on gait and balance during walking.

Conclusion

Clearly, older people with FoF have a slower gait velocity than older people without FoF. However, this should not be interpreted as a sign of decreased balance control. This decrease in the gait velocity may reflect a useful adaptation mechanism optimising balance, since no difference in the upper-body movement was shown. The ability to perform dual tasks, which is crucial in daily life, is not influenced by FoF.

A better understanding of the consequences of FoF may contribute to a better treatment and more focused interventions. Since we studied a sample with low levels of FoF, further research is necessary to conclude on the relation between FoF and gait and balance in older people with higher levels of FoF.

Key points

- About 30% of community-dwelling older people experience FoF.
- Older people with FoF have a slower gait velocity than those without.
- FoF does not influence other gait parameters or balance parameters, nor the ability to perform dual tasks.
- Older people with low levels of FoF use an adaptation mechanism optimising balance, rather than show decreased balance control.

Conflicts of interest

The authors declare that there are no conflicts of interest to report.

Supplementary data

References regarding used scales and questionnaires are available as supplementary data at *Age and Ageing* online.

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Received 8 October 2008; accepted in revised form 13 March 2009