Effect of increased fear of falling on falls in patients undergoing HD: A narrative review.

Fukushima J. Med. Sci.,
Vol. 71, No. 1, 2025

[Review article]

Effect of increased fear of falling on falls in patients undergoing HD : A narrative review

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(Received May 14, 2024, accepted August 21, 2024)

Abstract

Increased fear of falling (FOF) increases the risk of falling and is an important issue for living an independent life. Patients undergoing hemodialysis (HD) frequently fall, and this may be attributed to increased FOF due to common fall risk factors as well as severe chronic kidney disease and HD-related factors. The purpose of this narrative review was to summarize the current knowledge on the mechanisms of increased FOF leading to falls in patients undergoing HD.

Patients undergoing HD have enhanced FOF compared to community elderly people. Furthermore, an increase in FOF is correlated with a decrease in physical activity and physical function. It has been reported that FOF in patients undergoing HD may be associated with past and future falls, and the risk of falling increases sharply when FOF exceeds a certain threshold. Increased FOF may serve as a fundamental mechanism leading to increased fall risk by interacting with physical inactivity and physical frailty, affecting lower limb muscle activity during walking. Further research is needed to clarify the relationship between increased FOF and falls in patients undergoing HD. Regular clinical assessment of FOF is critical for identifying fall risk in patients undergoing HD.

Key words : hemodialysis, falls, fear of falling, rehabilitation, physical activity

Introduction

It has been reported that approximately 30% of community-dwelling elderly people aged ≥ 65 years fall every year, and the frequency of falls increases with age[1)]. Falls are associated with fractures[2)], decreased quality of life[3)], and increased mortality[4)]. Fear of falling (FOF) is a psychological condition in which there is an ongoing concern about falling, including fear of not being able to perform normal activities without falling, and fear of losing balance during normal activities. It has been variously defined as a lack of self-confidence to maintain balance[5)]. Furthermore, increases in FOF are not necessarily preceded by actual falls[6)]. The consequences of increased FOF include avoidance of activities, decreased physical function, increased risk of falls, and decreased social participation, all of which are important issues for independent living[7-9)].

Patients undergoing hemodialysis (HD) are at high risk of fracture due to falls[10,11)]. This is attributed to increased bone fragility due to bone mineral metabolism disorders in such patients, as well as physical/mental and psychological factors related to frailty[12–14)]. Therefore, in addition to common fall risk factors, HD patients may have increased FOF due to severe chronic kidney disease (CKD) and HD-related factors[15)]. Because FOF is modifiable[16)], approaches to FOF may reduce fall risk. However, the mechanism by which FOF causes falls in patients undergoing HD is not clear.

The purposes of this narrative review are (1) to

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summarize the literature on FOF in patients undergoing HD, and (2) to summarize the mechanism by which increased FOF causes falls. We believe that this review enhances the understanding of the relationship between FOF and falls in patients undergoing HD, providing insights for preventing falls.

Characteristics of falls in patients undergoing HD

According to reports on falls in patients undergoing HD, the proportion of patients who had experienced at least one fall within the previous year ranged from 26.3% to 55.8%[10,11,17–27]. Of these, the proportion of patients who experienced multiple falls was 30% to 57%[10,11,18,20,23–27]. The incidence of serious falls requiring medical attention was 10.7% to 33.3%[10,11,18,25,27,28]. Fractures occurred at a rate of 1.0% to 15.7%[10,11,18,25,27,28]. Patients undergoing HD have a higher fracture risk than the general population, with men at 6.2 times the risk and women at 4.9 times the risk[29]. It has also been reported that, compared to non-fallers, fallers had a 2.13 times higher risk of death, a 3.5 times higher risk of nursing home admission, and approximately doubled rate of hospitalization and length of stay[20].

General details and research reports on FOF in patients undergoing HD

Data sources and search strategy

The literature search consisted of a thorough search of PubMed and the Cochrane Central Register of Controlled Trials (CENTRAL), with further hand searches. The following terms were used in the literature search : renal dialysis, and fear of falling.

