Sleep and Falls: Prevalence of Subjective Sleep Difficulties in Community-Dwelling Older Fallers and Relationship between Sleep and Falls

Final Report for the Department of Veterans' Affairs

Dr Frances Batchelor, Dr Briony Dow, Dr David Berlowitz, Dr Melissa Russell, Ms Sue Williams, Professor Keith Hill

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National Ageing Research Institute
Institute for Breathing and Sleep

Frances Batchelor, Briony Dow, David Berlowitz, Melissa Russell, Sue Williams, Keith Hill

Project team:

- Dr Frances Batchelor (National Ageing Research Institute (NARI), project manager);
- Dr Briony Dow (National Ageing Research Institute, project manager)
- Dr David Berlowitz (Institute for Breathing and Sleep, project advisor)
- Dr Melissa Russell (University of Melbourne, project advisor);
- Ms Sue Williams (NARI, project advisor);
- Professor Keith Hill (Curtin University, project advisor);

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Abbreviations

AQoL	Assessment of Quality of Life
AMTS	Abbreviated Mental Test Score
CI	confidence interval
DVA	Department of Veterans' Affiars
ED	Emergency Department
FROP-Com	Falls Risk for Older People in the Community
IBAS	Institute for Breathing and Sleep
IQR	interquartile range
NARI	National Ageing Research Institute
RCT	Randomised controlled trial
sd	standard deviation

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Executive Summary

Background

Falls are a common problem for older people. Studies have shown a relationship between sleep and falls in older people but there is limited research evaluating the prevalence of subjective sleep difficulties in older fallers and most studies evaluating the effect of sleep quality on falls have been retrospective. As part of our staged research into sleep and falls, we aimed to address these gaps.

Aims

The aims of this project were to determine the prevalence of subjective sleep difficulties in community-dwelling older fallers, and to evaluate the relationship between subjective sleep quality and falls.

Research design

Cross-sectional and longitudinal analyses of data from a randomised controlled trial (Falls Aren't Us study) were undertaken. The original study evaluated a multi-factorial falls prevention program for community-dwelling older people presenting to an emergency department after a fall. Sleep quality was assessed using the sleep item of the Assessment of Quality of Life scale, and falls data was collected prospectively. A causal diagram was generated to establish covariates to include in the analysis.

Outcomes

Approximately 70% of this sample of community-dwelling older fallers reported interrupted sleep of varying degrees. The prevalence of subjective sleep problems was similar across Veterans, non-Veterans, males and females. Factors influencing sleep, such as sedative use, alcohol intake and nocturia were also examined. There was a high prevalence of nocturia (approximately 75%), which was similar in Veterans, non-Veterans, males and females. Self-reported sleep quality and sleep-related factors remained stable across a 12 month period, apart from sedative use which decreased.

No independent effect of sleep quality on falls rate was found; however there was a trend towards those who report waking occasionally to have a lower falls rate than those report not waking at all. This could reflect a threshold effect of sleep interruption on falls or a "survivor" bias. Sustaining a fracture at baseline modulated the effect of sleep on falls.

Conclusions and future directions

The study highlighted the complex nature of the relationship between sleep and falls. A high prevalence of sleep interruption and nocturia was found. Further research investigating the relationship between frequency of night time waking (objectively and subjectively) and falls and other outcomes is required. This necessitates the validation of home-based polysomnography in fallers and non-fallers. The information gained from these types of studies will help to develop and appropriately target sleep interventions, which we plan to evaluate in future studies.

1. Introduction

1.1. Research questions:

The primary research questions for this project were:

1. What is the quality of sleep in a sample of older fallers?
2. Does subjective sleep quality predict falls (independently or in conjunction with other factors)?

1.2. Background

Falls are a common problem for older people, with an estimated 30% of those aged 65 and over falling each year [1]. This percentage increases with age, with 40% of those aged over 80 falling each year [2], and 50% of those aged over 90 falling each year [3]. Falls can have serious consequences including injury, fear of falling, physical and functional decline, residential care admission and depression. As most World War 2 Veterans are now aged over 80, falls are an important issue to be addressed in this group.

There are many well established risk factors for falls including balance impairment, decreased strength, polypharmacy, and visual problems [4]. More recently, several studies have found an association between sleep and falls in older people [5-8]. For example, people experiencing daytime sleepiness and poor sleep efficiency (less than 70% of time in bed spent sleeping) were found to have significantly increased odds of falling compared to those without these difficulties [7, 9]. Additionally, it has been found that in older women, daytime napping is independently associated with falls risk (after adjustment for age and other co-variates) [7]. Potential mechanisms for the association between sleep disorders and falls include decreased reaction time [10], and the effect of sleep deprivation or fragmentation on postural control [11], cognitive function and motor performance [12].

Nocturia is also related to sleep and falls. Studies suggest that nocturia is the major reason for waking at night [13] and that an increased frequency of night-time toileting has negative effects on sleep and health-related quality of life [14]. Nocturia is also an established risk factor for falls [5], particularly if the frequency of toileting is three or more times per night [15].

