

# Effectiveness of autonomous home hazard reduction on fear of falling in community-dwelling older women

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## Abstract

**Background:** Many falls in older people occur at home, and home hazards (HOHA) are often involved. Fear of falling (FOF) is a frequent and serious consequence of falls. This study aimed to analyze the effectiveness of an autonomous reduction of HOHA on FOF.

**Methods:** In this single-blinded, prospective cohort study design, the inclusion criteria were female sex, age  $\geq 60$  years, no known dementia, community-dwelling, and written informed consent. Using a 54-item room-by-room checklist, the participants identified and autonomously reduced as many HOHA as possible, within 14 days. The FOF was measured using a dichotomous scale (D-FOF) and the Falls Efficacy Scale International (FES-I). Logistic regression models were used to identify the predictors of a substantial reduction of HOHA ( $\geq 50\%$ ) and FOF ( $\geq 25\%$ ).

**Results:** A total of 782 women fulfilled the inclusion criteria, and 431 (60.5%) returned the complete checklist on time. The mean age was 72.5 [SD 7.1] years. 43.8% of participants reduced  $\geq 50\%$  of the HOHA. The D-FOF (odds ratio 22.4 [95% confidence interval 11.0–45.3]), age  $\geq 75$  years (14.1 [7.5–26.4]), polypharmacy (3.0 [1.4–6.5]), and assumed improvability of housing conditions (2.4 [1.3–4.3]) were identified as predictors for substantially reducing HOHA with an area under the curve of 0.91. The initial FES-I score decreased from 24.5 to 19.5. Prior to the intervention, 53.1% showed a high FOF ( $>22$  FES-I scores). Of these, 70.7% participants reduced their high FOF to low FOF. 29.2% of all participants reduced FOF  $\geq 25\%$  postinterventionally, associated with a substantial reduction in HOHA (3.5 [2.2–5.7]) as the strongest independent factor in the multiple logistic regression analysis.

**Conclusion:** The use of a self-administered checklist led to a substantial reduction of HOHA and subsequently to a clinically relevant reduction of FOF in older community-dwelling women. Autonomous competence of older people should be considered when developing fall prevention strategies.

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## KEYWORDS

checklist, community-dwelling, fall prevention, fear of falling, home hazards, older women

## INTRODUCTION

Over the past three decades, falls in older people have become a focus of research owing to their frequency and far-reaching individual and socioeconomic consequences.<sup>3</sup> Approximately, one in three people older than 65 years of age fall once a year.<sup>2</sup> Most of these falls occur at home.<sup>14,32</sup> Women have a higher risk of falling than men.<sup>3</sup> Physiological aging processes and comorbidities can worsen the outcome of falls.<sup>37</sup> For instance, after a fall-related hip fracture, 60% do not regain their previous mobility; several people become dependent on nursing care, and 30% die within the first year after the fall.<sup>31</sup> Women are 2.2 times more likely to suffer a fall-related fracture and display a hospitalization rate 1.8 times higher than men,<sup>33</sup> resulting in higher costs.<sup>3</sup> Still, even minor injuries or near-falls can affect a person's confidence in his/her own abilities. A long-term consequence is fear of falling (FOF). FOF is defined as "a lasting concern about falling that leads to an individual avoiding activities that she/he remains capable of performing."<sup>34</sup> More than half of the older population suffers from FOF,<sup>27,30,41</sup> which can be both a consequence of a previous fall<sup>5,19</sup> and a risk factor for future falls<sup>27</sup> or can occur independently of falls.<sup>27,41</sup> Therefore, falls and FOF mutually reinforce each other and can lead to frailty through activity avoidance,<sup>9,41</sup> mobility restriction,<sup>9</sup> limitations in the living space,<sup>1</sup> and a severe reduction in the quality of life.<sup>20,29,30</sup>

Many risk factors for falls also apply to FOF, such as older age, female sex, gait and balance impairments, functional impairments, and polypharmacy.<sup>10,29,41</sup> However, the home environment also plays a significant role in the risk of falls, especially for people with disabilities.<sup>15</sup> Home hazards (HOHA) are defined as "aspects of the physical environment, including objects, space, and the elements in and about the house that pose a risk or danger of causing the person to fall and, therefore, risk injury."<sup>6</sup> They are common among older people,<sup>14</sup> but several HOHA are modifiable.<sup>24</sup>