Prevalence and enhancing factors of FOF in the general elderly population

The prevalence of FOF may increase with the experience of falls and fractures. The proportion of older adults with FOF is estimated to be 20% to 39% overall[30] and 40% to 73% in those with a history of falls[31]. Additionally, the prevalence of FOF after proximal femoral fractures ranged from 22.5% to 100%, with a tendency to decrease over time[32].

On the other hand, the increase in FOF is associated not only with a history of falls but also with factors. Chang *et al.* conducted a large-scale cross-sectional study involving 3,824 individuals to investigate the factors associated with FOF among community-dwelling older people. The results showed that the following were significantly associated with falls in the past year (odds ratio [OR] = 2.23, 95% confidence interval [95% CI] = 1.80–2.76) : age ≥ 75 years (OR : 1.52, 95% CI : 1.32–1.75) ; female gender (OR : 1.78, 95% CI : 1.55–2.05) ; needing assistance from relatives to access medical facilities (vs. self-help, OR : 1.32, 95% CI : 1.14–1.62) ; needing assistance from public resources to access medical facilities (vs. self-help, OR : 1.28, 95% CI : 1.03–1.58) ; diabetes (OR : 1.32, 95% CI : 1.09–1.62) ; cardiovascular disease (OR : 1.19, 95% CI : 1.00–1.41) ; history of stroke (OR : 1.94, 95% CI : 1.02–1.59) ; insomnia (OR : 1.50, 95% CI : 1.26–1.80) ; a Geriatric Depression Scale (GDS) score of ≥ 5 (vs. GDS score < 5, OR : 1.78, 95% CI : 1.34–2.33) ; good and fair subjective health status (vs. excellent and very good subjective health status, OR : 1.35, 95% CI : 1.13–1.62) ; and poor subjective health status (vs. excellent and very good subjective health status, OR : 2.52, 95% CI : 1.75–3.64). SF-36 score, which evaluates QOL, was significantly lower in the individuals with FOF than in those without FOF in both sexes ($p < 0.01$)[33]. Regarding the association between FOF and dementia, Uemura *et al.* conducted a prospective cohort study of 1,700 community-dwelling individuals aged ≥ 65 years without FOF at baseline. At 15-month follow-up, 452 individuals (26.5%) reported the onset of FOF. In addition, mild dementia (OR : 1.41, 95%CI : 1.07–1.87) and falls (OR : 3.00, 95%CI : 2.23–4.07) during the follow-up period were identified as independent predictors of the onset of FOF. Furthermore, the incidence of FOF was higher in individuals with both mild dementia and a history of falls compared to those without these factors (OR : 7.34 95%CI : 4.06–13.3)[34]. Regarding visual impairment, Ehrlich *et al.* conducted a questionnaire survey of 36,229 elderly people in the United States, and reported that those with visual impairment had a higher OR for FOF compared to those without (OR : 1.69, 95% CI : 1.53–1.88, $p < 0.001$)[35]. Additionally, in a systematic review investigating the association between frailty and FOF, the adjusted ORs in longitudinal studies ranged from 1.18 (95% CI : 1.02–1.36) to 9.87 (95% CI : 5.22–18.68), while the adjusted ORs in cross-sectional studies ranged from 1.04 (95% CI : 1.02–1.07) to 7.16 (95% CI : 2.34–21.89)[36]. Regarding depression, Choi *et al.* found in their longitudinal study of 6,299 older adults that those with FOF had significantly higher odds of depression compared to those without FOF (OR : 2.64, 95% CI : 1.98–3.51)[37].