From the literature, two particular research gaps have been identified. While studies have shown that subjective sleep difficulties are common in older people [16], there is limited research in the Australian population and no published studies reporting the prevalence of sleep difficulties in community-dwelling older fallers. Secondly, several studies have shown that sleep difficulties are associated with falls [5, 17], but the research has been limited as falls were examined retrospectively rather than prospectively and proportion of fallers rather than falls rates was used as the outcome.

This project is part of our staged research program into sleep and falls in older people and is linked to the project "Sleep and falls in older Veterans: safety, feasibility and validity of portable PSG", also submitted to the Department of Veterans' Affairs for ARP funding. The National Ageing Research Institute has formed a unique partnership with the Institute of Breathing and Sleep. This research partnership, with Department of Veterans' Affairs funding, has conducted an initial study examining the relationships between falls, falls risk and sleep [18]. This study, the first of its kind in Australia, also examined specific sleep disorders such as sleep-disordered breathing in 35 older Veterans and war widow/ers using in-laboratory polysomnography. A high rate of sleep difficulties was found, as well as a significant association between daytime sleepiness and falls risk and frequency of falls. Twenty-one (60%) of the sample were found to have severe obstructive sleep apnoea, 21 (60%) were found to have abnormal period leg movements, and the average sleep efficiency (proportion of time spent asleep compared to total time in bed) was found to be poor with only 64% of the night spent asleep. Of note was that only one participant was assessed as having "normal sleep". We also found associations between the level of falls risk, falls history and specific sleep difficulties. Participants who had two or more falls in the past 12 months reported significantly higher scores for current sleepiness than participants who had had only one fall. Furthermore, participants with higher falls risk had significantly higher underlying and daytime sleepiness.

It is hypothesised that improving sleep through a sleep optimisation intervention may prevent falls, but to test this, a randomised controlled trial would be required. Prior to this type of study, preliminary work is required to establish a causal link (if any) between sleep and falls, and to establish the prevalence of subjective sleep difficulties in fallers.

Therefore the aims of this project were to determine the prevalence of subjective sleep difficulties in a sample of community-dwelling older fallers and to evaluate the effect of sleep quality on falls.

1.3. Ethics

Ethics approval for the project was granted through the University of Melbourne Health Sciences Human Ethics Sub-committee.

2. Research design

2.1. Method and participants

This project involved a secondary analysis of existing data collected for the DVA-funded Emergency Department (ED) falls prevention study, Falls Aren't Us, conducted between 2003 and 2007. In the Falls Aren't Us study, approximately 700 people aged 60 and over who sustained a fall and presented to one of seven Melbourne EDs were recruited for a randomised controlled trial (RCT) of a multi-factorial falls prevention intervention. The details and results of this study have been reported elsewhere [19]. At baseline, participants were assessed at home after discharge from the ED. This assessment included demographic information, index fall circumstances and injuries, assessment of falls risk (Falls Risk for Older People in the Community – FROP-Com), and quality of life (Assessment of Quality of Life tool – AQoL [20]). Following this, participants were randomised to receive an intervention (multifactorial falls prevention program) or usual care

(control group). They were monitored for falls and health service use for 12 months and were reassessed after 12 months. Of relevance to the current project is the data collected at baseline and follow-up pertaining to sleep: item 13 from the AQoL relates to sleep quality. In the RCT, although this information was collected, individual items had not been entered or analysed. Therefore, these data were entered into the study database and analysed to extract information related to subjective sleep quality.

2.2. Data collection and entry

Variables of interest from the baseline assessment included age, gender, living arrangements, Veteran status, falls risk, mobility, medications (including those known to affect sleep such as sedatives), depression, alcohol intake, nocturia and sleep quality (as recorded in the AQoL). Variables of interest from the 12 month follow-up period included falls, and the same factors as those recorded in the baseline assessment.

2.3. Measurement tools and outcomes

2.3.1. Self-report of sleep quality

Self-report of quality of sleep was assessed using item 13 of the AQoL version 1 tool [20] (Figure 1). The AQoL was designed to measure health-related quality of life and covers five dimensions: illness, independent living, social relationships, physical senses and psychological wellbeing. It has been shown to be reliable and valid across a range of study populations. AQoL utility scores can be calculated for the overall scale. The utility score ranges from -0.04 – 1.00 with 0 reflecting a state equal to death, 1 equating to perfect health and -0.04 equivalent to a self-rated health state "worse than death". In this study the utility score was used to report overall quality of life.

AQoL Item 13
If I think about how I sleep:

A. I am able to sleep without difficulty most of the time.
B. My sleep is interrupted some of the time, but I am usually able to go back to sleep without difficulty
C. My sleep is interrupted most nights, but I am usually able to go back to sleep without difficulty.
D. I sleep in short bursts only. I am awake most of the night.