Based on known risk factors, fall prevention concepts<sup>12</sup> and methods for reducing FOF<sup>18,21,28,42</sup> have been developed.<sup>3</sup> Many prevention strategies focus on multilevel interventions using external resources, such as home checks by occupational therapists.<sup>11</sup> Gillespie et al. demonstrated in a meta-analysis that HOHA adjustment significantly reduced both the fall risk and the fall rate, especially in high-risk groups concurrent with occupational therapy monitoring.<sup>11</sup> Other studies demonstrated that home safety

## Key points

- The clinical relevance of the autonomous use of a home-safety checklist in older community-dwelling women with a higher risk for falling is shown in a substantial reduction of home hazards (HOHA) and fear of falling (FOF) in a short period.
- The strongest independent factor for the substantial reduction of FOF is an HOHA reduction of at least 50%.
- Women who may benefit from this intervention by substantially reducing their HOHA could be identified with a high discriminative value.

## Why does this paper matter?

Home hazards (HOHA) are often involved in indoor falls. This study shows that a simple, quick, and cost-effective prevention intervention based on the autonomous use of a checklist resulted in a substantial reduction of HOHA and thus fear of falling in older community-dwelling women. This simple and effective method of using a checklist may provide a targeted resource-saving preventive strategy for fall prevention and reduction of FOF. Future studies should investigate whether this intervention reduces falls.

improvement reduced fall-related injuries in older people by 39%<sup>16</sup> and in people with visual impairment by 41%.<sup>15</sup> Furthermore, demographic developments strengthen the need for simple, individualized, and effective fall prevention strategies. However, the effectiveness of self-administered checklists for the autonomous reduction of HOHA and their influence on FOF is unknown.

## METHODS

## Study design

This study was a prospective, single-blinded, cohort study. In 2016, the Department of Traumatology of

the Medical University Center of Schleswig-Holstein, Kiel, Germany, conducted a project with the “Landfrauenverband Schleswig-Holstein,” the largest community of women in Germany. A surgeon informed these mostly older women about fall risks and how to reduce them in local lectures that last approximately 90 min each. From February to June 2016, we recruited participants of these lectures for this study. All the women participated in the lecture on fall risks, completed two questionnaires for the collection of baseline data on age, living situation, falls, FOF, and functional problems, and received a checklist for home use. This newly designed checklist was structured as a room-by-room analysis containing 54 items. The answer options were dichotomous as a “yes” or a “no.” Existing problems were highlighted in grey. The items can be assigned to five categories: tripping hazards (i.e., loose cables, carpets), slipping hazards (i.e., slippery steps/stairs/floor, lack of antislip mats), hazards due to lack of lighting, hazards due to lack of safety elements (i.e., handholds), and hazards due to behavior (i.e., not using necessary walking aids, not wearing sturdy shoes). This detailed checklist is provided in the Data S1. The checklist was validated and cross-checked for readability and understandability in a preliminary setting prior to the original study. The participants were asked to identify HOHA in each room using the checklist and to reduce as many HOHA as possible within 2 weeks. Then, the participants reevaluated their homes for HOHA with the same checklist and returned it to the investigator.

The inclusion criteria were females aged 60 years and older with no known dementia who were community-dwelling and provided written informed consent and the final completed checklist after at least 14 days.

This study was approved by the local ethics committee of the Christian-Albrecht-University of Kiel, Germany (D 431/16). Written informed consent was obtained from all participants included in the analyses, and the study was conducted according to the WMA Declaration of Helsinki.

## Outcome measures

The primary outcome measure was a reduction of HOHA within 14 days of the completion of the original checklist. The reduction was measured as percent decrease from the initial value. We defined a substantial reduction of HOHA as a  $\geq 50\%$  reduction of preexisting HOHA.

The secondary outcome measure was the reduction of FOF measured by the Falls Efficacy Scale-International (FES-I), a validated assessment tool providing information on FOF for a range of daily living activities.<sup>38</sup> The scores ranged from 16 (no FOF) to 64 (maximum FOF).

For dichotomization between high and low FOF, we set the cutoff value at 22 according to Delbaere, wherein scores greater than 22 were considered as high FOF.<sup>8</sup> The validated German version of the FES-I was used<sup>17</sup> and measured at the beginning before the lecture and at the end of the intervention. A reduction in the initial FES-I score of  $\geq 25\%$  was defined as substantial before the beginning of the study for the univariate analyses.

Additionally, to test for clinical relevance, we asked the participants, postinterventionally, to complete the following sentence: “After the home check I feel ...” with the answer options being “significantly safer,” “safer,” “hardly safer,” and “not safer.”

## Independent variables

We selected potential risk factors for falls based on previous studies.<sup>10,29,41</sup> Individual factors included age, polypharmacy (daily use of five or more medications<sup>23</sup>), previous falls, socioeconomic status, mobility, and comorbidities.