Donoghue *et al.* reported an association between FOF and gait variability in a cross-sectional study of 1,307 community-dwelling elderly people. Compared to a group without FOF, a group with FOF and no activity limitations showed decreases in gait speed (β –4.18, $p < 0.01$) and stride length (β –3.41, $p < 0.01$), as well as increases in step width (β 0.55, $p < 0.01$) and double support phase (β 1.10, $p < 0.01$). In addition, even in the group with FOF but no activity limitations, decreases in walking speed (β –7.30, $p < 0.001$) and stride length (β –5.69, $p < 0.001$), as well as increases in step width (β 0.71, $p < 0.05$) and double support phase (β 1.15, $p < 0.05$) were observed[38]. Regarding physical activity, Jefferis *et al.* conducted a cross-sectional study involving 1,680 elderly men living in the community. The study revealed that men with FOF, compared to those without, took 1,766 fewer steps per day (95% CI : 1391–2142), and spent 27 minutes less in light physical activity (95% CI : 18–36), 18 minutes less in moderate to vigorous physical activity (95% CI : 13–22), and 45 minutes more in sedentary behavior (95% CI : 34–56)[39]. Regarding living space, Auais *et al.* reported a significant association between FOF and spatial mobility in a cross-sectional study involving 1,841 community-dwelling older adults (aged 65–74 years) (B : –0.15, 95%CI : –0.26 to –0.04, $p < 0.001$)[40]. Regarding anxiety and ADL limitations, Bahat Öztürk *et al.*'s cross-sectional study of 1,021 community-dwelling elderly people revealed associations between FOF and anxiety (OR : 2.8, 95% CI : 1.2–6.8, p = 0.02), as well as ADL limitations (OR : 2.6, 95% CI : 1.06–6.4, p = 0.04) [41]. Regarding physical function and pain, Tomita *et al.* conducted a cross-sectional study of 278 community-dwelling Japanese women aged ≥ 65 years. As a result, FOF was significantly associated with the following physical function measurements : increased 6-m walking time (OR : 1.99, 95%CI : 1.35–2.91), increased time to stand up from a chair (OR : 2.11, 95%CI : 1.42–3.15), decreased grip strength (OR : 1.38, 95%CI : 1.01–1.87), and increased Timed Up and Go test (TUG) (OR : 2.62, 95%CI : 1.76–3.90). In terms of pain, low back pain (OR : 2.12, 95%CI : 1.16–3.87), upper limb pain (OR : 1.93, 95%CI : 1.04–3.57), and lower limb pain (OR : 2.06, 95%CI : 1.223.49) were significantly associated with FOF[42]. The studies reporting factors related to FOF mentioned above include cross-sectional results, and large-scale longitudinal studies are needed to demonstrate a causal relationship with FOF.

FOF evaluation tool

The most commonly used FOF assessment tool is the Falls Efficacy Scale-International (FES-I)[43]. The FES-I is a scale used for quantitatively evaluating self-efficacy regarding falls and has been confirmed to have good validity and reliability. It was developed through joint research in Europe, with international use in mind. The FES-I consists of 16 items asking about concerns regarding falls in daily life, and each item is rated on a scale of 1–4 points : 1 = not concerned at all ; 2 = somewhat concerned ; 3 = quite concerned ; and 4 = very concerned. Total scores range from 16 to 64 points, with higher scores indicating lower self-efficacy for falls. Additionally, previous research has shown that the FES-I total score can be categorized into two groups for fall concerns : mild (16–22 points) and severe (23–64 points). It can also be classified into three groups : mild (16–19 points), moderate (20–27 points), and severe (28–64 points)[44]. The FES-I has been confirmed to have good validity and reliability[45].

Another commonly used assessment tool was the Modified Falls Efficacy Scale (MFES), which consists of 14 items on activities of daily living and applied activities of daily living related to falls. Each item is scored on a numerical rating scale from 0 to 10, with 0 indicating not confident, and 10 indicating completely confident. In other words, the lower the score, the stronger the FOF[46]. The overall score is calculated as the average of the scores for each of the 14 questions.

The FES-I and MFES are both questionnaire-based assessment tools available in Japanese, consisting of items related to fall-associated ADLs and Instrumental Activities of Daily Living. The main difference is that each item is scored from 0 to 4 points in the FES-I, but 0 to 10 points in the MEFS. Therefore, the FES-I can be used to roughly evaluate FOF, while the MFES may be more appropriate for a more detailed evaluation. However, there are no papers showing the translation process of either evaluation method into Japanese, and no published reports verifying their reliability, which is a cause for concern.