Figure 1 Subjective sleep quality

2.3.2. Falls outcome

The total number of falls over the follow-up period was the main outcome measure (recorded prospectively using falls diaries in the original RCT).

2.3.3. Other measures

Information on cognition, presence of back pain or arthritis, nocturia (regularly getting up at night to go to the toilet), sedative use, diuretic use and alcohol intake was all collected as part of the FROP-Com assessment [21], undertaken at baseline in the randomised trial..

2.3.4. Data analysis:

Participant characteristics were described using percentages (for categorical data), or means and standard deviations (for normally distributed continuous data), or medians and interquartile ranges (for other data). Comparisons between groups were made using independent t-tests for normally distributed data and non-parametric analyses for data that was categorical or continuous data that was not normally distributed.

Sleep quality analyses described above were conducted for the overall sample and according to Veteran status and gender. In addition, for control participants in the randomised trial (who received "usual care" through the ED and other health community services), a comparison was made between baseline and follow-up sleep quality to determine if sleep changed over the 12 month period.

To investigate if sleep disturbance was predictive of falls, associations between baseline report of quality of sleep (item 13 of the AQoL) and other potential confounding variables were investigated for participants in the control group of the original RCT using negative binomial regression analytical models, with the total number of falls over the 12 month follow-up period as the outcome measure of interest. The participants in the intervention group were excluded from the analysis as the intervention may have confounded the relationship between sleep and falls. To determine which co-variates to include in the model, a casual diagram was generated [22]. Co-variates were included if they were known to be directly associated with both sleep and falls and excluded if they were on the causal pathway. Participants with more than 100 falls were excluded from the analysis because of the potential to skew the results.

For the evaluation of the effects of baseline sleep on falls, a sensitivity analysis was done to determine whether having a fracture as a result of the index fall influenced this relationship. This was done by reanalysing the data with these cases removed.