FOF was evaluated using the simple question “Do you actually have a FOF?” with the possible answers of “yes” or “no” (dichotomous fear of falling; D-FOF). Initial FES-I scores and D-FOF served as independent variables for the analyses of HOHA reduction.

Continuous data were dichotomized to predefined values according to the literature or to general medical usage. Baseline parameters were sorted into functional groups as appropriate. Multiple answers were not included in the analyses. All parameters were self-reported according to the structured questionnaires.

## Statistical methods

Continuous data are expressed as mean and standard deviation (SD). For proportions, a  $\chi^2$  test or Fisher's exact test was employed as appropriate. To compare the differences between the means of quantitative parameters, we conducted the Mann-Whitney U-test. The Wilcoxon signed-rank test was employed for repeated measurements. The risk factors were calculated via univariate analyses as odds ratios (OR). Due to rounding, the values did not sum to 100. Parameters with the largest OR in a group were entered into a logistic regression model having first checked for multicollinearity. Multiple logistic regression analysis was conducted using a forward stepwise method (Wald), and the logistic regression coefficients were further analyzed via the receiver operating characteristic (ROC) curve. The predictive accuracy of the model was expressed using the area under the curve (AUC) of the ROC curve.

TABLE 1 Baseline Characteristics

Characteristics	n	(%)
Age		
≥ 75 years	190	44.1
Fear of falling		
Actual fear of falling (D-FOF)	245	56.8
FES-I ≥ 22 points	229	53.1
Fall history		
Fall within the last 12 months	174	40.4
Fall with surgery consequence <sup>a</sup>	74	17.2
Mobility		
Gait unsteadiness	100	23.2
Muscle weakness	25	5.8
Foot problems	46	10.7
Osteoarthritis (lower extremities) <sup>b</sup>	220	51.0
≥ 1 prosthesis <sup>c</sup>	93	21.6
Walking aid	31	7.2
Walking distance <500 m	107	24.8
Neurological dysfunctions		
Visual dysfunction	362	84.0
Peripheral nerve dysfunction	35	8.1
Balance problems	37	8.6
Concentration problems	30	7.0
Memory problems	47	10.9
General dysfunctions		
Polypharmacy <sup>d</sup>	77	17.9
Cardiovascular diseases <sup>e</sup>	154	38.1
Osteoporosis	88	20.4
Living situation		
Living alone	145	33.6
Village or small town <sup>f</sup>	390	90.5
Housing condition		
Assumed importance for own fall risk	399	92.6
Assumed improvability	206	47.8

Abbreviations: D-FOF, dichotomous fear of falling (“Do you actually have a fear of falling?” “Yes”/“No”), FES-I, falls efficacy scale - international, n, number.

<sup>a</sup>Surgery consequences included soft tissue injuries or bone fractures requiring operation.

<sup>b</sup>Articular wear and tear in hip, knee, or ankle joints.

<sup>c</sup>Prosthesis = artificial joints of hip, knee, or shoulder.

<sup>d</sup>Polypharmacy was defined as ≥5 medications per day.

<sup>e</sup>Cardiovascular diseases included heart failure, cardiac arrhythmia, or circulatory disorders of the legs.

<sup>f</sup>Village or small town is defined ≤20,000 inhabitants.

A two-sided  $p < 0.05$  was considered significant. Statistical analyses were conducted using the SPSS software (v.27, IBM Corporation).