Research report on FOF in patients undergoing HD (Table 1)

Prevalence of FOF in patients undergoing HD

Patients undergoing HD have stronger FOF than community-dwelling older people, particularly

Table 1. Reports on fear of falling in patients undergoing HD

Author, Year, Country	Design, Setting (study period) Sample size	Age (years) Male/Female (%) HD vintage	Fear of falling evaluation	Main results
van Loon IN, et al. Arch Gerontol Geriatr. 2019[47] Netherlands	Prospective cohort study (24 months) 22 outpatient HD units n = 203 (49% HD and 51% peritoneal dialysis)	Mean 75.0 ± 7.0 Male 60.0% Female 40.0%	"Have you limited any of your activities due to fear of falling?" and "Do you leave your home less often now due to fear of falling?"	Significant association between fall history and impaired quality of life. Activity limitations due to fear of falling: 68% in fallers vs. 42% in non-fallers, $p < 0.01$. Avoidance of leaving home due to fear of falling: 59% in fallers vs. 31% in non-fallers, $p < 0.01$.
Erdoğanoğlu Y, et al. Hemodial Int. 2019[48] Turkey	Cross-sectional study 1 university hospital HD group n = 24 Control group n = 20	●HD group Mean 59.41 ± 13.35 Male 62.5% Female 37.5% 7.87 ± 6.16 years ●Control group Mean 59.45 ± 15.82 Male 40.0% Female 60.0%	FES	Significant difference in plantar foot sensation, static balance, and physical performance between patients undergoing HD and healthy controls ($p < 0.05$). Strong correlations observed in HD patients ($p < 0.05$) between: foot sensation and both static balance and physical performance; fear of falling and both static balance and physical performance; quality of life and both static balance and physical performance.
da Silva de Jesus LA, et al. Int Urol Nephrol. 2021 [44] Brazil	Cross-sectional study (15 months) 3 hospitals HD group n = 60 Control group n = 40	●HD group Mean 55.4 ± 7.6 Male 55.0% Female 45.0% 4.2 years ●Control group Mean 55.1 ± 7.5 Male 52.5% Female 47.5%	FES-I	Higher FES-I score in HD group compared to control group (28.2 ± 9.7 vs. 23.3 ± 5.1, $p = 0.020$). Higher prevalence of stronger concern about falling in HD group than control group (41.7 vs. 17.5%, $p = 0.033$). Associations between FES-I and both poor postural balance and physical component summary of quality of life by multiple linear regression (coefficient of determination 0.51, adjusted coefficient of determination 0.46).
Shirai N, et al. Ren Replace Ther. 2021[45] Japan	Cross-sectional study 1 hospital n = 46	Median 70.5 (65.0, 75.0) Male 39.1% Female 60.9% 7.5 (3.0−10.0) years	MFES	Median MFES of 9.2 (7.4, 10.0). Association of MFES with step count ($r = 0.608$, $p < 0.001$), light PA ($r = 0.421$, $p = 0.004$), and MVPA ($r = 0.546$, $p < 0.001$). Experienced at least one fall within previous one year: 39.1% (18 patients). Lower MFES in fall group than non-fall group (7.4 [5.1, 9.0] vs. 9.7 [8.5, 10.0], $p < 0.001$). Independent association of MFES with step count (B = 279.7, 95% CI = 90.5–469.0, $p = 0.005$) and MVPA (B = 3.52, 95% CI = 1.14–5.90, $p = 0.005$) by multiple regression analysis.
de Jesus LADS, et al. Ther Apher Dial. 2023[49] Brazil	Retrospective study (12 months) 2 university hospitals n = 183	Mean 58.1 ± 15.4 Male 55.2% Female 44.8% 3.0 years	FES-I	Significant association between FES-I and fall history in univariate linear regression model ($p = 0.01$). Significant association after adjustment for potential confounders (R2 = 0.19, $p < 0.001$). FES-I score with an area under the curve of 0.660 and a cutoff point of 25 (sensitivity 61.8%; specificity 62.2%).