2.3.5. Causal diagram

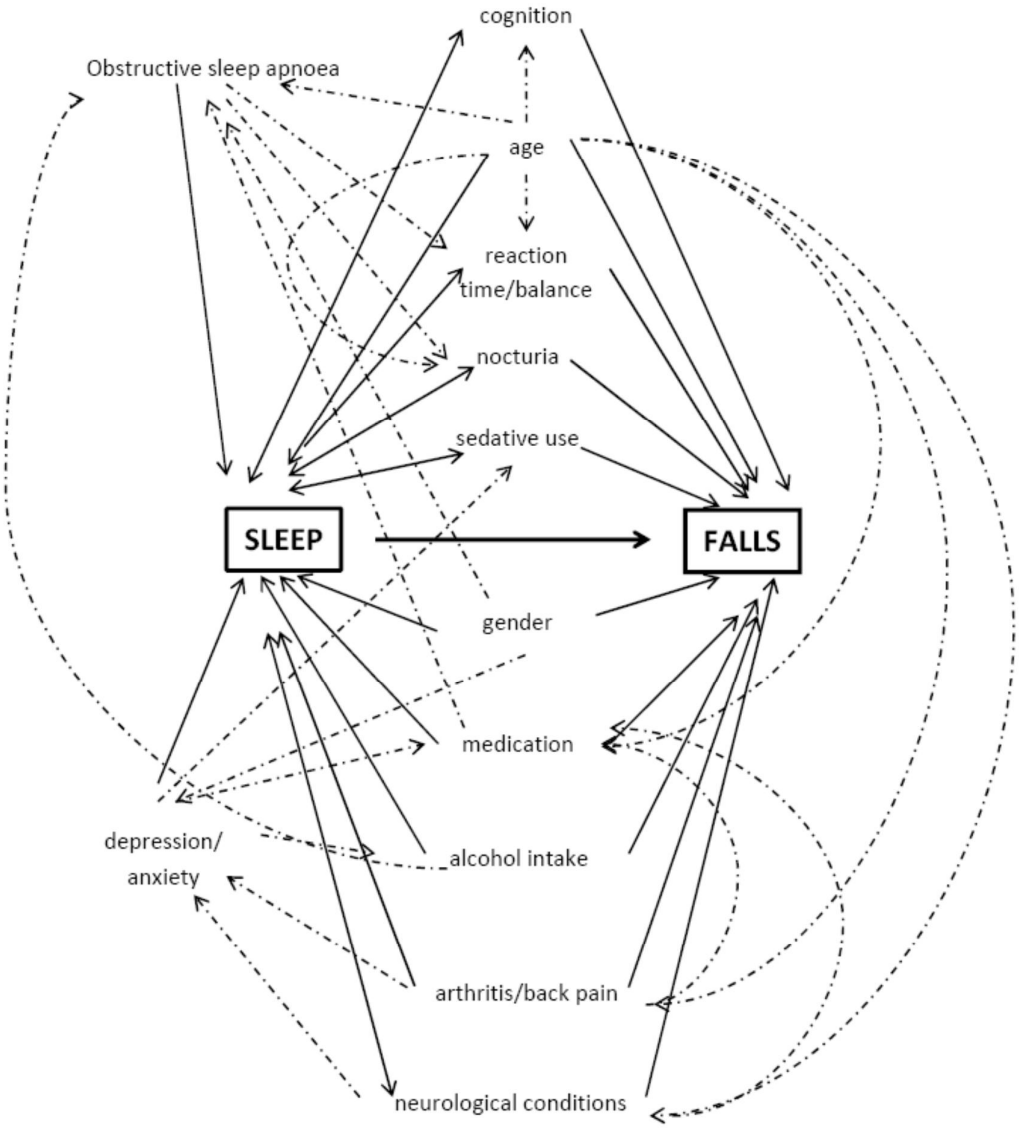

Figure 2 Relationship between sleep and falls including known covariates

3. Results

In the original RCT, 712 participants were recruited. Of those, 14 withdrew or died before completing one month of follow up, leaving 698 participants with falls outcome data available for analysis.

3.1. Baseline characteristics

3.1.1. Demographics

At baseline, the sample had a mean age of 75.3 years (sd 8.6), with the majority (n = 490, 70.2%) being female. The majority lived at home, either alone (n = 266, 38.1%) or with a spouse or carer (n = 375, 53.7%). Forty-eight per cent had fallen once in the previous year, 46% twice and 7% had fallen three or more times. On average participants had high falls risk, with a mean FROP-Com score of 19.7 (sd 6.8), which is considered to be high. For 251 (36.0%) the index fall resulted in a fracture (Table 1).

Table 1 Demographic and falls characteristics of participants at baseline, n = 698

Characteristic	Baseline
Age, mean (sd)	75.3 (8.6)
Gender, female, n (%)	490 (70.2)
AMTS < 7 (cognitively impaired), n (%)	30 (4.3)
Living arrangement, n (%)	
- Home alone	266 (38.1)
- Home with spouse/carer	375 (53.7)
- with family	51 (7.3)
- with others	6 (0.9)
Veteran status	
Veteran or war widow/er	74 (10.6)
Non-veteran	335 (48.0)
Unknown (not collected in original study)	289 (41.4)
Number of medications, mean (sd)	5.0 (3.5)
AQoL utility score, mean (sd)	0.539 (0.277)
Falls risk (FROP-Com score), mean (sd)	19.7 (6.8)

Characteristic	Baseline
Falls in 12 months prior, N (%)	
- 0 falls in past 12 months	n/a*
- 1 fall in past 12 months	336 (48.1)
- 2 falls in past 12 months	318 (45.6)
- 3 or more falls in past 12 months	44 (6.3)
Index fall resulting in fracture, n (%)	251 (36.0%)

Note: *not applicable as participants were included in the original study if they presented to ED after a fall; AMTS = Abbreviated Mental Test Score (/10); AQoL = Assessment of Quality of Life; FROP-Com = Falls Risk for Older People in the Community assessment tool (/60; higher score indicates higher falls risk).

3.1.2. Distribution of falls according to time of day

The majority of falls occurred during the day, with peaks at 10 and 11 am, and again at 2 and 3pm. At night, there was a peak in falls frequency at 11pm and again at 3am (Figure 3). However, the number of falls at these time-points was considerably lower than the number occurring during the day.