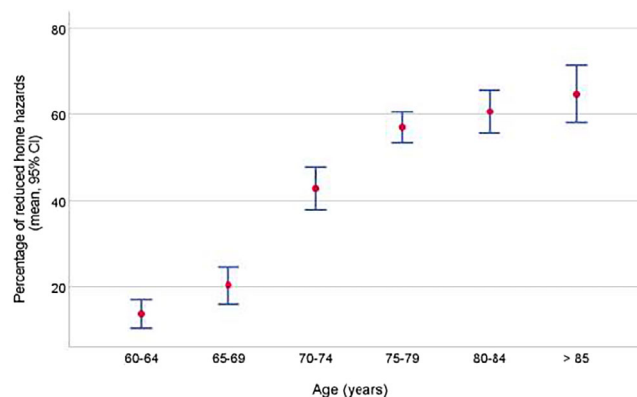


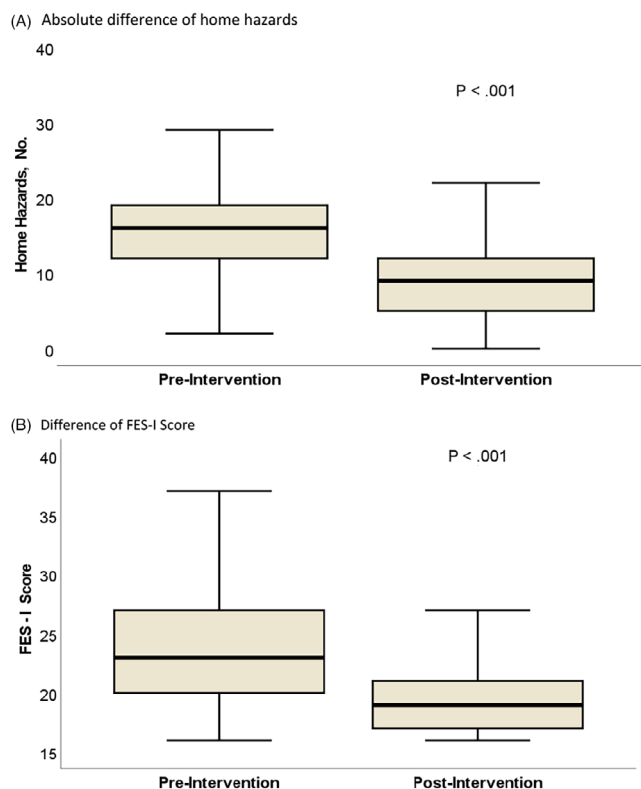
FIGURE 1 Association between age groups and reduced home hazards. Figure 1 shows the mean percentage of reduced home hazards categorized into age groups. The whiskers represent the 95% confidence interval (95% CI)

## RESULTS

A total of 782 women participated in the local lectures. Of these, 431 met the inclusion criteria and completed the home checklist within 14 days. The mean age was 72.5 (SD 7.1) years, with a median of 74 years (interquartile range 66–78, range 60–92). About 174 (40.4%) had a fall in the last year. Furthermore, 56.8% reported having an actual FOF (D-FOF), and the mean initial FES-I score was 24.5 (SD 6.7). The baseline characteristics are presented in Table 1. The participants identified a total of 6905 HOHA. In the subsequent 14 days, the participants reduced 3106 of these HOHA (45%, 7.2 [SD 5.7] per person,  $p < 0.001$ ). The number of HOHA decreased from a mean of 16.0 (SD 5.6) and a median of 16 (interquartile range 12–19) to a mean of 8.8 (SD 4.7) with a median of 9 (interquartile range 5–12) (Figure 2A). The percentage reduction of HOHA was significantly associated with older age, high FOF (FES-I ≥ 22 scores), and different comorbidities (Table 2).

Figure 1 shows the association of age groups with the percentage of HOHA reduction. There was a strong association ( $p < 0.001$ ) between older age and a higher amount of reduced HOHA.

The parameter “reduction of HOHA ≥ 50%” was also included in the analyses of FOF. Factors associated with a significant reduction of FOF as measured by the FES-I score were age, previous falls, falls resulting in surgery, and various comorbidities (Table 3). Univariate analyses revealed that the highest odds ratio (OR) per group for a reduction of HOHA ≥ 50% were using a walking aid, balance problems, polypharmacy, a fall resulting in surgery, assumed improvability of the home, and age ≥ 75 years (Table 3).



**FIGURE 2** (A),(B) Reduction of home hazards and fear of falling. In Figure 2A,B the boxes represent the median and quartiles of the number of home hazards (Figure 2A) or the Fall Efficacy Scale International (FES-I, Figure 2B) scores before and after the intervention. Possible FES-I scores ranged from 16 to 64

### Initial predictors for HOHA reduction of $\geq 50\%$

The multivariate analyses in Table 2 ( $\chi^2 = 292.6$ ,  $df = 4$ ,  $p < 0.001$ ) revealed an age  $> 75$  years (odds ratio (OR) 14.0 [95% confidence interval (CI) 7.5–26.4],  $p < 0.001$ ), D-FOF (OR 22.4 [11.0–45.3],  $p < 0.001$ ), polypharmacy (OR 3.0 [1.4–6.5],  $p = 0.005$ ), and assumed improbability of the home (OR 2.4 [1.3–4.3],  $p = 0.003$ ) as predictors for a substantial reduction of HOHA (Nagelkerke  $R^2 = 0.66$ , effect size  $f^2 = 1.94$ ). ROC analysis of the regression model coefficients revealed an AUC of 0.91 [0.89–0.94],  $p < 0.001$ .