Shirai N, et al. Phys Ther 2024[27] Japan	Prospective cohort study (12 months) 9 dialysis clinics and hospitals *n* = 253	Median 70.0 (59.0–77.0) Male 58.5% Female 41.5% 7.0 (3.0–12.0) years	FES-I	Median FES-I score of 36.0 (24.0–47.0) points. Patients with higher FES-I scores with higher frequency of falls. Independent association of FES-I with falls (OR 1.04, 95% CI 1.01–1.06, p < 0.01), but not with physical activity, following adjusted logistic regression analysis. Area under the ROC curve of 0.70 (95% CI 0.64–0.77, p < 0.001). FES-I threshold value for distinguishing fallers from non-fallers determined as 37.5 points (sensitivity 65.6%, specificity 35.0%). Non-linear relationship between falls and FES-I (p < 0.001).

HD, hemodialysis; FES-I, Falls Efficacy Scale-International; FES, Falls Efficacy Scale; MFES, Modified Falls Efficacy Scale; OR, odds ratio; CI, confidence interval

among those with a history of falls or who are at risk of future falls. da Silva de Jesus *et al.* reported that FES-I scores were higher in the patients undergoing HD compared to age- and sex-matched individuals without CKD (28.2 ± 9.7 vs. 23.3 ± 5.1, $p = 0.020$). Furthermore, the prevalence of strong FOF was higher in patients undergoing HD (41.7% vs. 17.5%, $p = 0.033$). These findings indicate that patients undergoing HD have less confidence in performing activities of daily living without falling[47]. According to Shirai *et al.*'s study, 39.1% of patients undergoing HD experienced at least one fall within the previous year, and showed lower MFES scores and stronger FOF compared to patients undergoing HD without a history of falls (falls group, 7.4 [interquartile range 5.1, 9.0] points, vs. non-falls group, 9.7 [8.5, 10.0] points, $p < 0.001$)[48]. Furthermore, Shirai *et al.* reported that as the FES-I score increased, the likelihood of future falls increased, and the falls group had higher scores than the non-falls group for all FES-I items ($p < 0.01 - p < 0.001$)[27]. These findings suggest increased FOF among patients undergoing HD and a high possibility of association between FOF and falls Furthermore, it has been reported that increased FOF in patients undergoing HD may be associated with reduced physical activity and impaired physical function (Table 1).

Relationship between FOF and physical activity in patients undergoing HD

There may be a bidirectional relationship between increased FOF and decreased physical activity in patients undergoing HD. van Loon *et al.* reported that 68% of fallers limited their activities due to FOF compared to 42% of non-fallers ($p < 0.01$). Additionally, fallers were significantly more likely than non-fallers to report leaving the house less often due to FOF (59% vs. 31%, $p < 0.01$) [49]. Furthermore, in a report by Shirai *et al.* a negative correlation was observed between FES-I and total physical activity assessed using the International Physical Activity Questionnaire short form ($r = -0.41$, $p < 0.001$)[27]. They also reported that MFES was significantly associated with the number of steps ($B = 279.738$, 95% CI = 90.478–468.998, $p = 0.005$) and physical activity of ≥ 3 Metabolic equivalents (METs) ($B = 3.521$, 95% CI = 1.142–5.901, $p = 0.005$) [48].

Relationship between FOF and physical function in patients undergoing HD

FOF in patients undergoing HD may be related to physical function. Erdoğanoğlu *et al.* reported that FOF showed a positive correlation with both static balance assessed using the single-leg standing test ($r = 0.300, p = 0.001$) and physical performance assessed using the Timed Up and Go test ($r = 0.700, p = 0.001$)[50]. In addition, Shirai *et al.* reported that there was a negative correlation between the FES-I and lower limb physical performance assessed by the Short Physical Performance Battery ($r = –0.59, p < 0.001$)[27]. da Silva de Jesus *et al.* reported that FES-I scores were independently associated with poor postural balance as assessed by the Mini-BESTest score ($B = 1.216$, CI = –2.064 to –0.368, $p = 0.006$) and physical components of QOL as assessed by the SF-36 ($B = –0.427$, CI = –0.602 to –0.251, $p < 0.001$)[47].