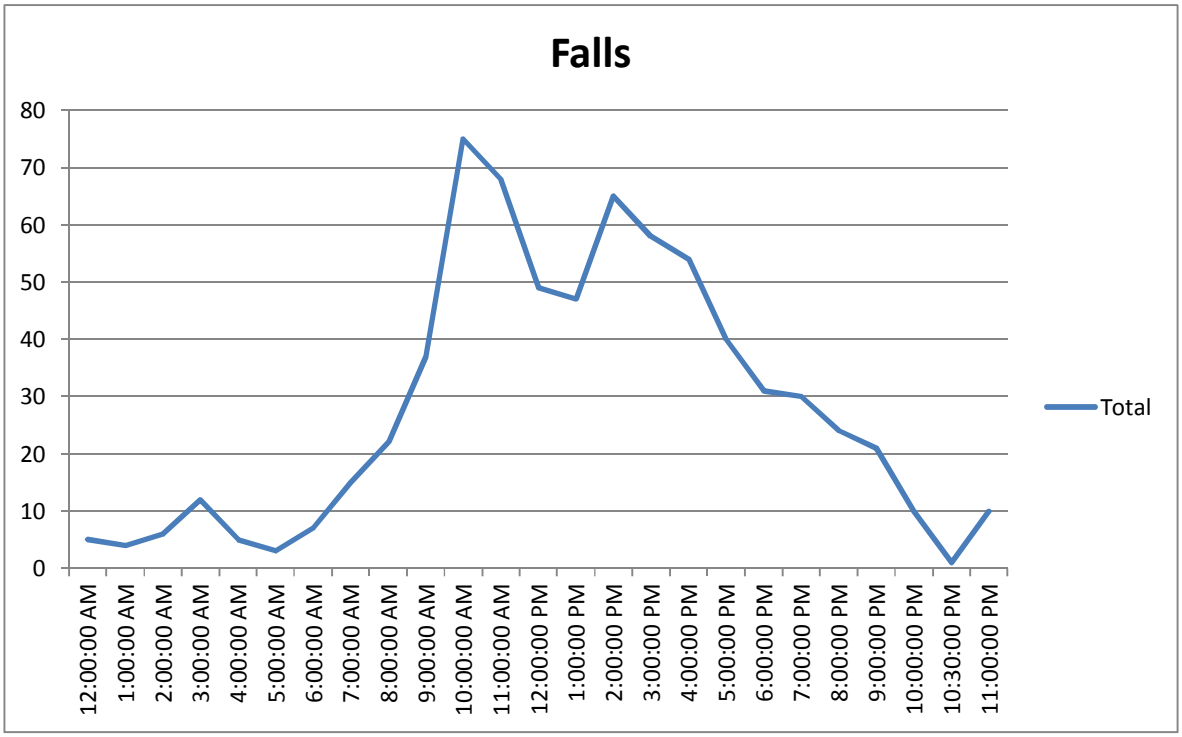

Figure 3 Distribution of falls according to time of day

3.1.3. Sleep

At baseline, nearly 70% of participants reported having sleep difficulties of varying severity. Less than one third of participants (n = 207, 29.7%) reported sleeping without difficulty most of the

time. Of the remainder, 218 (31.2%) had sleep interruption some of the time, 148 (21.2%) had sleep interruption most nights and 115 (16.5%) reported being awake most of the night (Table 2). Nearly three quarters (n = 510, 73.0%) of participants reported going to the toilet regularly at night. Sedative use was reported by 107 participants (15.3%) and diuretic use by 129 (18.5%). The majority of participants reported no or little alcohol intake (n = 529, 76.2%) (Table 2).

Table 2 Sleep and related characteristics at baseline, n = 698

Characteristic	Baseline
Sleep quality (AQoL question 13), N (%)	
Able to sleep without difficulty most of the time	207 (29.7)
Sleep is interrupted some of the time, but usually able to go back to sleep without difficulty	218 (31.2)
Sleep is interrupted most nights, but usually able to go back to sleep	148 (21.2)
Sleep in bursts only. Awake most of the night.	115 (16.5)
No response to question	10 (1.4)
Nocturia (regularly going to the toilet at night), N (%)	
Yes	510 (73.0)
No	188 (26.9)
Sedative use, N (%)	
Yes	107 (15.3)
No	590 (84.5)
Unknown	1 (0.1)
Diuretic use, N (%)	
Yes	129 (18.5)
No	568 (81.4)
Unknown	1 (0.1)
Alcohol intake, no. of drinks in previous week, N (%)	
Nil	387 (55.4)
1-3	145 (20.8)
4-10	100 (14.3)
11+	66 (9.5)

AQoL = Assessment of quality of life;

3.1.4. Demographics according to Veteran status

Information on Veteran status was available for 409 participants. This was because status information was only collected for part of the original study. Of the 409 participants, 74 (18.1%) were Veterans or war widow/ers. Those participants who were part of the Veteran community

were significantly older than non-Veterans (mean ages 82.3 and 74.8 respectively, $p < 0.05$). There was a significantly higher proportion of males in the Veteran sample compared to the non-Veteran sample (48.6% and 26.9% respectively). In terms of living arrangement, number of medications, quality of life, and falls characteristics, there was no difference between the two groups (Table 3).

Table 3 Demographic and falls characteristics of participants at baseline according to Veteran status (n = 409)

Characteristic	Veterans or war widow/ers (n = 74)	Non-veterans (n = 335)
Age, mean (sd)	82.3 (5.6)	74.8 (8.2)*
Gender, female, n (%)	38 (51.4)	245 (73.1)*
AMTS < 7 (cognitively impaired), n (%)	1 (1.4%)	16 (4.8%)
Living arrangement, n (%)		
- Home alone	33 (44.6)	137 (40.9)
- Home with spouse/carer	38 (51.4)	180 (53.7)
- with family	3 (4.1)	15 (4.5)
- with others	0 (0)	3 (0.9)
Number of medications, mean (sd)	5.4 (3.4)	5.1 (3.4)
AQoL utility score, mean (sd)	0.586 (0.270)	0.532 (0.271)
Falls risk (FROP-Com score), mean (sd)	19.5 (6.5)	19.9 (6.6)
Falls in 12 months prior, N (%)		
- 0 falls in past 12 months	n/a*	n/a*
- 1 fall in past 12 months	39 (52.7)	146 (43.6)
- 2 falls in past 12 months	30 (40.5)	167 (49.9)
- 3 or more falls in past 12 months	5 (6.8)	22 (6.6)
Index fall resulting in fracture, n (%)	23 (31.1)	124 (37.0)

AQoL = Assessment of quality of life; AMTS = Abbreviated Mental Test Score; FROP-Com = Falls Risk in Older People – Community; *significant difference between Veteran/non-Veteran groups at $p < 0.05$ using unpaired t-test for normally distributed variables and chi^2 analysis for categorical variables;

3.1.5. Sleep according to Veteran status

Sleep quality in the Veteran sample was similar to the overall sample as described in section 3.1.2 above. There were no significant differences in sleep between Veterans and non-Veterans and there were no significant differences in nocturia, sedative use or diuretic use. However, there was a significant difference in alcohol intake between Veterans and non-Veterans (Table 4).