### Independent factors for FOF reduction of $\geq 25\%$

The logistic regression analysis ( $\chi^2 = 71.910$ ,  $df = 4$ ,  $p < 0.001$ ) for an FOF reduction of  $\geq 25\%$  revealed that the strongest association was a HOHA reduction of at least 50% (OR 3.5, [95% CI 2.2–5.7,  $p < 0.001$ ). Other

factors were assumed improbability of housing conditions (OR 2.1 [1.3–3.3],  $p = 0.003$ ), balance problems (OR 2.0 [1.1–5.2],  $p = 0.022$ ), and a fall resulting in surgery (OR 1.9 [1.1–3.3],  $p = 0.033$ ).

### The influence of HOHA reduction on FOF

About 126 (29.2%) of the participants were able to reduce at least 25% of their FOF. The mean FES-I score decreased from 24.5 (SD 6.7) to 19.5 (SD 3.2) (Figure 2B). 53.1% ( $n = 229$ ) showed a high FOF before the intervention. Of these, 70.7% ( $n = 162$ ) participants reduced their high FOF to low FOF. 82.1% of the participants felt safer or much safer after the intervention.

### DISCUSSION

The primary aim of this study was to examine whether self-administered reduction to HOHA was associated with the reduction of FOF. This study shows that older community-dwelling women are able to autonomously check and improve their home safety within 14 days using a checklist. In addition, we show that a self-reduction of HOHA can lead to a significant reduction of FOF. This result was achieved through local lectures on fall prevention and the application of a checklist specifically developed for older people for self-use. The checklist is clearly structured as room-by-room with 54 easy-to-solve HOHA.

The finding that 45% of the identified HOHA could be autonomously reduced within 14 days is an unexpected high percentage. Although the benefits of home modifications are controversial,<sup>11,22,36</sup> overall, both the risk of falls<sup>15</sup> and the risk of fall-related injuries<sup>12</sup> could be reduced as a result. A reduction of FOF not only is relevant to the quality of life<sup>20</sup> but also leads to a further reduction of fall risk.<sup>19,21</sup> Another study found that home modification can lead to a reduction of FOF.<sup>4</sup> However, the modifications in that study were not self-administered and were only evident for 3 months.

In the present study, almost one-third of the participants were able to reduce their initial FOF by  $\geq 25\%$  as a result of the intervention.

To determine why a reduction in HOHA has a positive impact on the FOF is challenging. The interaction between individuals and the environment is complex.<sup>27</sup> Therefore, it can be assumed that the sole reduction in the number of HOHA is not the only factor in reducing the risk of FOF. Rather, the independent and successful use of this checklist may have promoted one's own empowerment. Conducting home checks independently



TABLE 2 Reduction of home hazard (HOHA)