Relationship between FOF and falls in patients undergoing HD

FOF in patients undergoing HD may be associated with past and future falls. da Silva de Jesus *et al.* reported that FOF was associated with fall history ($B = 4.872$, CI = 1.693 to 8.051, $p = 0.003$), and the FES-I cutoff value to distinguish between fallers and non-fallers was 25 points (sensitivity 61.8%, specificity 62.2%), with an area under the ROC curve of 0.660[51]. Shirai *et al.* reported that FOF was associated with future falls (OR 1.04, 95%CI 1.01–1.06, $p = 0.003$), and the FES-I cutoff value to distinguish between fallers and non-fallers was 37.5 points (sensitivity 65.6%, specificity 35.0%), with an area under the ROC curve of 0.70 (95% CI 0.64–0.77, $p < 0.001$). In addition, a relationship was observed between falls and FES-I when the cut-off value of the ROC curve was used as the reference, and it has been confirmed that the risk of falls increases sharply when the cut-off value is exceeded[27].

Mechanism of increased FOF leading to falls in patients undergoing HD

Patients undergoing HD have more FOF-related factors than healthy people. First, as a result of advanced CKD, the accumulation of uremic substances may cause abnormalities within muscle cells, leading to muscle atrophy. Indoxyl sulfate and p-cresyl sulfate are difficult to remove by HD due to their strong protein binding and large molecular weight, leading to their accumulation in muscle cells and causing abnormalities[52,53]. Fatigue, with a prevalence ranging from 20% to 91% among non-dialysis CKD patients, may also contribute to reduced physical activity and increases as CKD progresses[54]. Diabetes is also a risk factor for CKD, and impaired balance function and muscle strength due to diabetic peripheral neuropathy, as well as vision impairment due to diabetic retinopathy, may increase the risk of falls [55,56]. Furthermore, vitamin D deficiency, which has been reported to be associated with falls and decreased physical function in the general older population[57], is frequently observed in CKD and patients undergoing HD[58]. The reduction in falls due to vitamin D administration was correlated with improvements in quadriceps muscle strength and TUG test scores[59]. Decreased TUG has also been reported as an independent factor associated with increased frequency of falls in patients undergoing HD[10]. In addition, intermittent claudication due to peripheral arterial disease (PAD), which is common in patients undergoing HD, also increases the risk of falls. It has been reported that PAD patients have an 86%-higher incidence of stumbling or unsteadiness while walking and a 73% higher incidence of falls compared to healthy controls[60]. Furthermore, PAD patients have been shown to exhibit fluctuations in the minimum vertical distance between the toes and the walking surface during the mid-swing phase of the gait cycle, which may increase the risk of falls[61].

As a result of due to dialysis-related factors have the potential to cause a decrease in blood pressure and muscle blood flow due to water removal[62], which may lead to impaired balance function. Additionally, loss of nutrients related to muscle metabolism[63,64] and decreased physical activity due to bed rest during HD[65] cause frailty, thereby exacerbating CKD. Furthermore, the presence of multiple comorbidities may also be a cause of increased FOF[66]. In addition, we now reiterate at this point that pain and depression are factors that increase FOF in the general elderly [67,68]. Among patients undergoing HD, 61% experience chronic pain, and 44% experience moderate to severe pain[69]. In addition, patients undergoing HD have a very high prevalence of depression, at 13.1% to 76.3% [70]. From the above, in patients undergoing HD, the increase in FOF caused by psychosomatic problems is not only related to common factors such as age and history of falls, but also to the severity of frailty, psychological status, comorbidities, and repeat falls. As a result, may be strongly associated with increased falls and fracture risk in patients undergoing HD.

Figure 1 shows the mechanism by which increased FOF causes falls in patients undergoing HD. Previous research has demonstrated associations of increased FOF with decreased muscle mass, strength, and physical function[71]. Additionally, ex-