Table 4 Sleep and related characteristics according to Veteran status (n = 409)

Characteristic	Veterans or war widower/s (n = 74)	Non-Veterans (n = 335)
Sleep quality (AQoL question 13), N (%)		
Able to sleep without difficulty most of the time	19 (25.7)	102 (30.8)
Sleep is interrupted some of the time, but usually able to go back to sleep without difficulty	23 (31.1)	118 (35.6)
Sleep is interrupted most nights, but usually able to go back to sleep	19 (25.7)	66 (19.9)
Sleep in bursts only. Awake most of the night.	13 (17.6)	45 (13.6)
No response to question	0	4
Nocturia (regularly going to the toilet at night), N (%)		
Yes	52 (70.3)	237 (70.7)
No	22 (29.7)	98 (29.3)
Sedative use, N (%)		
Yes	12 (16.2)	41 (12.2)
No	62 (83.8)	294 (87.8)
Diuretic use, N (%)		
Yes	15 (20.3)	69 (20.6)
No	59 (79.7)	266 (79.4)
Alcohol intake, no. of drinks in previous week, N (%)		
Nil	32 (43.2)	187 (55.8)*
1-3	22 (29.7)	66 (19.7)
4-10	17 (23.0)	53 (15.8)
11+	3 (4.1)	29 (8.7)

AQoL = Assessment of quality of life; *significant difference between Veterans and non-Veterans at $p < 0.05$.

3.1.6. Demographics according to gender

On average, males were significantly older than females and were more likely to live with a spouse or carer. For female participants, the index fall was significantly more likely to have resulted in fracture. For all other demographic characteristics, there was no significant difference between male and female participants (Table 5).

Table 5 Demographic characteristics according to gender, n = 698

Characteristic	Female N = 490	Male N = 208
Age, mean (sd)	74.6 (8.4)	77.0 (8.9)*
AMTS < 7 (cognitively impaired), n (%)	26 (5.3)	4 (2.0)
Living arrangement, n (%)		
- Home alone	213 (43.5)	53 (25.5)*
- Home with spouse/carer	232 (47.3)	143 (68.8)
- with family	39 (8.0)	12 (5.8)
- with others	6 (1.2)	0 (0)
Number of medications, mean (sd)	5.0 (3.4)	5.0 (3.6)
AQoL utility score, mean (sd)	0.532 (0.272)	0.555 (0.288)
Falls risk (FROP-Com score), mean (sd)	19.8 (6.7)	19.5 (7.1)
Falls in 12 months prior, N (%)		
- 0 falls in past 12 months	n/a	n/a
- 1 fall in past 12 months	235 (48.0)	101 (48.6)
- 2 falls in past 12 months	223 (45.5)	95 (45.7)
- 3 or more falls in past 12 months	32 (6.5)	12 (5.8)
Index fall resulting in fracture, n (%)	204 (41.6)	47 (22.6)*

*significant difference between male and female participants at $p < 0.05$;

3.1.7. Sleep according to gender

There was no significant difference in sleep quality or nocturia between male and female participants. Although sedative use and diuretic use were more prevalent in women than men, these differences were not significant. However, there was a significant difference between males and females in self-reported alcohol intake, with males drinking more (Table 6).

Table 6 Sleep and related characteristics according to gender, n = 698

Characteristic	Female (n = 490)	Male (n = 208)
Sleep quality (AQoL question 13), N (%)		
Able to sleep without difficulty most of the time	145 (30.0)	62 (30.2)
Sleep is interrupted some of the time, but usually able to go back to sleep without difficulty	157 (32.5)	61 (29.8)
Sleep is interrupted most nights, but usually able to go back to sleep	95 (19.7)	53 (25.9)
Sleep in bursts only. Awake most of the night.	86 (17.8)	29 (14.1)
Nocturia (regularly going to the toilet at night), N (%)		
Yes	360 (73.5)	150 (72.1)
No	130 (26.5)	58 (27.9)
Sedative use, N (%)		
Yes	81 (16.5)	26 (12.5)
No	409 (83.5)	182 (87.5)
Diuretic use, N (%)		
Yes	95 (19.4)	34 (16.3)
No	395 (80.6	174 (83.7)
Alcohol intake, no. of drinks in previous week, N (%)		
Nil	305 (62.2)	82 (39.4)*
1-3	102 (20.8)	43 (20.7)
4-10	58 (11.8)	42 (20.2)
11+	25 (5.1)	41 (19.7)

*significant difference between males and females at $p < 0.05$;

3.1.8. Change in sleep-and related variables between baseline and follow-up

Three hundred and twelve participants were included in this analysis, consisting of only the control participants from the original RCT who completed the follow-up (see section 2.3.4 above). At follow-up more participants reported sleeping with interruption most of the time (37.2% compared with 31.7%) but this difference was not statistically significant. There was a significant change in prevalence of sedative use between baseline and follow-up (11.2% at follow up compared with 14.7% at baseline) but there was no significant change in nocturia, diuretic use or alcohol intake (Table 7).