Characteristics	Home hazard reduction in % (SD)			Univariate Analyses		Multivariate Analyses	
	Yes	No	<i>p</i> value	Home hazard reduction $\geq 50\%$ OR (95% CI)	<i>p</i> value	Home hazard reduction $\geq 50\%$ OR (95% CI)	<i>p</i> value
Age							
≥75 years	62.4 (20.6)	28.3 (25.3)	<0.001	12.2 (7.7–19.3)	<0.001	14.1 (7.5–26.4)	<0.001
Fear of falling							
Actual fear of falling (D-FOF)	58.4 (23.1)	28.3 (23.1)	<0.001	23.4 (13.3–41.4)	<0.001	22.4 (11.0–45.3)	<0.001
FES-I $\geq 22$ points	54.0 (26.8)	31.3 (26.2)	<0.001	7.5 (4.9–11.7)	<0.0001		
Fall history							
Fall within the past 12 months	46.2 (27.5)	41.4 (29.6)	0.079	1.1 (0.9–1.4)	0.464		
Fall with surgery consequence <sup>a</sup>	54.0 (26.5)	41.2 (28.8)	<0.001	2.6 (1.6–4.4)	<0.001	-	0.066
Mobility							
Gait unsteadiness	59.7 (23.5)	38.4 (28.5)	<0.001	4.2 (2.6–6.7)	<0.001		
Muscle weakness	64.4 (17.5)	41.6 (28.7)	<0.001	5.6 (2.1–5.3)	<0.001		
Foot problems	47.0 (09.6)	42.5 (28.6)	0.360	1.5 (0.8–2.7)	0.228		
Osteoarthritis (lower extremities) <sup>b</sup>	47.5 (27.9)	39.0 (29.1)	0.002	1.8 (1.2–2.7)	0.003		
≥ 1 prosthesis <sup>c</sup>	57.0 (24.7)	39.6 (28.7)	<0.001	3.1 (1.9–5.1)	<0.001		
Walking aid	66.5 (19.3)	41.6 (28.6)	<0.0001	7.6 (2.8–20.1)	<0.001	-	0.525
Walking distance <500 m	49.6 (27.6)	41.3 (28.9)	0.009	1.8 (1.2–2.9)	0.007		
Neurological dysfunctions							
Visual dysfunction	42.9 (28.5)	45.9 (30.1)	0.448	1.0 (0.6–1.6)	0.844		
Peripheral nerve dysfunction	58.7 (26.9)	41.6 (08.5)	0.001		<0.001		
Balance problems	62.0 (22.7)	41.6 (28.7)	<0.001	3.9 (1.8–8.2)	<0.001		
Concentration problems	58.8 (26.2)	42.2 (28.7)	0.002	5.7 (2.3–14.3)	<0.001	-	0.117
Memory problems	55.7 (23.5)	41.8 (29.0)	0.002	2.8 (1.5–5.2)	0.001		
General dysfunctions							
Polypharmacy <sup>d</sup>	60.2 (23.5)	39.7 (28.6)	<0.001	5.2 (3.0–9.1)	<0.0001	3.0 (1.4–6.5)	0.005
Cardiovascular diseases <sup>e</sup>	46.6 (28.6)	36.4 (28.2)	0.001	1.9 (1.3–3.0)	0.002		
Osteoporosis	56.9 (25.1)	39.7 (28.5)	0.001	3.6 (2.2–5.9)	<0.001		
Living situation							
Living alone	53.0 (27.4)	38.5 (28.3)	0.001	2.3 (1.5–3.4)	<0.001	-	0.104
Village or small town <sup>f</sup>	43.2 (28.9)	45.0 (27.6)	0.705	0.9 (0.5–1.6)	0.604		
Housing condition							
Assumed importance for own fall risk	44.7 (28.6)	27.2 (26.1)	0.001	3.0 (1.3–7.1)	0.009		
Assumed improvability	52.1 (27.4)	35.3 (27.7)	<0.001	3.4 (2.3–5.1)	<0.001	2.4 (1.3–4.3)	0.003

Abbreviations: CI, confidence interval, D-FOF, dichotomous fear of falling (“Do you actually have a fear of falling?” “Yes”/“No”), FES-I, falls efficacy scale - international, n, number, OR, odds ratio, *p* value, significance, SD, standard deviation, “Yes” or “No” means with or without characteristic.

<sup>a</sup>Surgery consequences included soft tissue injuries or bone fractures requiring operation.

<sup>b</sup>Articular wear and tear in hip, knee, or ankle joints.

<sup>c</sup>Prosthesis = artificial joints of hip, knee, or shoulder.

<sup>d</sup>Polypharmacy was defined as  $\geq 5$  medications per day.

<sup>e</sup>Cardiovascular diseases included heart failure, cardiac arrhythmia, or circulatory disorders of the legs.

<sup>f</sup>Village or small town is defined  $\leq 20,000$  inhabitants.

TABLE 3 Reduction of fear of falling (FES-I)