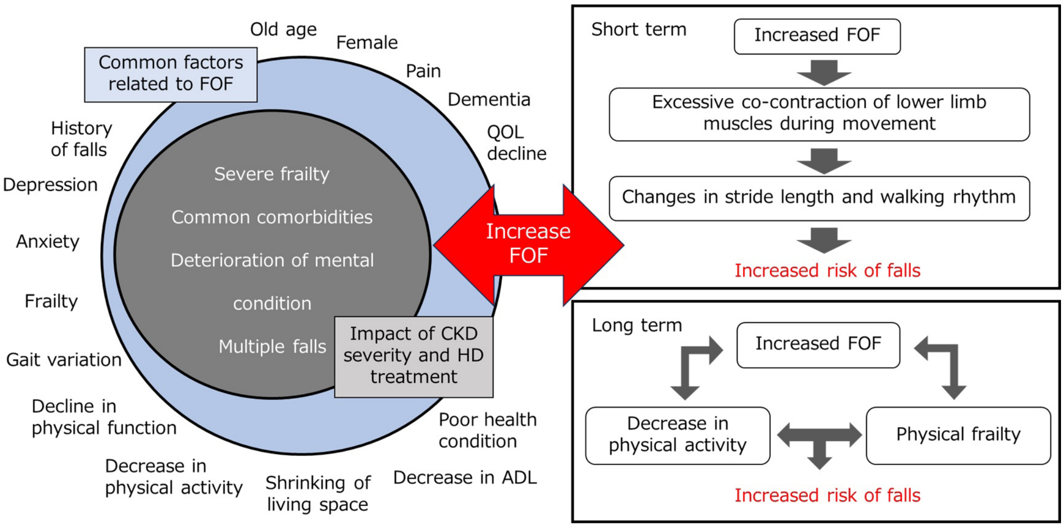

Fig. 1. Possible mechanisms of FOF causing falls in patients undergoing HD
FOF, fear of falling ; HD, hemodialysis ; CKD, chronic kidney disease ; QOL, quality of life, ADL ; Activities of Daily Living.

cessive FOF is associated with physical activity limitations, avoidance behaviors, and increased frailty[72]. Shirai *et al.* reported a moderate or higher significant correlation between FOF and both physical function and physical activity using the FES-I[27]. FOF may therefore serve as one of the fundamental mechanisms contributing to increased fall risk in the long term by interacting with reduced physical activity and physical frailty. Thus, patients with high FOF, poor physical function, and low physical activity may be at a very high risk of falls.

An increase in FOF may affect muscle activity in the lower limbs during movement. In general, co-contraction of agonist and antagonist muscles is important as a normal motor control strategy. Co-contraction is actively regulated, especially during movements such as walking, allowing stable walking by increasing joint stiffness[73]. However, excessive co-contraction reduces the performance of agonist muscles[74] and increases the amount of energy required the amount of energy required during walking, making it easier to become fatigued[75], thereby increasing the risk of falls. Additionally, it has been found that people with stronger FOF have increased co-contraction of the tibialis anterior and soleus muscles during walking compared to people with less FOF [76]. In addition, elderly people with strong FOF tend to have fluctuations in stride length and walking rhythm[77,78]. Measurements of step length variability have been shown to predict future falls, with patients with higher variability being more likely to experience falls compared to those with lower variability[79]. It has been reported that decreased walking speed and step length are also associated with fall risk in CKD and patients undergoing HD[80,81]. Therefore, increased FOF may serve as a fundamental mechanism leading to higher fall risk in the short term, due to elevated co-contraction of lower limb muscles during movement and its impact on gait. This leads to the speculation that although mild FOF may help avoid falls, the risk of falling increases when FOF exceeds the fall risk cut-off value due to re-falls as well as worsening of comorbidities and frailty[27].

Intervention to reduce FOF

Exercise therapy and cognitive behavioral therapy are effective in reducing FOF[82,83]. Common exercise therapies include tai chi, resistance training, and balance exercises, but there is no evidence of varying effects on FOF depending on the type of exercise intervention[84]. In addition, interventions that simulate walking situations encountered in daily life are likely to be effective in increasing self-efficacy against falls[85]. In Shirai *et al.*'s study, the daily step count of patients undergoing HD was 2,046 steps on non-HD days and 1,381 steps on HD days[47]. This suggests that additional exercise is needed to improve FOF and physical activity, given that the recommended step count on non-HD days is ≥ 4,000[86]. A Cochrane review on FOF and exercise interventions in community-dwelling older adults reported that FOF was reduced to a limited extent immediately post-intervention, without increasing the risk or frequency of falls. However, there is insufficient evidence to determine whether FOF is reduced long-term after exercise interventions[84]. Therefore, continuing exercise is important for reducing FOF.