Table 7 Baseline and follow-up change in sleep variables (control participants only), n = 312

Characteristic	Baseline	Follow-up
Sleep quality (AQoL question 13), N (%)		
Able to sleep without difficulty most of the time	99 (31.7)	116 (37.2)
Sleep is interrupted some of the time, but usually able to go back to sleep without difficulty	102 (32.7)	70 (22.4)
Sleep is interrupted most nights, but usually able to go back to sleep	65 (20.8)	64 (20.5)
Sleep in bursts only. Awake most of the night.	44 (14.1)	56 (17.9)
No response	2 (0.6)	6 (1.9)
Nocturia (regularly going to the toilet at night), N (%)		
Yes	227 (72.8)	224 (71.8)
No	85 (27.2)	88 (28.2)
Sedative use, N (%)		
Yes	46 (14.7)	35 (11.2)*
No	265 (84.9)	277 (88.8)
Missing	1 (0.3)	
Diuretic use, N (%)		
Yes	56 (17.9)	53 (17.0)
No	255 (81.7)	258 (82.7)
Missing	1 (0.3)	1 (0.3)

Characteristic	Baseline	Follow-up
Alcohol intake, no. of drinks in previous week, N (%)		
Nil	173 (55.4)	180 (57.7)
1-3	72 (23.1)	56 (17.9)
4-10	42 (13.5)	47 (15.1)
11+	25 (8.0)	29 (9.3)

*Significant difference between baseline and follow-up at p<0.05

3.2. Relationship between baseline sleep and falls.

Three hundred and forty-eight participants were included in the full analysis. The covariates included in the adjusted negative binomial regression models were, age, gender, cognition, nocturia, sedative use, presence of arthritis or back pain, and alcohol intake. The incidence rate ratios (IRR), 95% confidence intervals of the IRR and p-values are presented below (Table 8).

In the unadjusted model, baseline sleep quality as assessed by the AQoL was not related to the outcome of falls rate, although the difference in rate of falls in those reporting waking occasionally (AQoL category B) compared those not waking at night (AQoL Category A) approached significance (IRR 0.61, 95%CI 0.37-1.02, p = 0.06) (Table 8).

When all the covariates in the model were included, only gender and presence of back pain or arthritis were significantly associated with total falls (Table 9).

Two hundred and twenty-two participants were included in the sensitivity analysis (participants with index fall resulting in fracture excluded). In the unadjusted model, the rate of falls was significantly lower for those waking occasionally (AQoL category B) compared to those not reporting waking (AQoL category A) with an estimated incidence rate ratio of 0.52 (95% CI 0.29 – 0.94, p = 0.03) (Table 8). However, when all the covariates were included in the model, this difference, although close, no longer reached significance (IRR 0.55, 95%CI 0.30 – 1.01, p = 0.05) (Table 9).

Table 8 Incidence rate ratios for the effect of sleep on falls (unadjusted)

	All control participants, n = 348			Participants with index fracture excluded, n = 222		
Variable	Incidence rate ratio	95% CI of the incidence rate ratio	p-value	Incidence rate ratio	95% CI of the incidence rate ratio	p-value
A AQoL 1 (reference category)	1.0			1.0		
B AQoL 2	0.61	0.37 – 1.02	0.06	0.52	0.29 – 0.94	0.03*
C AQoL 3	0.98	0.56 – 1.74	0.96	1.09	0.56 – 2.14	0.81
D AQoL 4	1.38	0.73 – 2.6	0.32	1.54	0.74 – 3.20	0.24