Characteristics	FES-I-Reduction (score) mean value (SD)			Univariate Analyses		Multivariate Analyses	
	Yes	No	<i>p</i> value	FES-I-Reduction $\geq 25\%$		FES-I-Reduction $\geq 25\%$	
				OR (95% CI)	<i>p</i> value	OR (95% CI)	<i>p</i> value
Age							
≥75 years	6.3 (5.4)	3.9 (3.8)	<0.001	2.5 (1.6–3.8)	<0.001	-	0.518
Reduction of home hazards							
Reduction of home hazards $\geq 50\%$	7.3 (5.5)	3.1 (3.0)	<0.001	5.1 (3.2–8.1)	<0.001	3.5 (2.2–5.7)	<0.001
Fall history							
Fall within the past 12 months	5.6 (4.9)	4.5 (4.5)	0.016	1.8 (1.2–2.8)	0.006		
Fall with surgery consequence <sup>a</sup>	6.9 (5.0)	4.6 (4.5)	<0.001	2.7 (1.6–4.5)	<0.001	1.9 (1.1–3.3)	0.033
Anamnesis of movement							
Gait unsteadiness	7.3 (5.6)	4.2 (4.1)	<0.001	2.4 (1.5–3.8)	<0.001		
Muscle weakness	7.6 (5.6)	4.8 (4.5)	<0.001	3.6 (1.6–8.1)	0.001		
Foot problems	6.3 (5.4)	4.8 (4.5)	0.082	1.6 (0.8–3.0)	0.161		
Osteoarthritis (lower extremities) <sup>b</sup>	5.3 (4.9)	4.6 (4.5)	0.083	1.2 (0.8–1.8)	0.421		
≥ 1 prosthesis <sup>c</sup>	6.5 (5.5)	4.5 (4.4)	0.001	1.8 (1.1–2.9)	0.017		
Walking aid	9.5 (6.7)	4.6 (4.3)	<0.001	4.1 (1.9–8.6)	<0.001	-	0.095
Walking distance <500 m	6.3 (5.6)	4.5 (4.3)	0.006	2.2 (1.4–3.4)	0.001		
Neurological dysfunctions							
Visual dysfunction	5.0 (4.7)	4.8 (4.5)	0.771	1.1 (0.6–2.0)	0.723		
Peripheral nerve dysfunction	7.0 (4.6)	4.8 (4.6)	0.001	2.7 (1.3–5.4)	0.005		
Balance problems	9.6 (5.7)	4.5 (4.3)	<0.001	3.9 (2.0–7.8)	<0.001	2.0 (1.1–5.2)	0.034
Concentration problems	8.9 (6.0)	4.7 (4.4)	<0.001	3.8 (1.8–8.1)	<0.001		
Memory problems	7.4 (6.2)	4.7 (4.4)	0.004	2.3 (1.3–4.3)	0.006		
General dysfunctions							
Polypharmacy <sup>d</sup>	8.2 (6.3)	4.3 (3.9)	<0.001	3.2 (1.9–5.4)	<0.0001	-	0.053
Cardiovascular diseases <sup>e</sup>	6.5 (6.9)	4.1 (3.8)	<0.001	1.9 (1.2–2.9)	0.003		
Osteoporosis	7.0 (5.3)	4.4 (4.4)	<0.001	1.9 (1.2–3.1)	0.010		
Living situation							
Living alone	5.4 (5.3)	4.7 (4.3)	0.499	1.2 (0.8–1.9)	0.409		
Village or small town <sup>f</sup>	4.9 (4.7)	5.6 (4.6)	0.242	0.7 (0.3–1.3)	0.231		
Housing condition							
Assumed importance for own fall risk	5.1 (4.7)	3.8 (4.0)	0.158	2.2 (0.8–5.8)	0.109		
Assumed improvability	6.2 (5.2)	3.8 (3.8)	<0.001	2.7 (1.7–4.1)	<0.001	2.1 (1.3–3.3)	0.003

Abbreviations: CI, confidence interval, D-FOF, dichotomous fear of falling (“Do you actually have a fear of falling?” “Yes”/“No”), FES-I, falls efficacy scale - international, n, number, OR, odds ratio, *p* value, significance, SD, standard deviation, “Yes” or “No” means with or without characteristic.

<sup>a</sup>Surgery consequences included soft tissue injuries or bone fractures requiring operation.

<sup>b</sup>Articular wear and tear in hip, knee, or ankle joints.

<sup>c</sup>Prosthesis = artificial joints of hip, knee, or shoulder.

<sup>d</sup>Polypharmacy was defined as  $\geq 5$  medications per day.

<sup>e</sup>Cardiovascular diseases included heart failure, cardiac arrhythmia, or circulatory disorders of the legs.

<sup>f</sup>Village or small town is defined  $\leq 20,000$  inhabitants.

could offer further benefits; older people can survey their homes at their own pace as required, thus maintaining privacy. Additionally, the checklist contained repeated

items as per each room. This may have increased attention to common risk factors to maximize the possibility that these would be attended to in the future.

It is interesting to note that a substantial reduction of both HOHA (Table 2) and FOF (Table 3) shows significant associations with older age, comorbidities, polypharmacy, and previous falls, especially those with severe fall consequences. The more additional risk factors there are, the greater the risk of falling due to HOHA.<sup>35</sup> Accordingly, in this research, the group with the highest risk of falling benefited the most from this type of intervention. In terms of home modification, this finding is consistent with those of other studies: Yardley et al. also found associations with an age of 75 or older, female sex, having had recurrent falls, and a significantly higher likelihood of home modification.<sup>39</sup> Another study found that comorbidities<sup>7</sup> or prior falls<sup>25</sup> were associated with a higher propensity for home modification. It is possible that the experience of a fall increases a person's awareness of their environment.<sup>13</sup> One of the main factors for a successful participation in a fall prevention effort is the desire for independence.<sup>26</sup> Many older people want to be able to live independently as long as possible and not be a burden to the younger generation,<sup>26</sup> which could motivate them.