In recent years, the number of facilities that offer exercise therapy during HD has increased[87], and its effectiveness in improving physical function has been demonstrated[88]. Although exercise therapy during HD is less effective than supervised exercise therapy on non-HD days, it has been shown to reduce dropout rates[89]. To maintain decreased FOF, exercise therapy during HD is recommended. However, it has been reported that lower baseline walking speed, older age, higher inflammation, and lower HD volume are determinants of dropping out of an exercise program during HD[90]. For such patients, it may be necessary to consider measures such as exercise intensity adjustment and goal setting. patients undergoing HD also have a high prevalence of depression[91]. Given that depression is associated with increased FOF in the elderly and stroke patients[92,93], addressing depression may reduce FOF in patients undergoing HD. Furthermore, poor subjective health status is strongly associated with increased FOF (OR = 6.268)[94]. Patients undergoing HD have multiple comorbidities, including HD-related complications such as decreased blood pressure and fatigue due to HD treatment[61]. Therefore, management of complications and appropriate HD treatment may also contribute to a reduction in FOF. For example, vitamin D administration may have an effect on reducing the frequency of falls : Daily supplementation of community-dwelling older adults with 800 IU of vitamin D and calcium reduced falls by 27% and 39% at 1 and 20 months, respectively, compared with calcium alone[59].

Based on the above, although exercise therapy and cognitive behavioral therapy reduce FOF, it is possible that addressing mental aspects, CKD severity, and HD-related factors may also lead to reducing FOF in patients undergoing HD. Therefore, we believe that comprehensive multi-disciplinary intervention is essential to reduce FOF and fall risk (Figure 2).

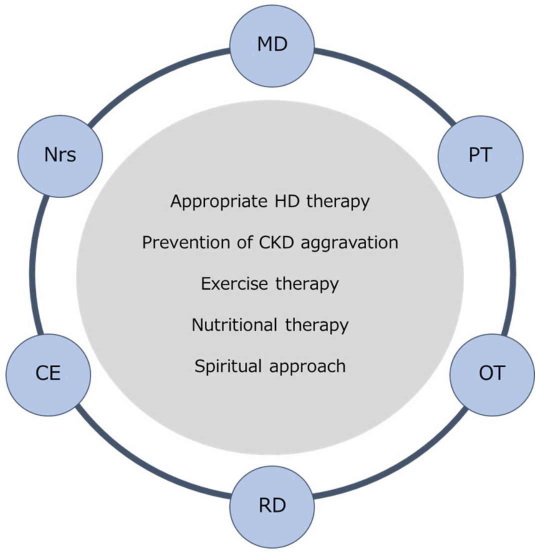

Fig. 2. A disciplinary approach to prevent falls in patients undergoing HD
MD, medical doctor ; PT, physical therapist ; OT, occupational therapist ; RD, registered dietitian ; CE, clinical engineer ; Nrs, nurse ; HD, hemodialysis ; CKD, chronic kidney disease.

Limitations of studies on FOF in patients undergoing HD

FOF in patients undergoing HD has been reported to be associated with physical function, physical activity, and falls, but the relationship between CKD and HD-related factors has not been investigated. Many studies investigating FOF in patients undergoing HD had small sample sizes, and large-scale prospective cohort studies are needed to clarify the causal relationship between FOF and physical function, physical activity, and falls. In addition, future research is needed on simple screening and reproducible methods for assessing FOF that can be easily used in daily clinical practice.

Conclusion

There have been limited studies on FOF in patients undergoing HD. Patients undergoing HD have many factors that increase FOF, increased FOF was associated with falls, physical activity level, and physical function. Regular clinical assessment of FOF is important to identify the risk of falls in patients undergoing HD. Further research is needed to elucidate the mechanisms of FOF and falls in patients undergoing HD.

Acknowledgments

The authors have no acknowledgments to make for the present study.

Funding

This research did not receive funding from public, commercial, or not-for-profit agencies.

Conflicts of interest

All authors have no conflicts of interest to declare.

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