The results of these studies may explain why, in the present work, in particular, older women with FOF who had consequential fall experience, disorders such as gait and balance problems, cardiovascular diseases, and polypharmacy and who used a walking aid reduced significantly more risks than younger, healthier participants without FOF. They rated their own fall risk higher and were more likely to make changes as a result. At the same time, making these changes themselves supported their need for independence and promoted a sense of personal responsibility. The self-driven action potential of older people may therefore be underestimated.

In our study, especially those women with a high risk of falling due to their age and comorbidities were able to reduce their FOF substantially. The validated FES-I sets a cutoff value at 22 scores to differentiate between high and low FOF.<sup>8</sup> The mean FES-I score of all participants decreased from 24.5 to 19.5, and this reduction crossed the cutoff value. 53.1% showed a high FOF before the intervention. Of these, 70.7% reduced their high FOF to low FOF. Consequently, 82.1% of all participants stated that they felt subjectively safer or much safer after using the checklist. Several studies showed that higher FOF leads to activity avoidance,<sup>9,41</sup> mobility restriction,<sup>9</sup> higher risk for falling,<sup>27</sup> and a reduction in the quality of life.<sup>20,29,30</sup> Therefore, it can be assumed that the participants improved not only subjective factors but also their activity behavior and reduced their risk for falling. Further studies should verify this relationship.

To calculate the individual probability of a substantial reduction of HOHA (at least 50%) or FOF (at least 25%), logistic regression models were developed. The strongest

predictor of substantial HOHA reduction was FOF (22-fold), followed by age  $\geq 75$  years (14-fold), polypharmacy (3-fold), and assumed improvability of the housing condition (2-fold) (Table 2). With an AUC of 0.91 (Figure 2), this model exhibits an excellent discriminant ability according to Cohen.<sup>13</sup> The identified parameters could be developed into an easy-to-use tool for focused and individualized use of such a checklist in practice.

The strongest independent factor for a substantial reduction of FOF is a HOHA reduction of at least 50% (Table 3). This indicates that a reduction of HOHA seems to have a positive effect on FOF. Whether this is due to the actual reduction in the number of HOHA or whether it is also due to the participants acting independently remains unclear and should be investigated further.

To the best of our knowledge, this is the first study to show that the use of a self-administered, paper-based, room-by-room checklist in older women results in a significant reduction of HOHA and FOF in a short period of time (Figure 2A,B). These findings open new possibilities of simple, low-cost, and effective prevention interventions.

Given the ongoing digitization of medicine and increasing acceptance in the older population, this checklist could be used in a digital form in the future. This would also facilitate regular repetition of the intervention to achieve long-term effects.

## Strengths and limitations

The strengths of this prospective cohort study include the simplicity of the method, the effectiveness of the intervention over 14 days, and the focus on women who are at a higher fall risk. Our checklist, developed for older people, was shown to be suitable for self-administered use, which supports a self-responsible action.

In data collection, the nature of self-reporting leads to some limitations. This method entails a risk that the data are limited in their informative value and in their ability to capture existing HOHA. The developed checklist should be tested in terms of validity and reliability by testing in a higher number of homes. A possible limitation of the checklist could be a maladaptation to real households. Depending on local conditions, rooms and items could have been missing or in excess. For a more detailed analysis, an individually adapted checklist would be beneficial.

This study was conducted regionally in the north of Germany and administered only to women living primarily in villages and small towns. Women differ from men in their fall risk, injury rate and severity, and incidence of FOF.<sup>3,33,40</sup> Therefore, it is important to consider this potential bias in the interpretation of the study results.



Further studies that include older male participants as well as urban dwellers from several countries should be conducted.

## Conclusions

This study shows that a simple prevention intervention based on the autonomous use of a checklist resulted in a substantial reduction of HOHA and thus FOF in older community-dwelling women. Using this checklist, two acknowledged fall risk factors were reduced. The autonomous action competence of older people and especially those with risk factors should be considered in fall prevention programs. The identified predictors of a reduction of HOHA and FOF could help provide prevention interventions in a more focused and economical manner.

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## CONFLICT OF INTEREST

All authors have no potential conflicts of interest.

## AUTHOR CONTRIBUTIONS

All authors have read and approved the submission of this manuscript. All authors contributed to the study concept and design and the interpretation of data. Ove Schroeder initiated and led the study, conducted the lectures, and was in charge of data collection and analysis together with Julia Schroeder. Both drafted the manuscript. Open Access funding enabled and organized by Projekt DEAL.

## SPONSOR'S ROLE

None.

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## SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

**Data S1.** Checklist for Home Hazard Reduction (CHHR-1).

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