*significant at $p < 0.05$

Table 9 Incidence rate ratios for the effect of sleep on falls with covariates

	All control participants, n = 348			Participants with index fracture excluded, n = 222		
Variable	Incidence rate ratio	95% CI of the incidence rate ratio	p-value	Incidence rate ratio	95% CI of the incidence rate ratio	p-value
Sleep						
AQoL 1 (ref category)	1			1		
AQoL 2	0.67	0.40 – 1.12	0.13	0.55	0.30 – 1.01	0.05
AQoL 3	1.13	0.62 – 2.05	0.69	1.21	0.60 – 2.44	0.60
AQoL 4	1.07	0.54 – 2.14	0.85	1.11	0.49 – 2.47	0.81
Age	1.01	0.98 – 1.03	0.52	0.99	0.96 – 1.02	0.46
Gender (female ref)	1.69	1.06 – 2.69	0.03*	1.55	0.90 – 2.65	0.11
Cognitive status (AMTS > 7 ref)	1.29	0.46 – 3.62	0.62	1.49	0.44 – 5.03	0.53
Alcohol intake in prev week						
0 (ref)	1			1		
1-3 drinks	0.77	0.45 – 1.34	0.36	1.06	0.56 – 2.01	0.87
4-10 drinks	0.78	0.40 – 1.50	0.46	0.80	0.37 – 1.74	0.58
11 +	1.14	0.52 – 2.47	0.75	1.34	0.55 – 3.29	0.52
Presence of back pain or arthritis	1.91	1.21 – 3.02	< 0.01*	2.32	1.29 – 4.17	< 0.01*
Presence of nocturia	0.89	0.54 – 1.46	0.63	1.02	0.55 – 1.90	0.95
Sedative use	1.48	0.82 – 2.67	0.19	1.31	0.67 – 2.57	0.43

*significant at $p < 0.05$

4. Discussion

The results of this study provide valuable information regarding sleep quality in older people and the relationship between sleep and falls, which can be used to guide further research and improve quality of life for older people.

Overall, a high proportion of the sample reported sleep difficulties. At baseline approximately 70% of participants in this study reported regular interruptions to their sleep of varying frequency. There was no change in sleep quality after 12 months, with this stability confirming the high prevalence of sleep difficulties in this sample of community-dwelling older fallers. However, because of the lack of established norms in older people, it is still unclear as to what constitutes "normal" sleep, that is, whether waking once per night can be considered normal.

Waking at night to go to the toilet is known to affect quality of life and in this study we found a concerning level of nocturia. The proportion of people reporting getting up to the toilet regularly at night was approximately 75%, which is considerably higher than the prevalence rate of 30% reported in one study [14] but comparable to the 70% reported in another study [13]. A peak in frequency of night-time falls at 3am was seen, and it is probable that this corresponds to episodes of nocturia. There was no difference in levels of nocturia at baseline and 12 months later. This warrants further investigation, particularly because of the impact on quality of life and on the potential for falls.

Sleep quality and other sleep-related variables were no different in Veterans compared to non-Veterans. It can be assumed, therefore, that future research investigating the relationship between sleep and falls undertaken in the general older population will also be applicable and clinically relevant to the Veteran community. In addition, there was no difference in sleep quality between males and females. This contrasts with studies showing that self-reported sleep is worse in females than males [23]

The prevalence of sedative use of approximately 14% at baseline and 10% after 12 months is consistent with prevalence estimates from several years ago, but less than the current estimates of approximately 25% [24, 25]. This may reflect the knowledge of emergency department medical staff (at the time of recruitment into the original RCT) on the relationship between sedative use and falls in this high falls risk group. There was no differences in sedative use between Veteran and non-Veteran participants, and no significant difference between males and females, although the prevalence was higher in females than males, consistent with previous studies [23].

In this sample, no independent relationship between sleep quality and falls rate was found both for the unadjusted model and after adjustment for covariates known to influence both sleep and falls. However, in the unadjusted model there was a trend for those who report waking occasionally to have a lower falls rate than those not waking at all (IRR 0.61, 95%CI 0.37 – 1.02, p = 0.06). It appears that the influence of injury severity at the time of the index fall modulates the strength of this relationship, although the same pattern is seen. In those who did not experience a fracture at the time of original fall, there was a significantly lower rate of falls in those waking

occasionally compared to those not waking at all (IRR 0.52 95%CI 0.29 – 0.94, p = 0.03), with the trend continuing after adjustment, although no longer significant (IRR 0.55, 95%CI 0.30 – 1.01, p = 0.05). Possible explanations for this include the concept of survivor bias, in which those with worse sleep have better outcomes, or might relate to the use of sedatives, that is, those taking sedatives may sleep well but have an increased risk for falls during the day due to the effect of the medication on balance. As mentioned above, it is unclear whether waking occasionally can be considered normal in this age group; however, the pattern of a decreased falls rate in people waking occasionally compared to not waking lends support to the concept that this may be protective. This warrants further investigation, particularly using both objective and subjective measures of sleep quality.

This study reinforces the complex nature of the relationship between sleep and falls. While no completely independent effects of sleep quality on falls rate was found, it was observed that factors such as presence of back pain or arthritis do influence the relationship. In particular, the relationship was strengthened when people sustaining a fracture at baseline were excluded from the analysis.

This study provides guidance for the assessment of people presenting with falls. Sleep quality and other sleep-related factors such as sedative use and alcohol intake should be routinely assessed and appropriate management implemented. Health professionals also need to consider nocturia and address this if specific causes are found that are remediable.

5. Future directions

Our recommendations for future directions include:

- Establishing the validity and reliability of portable polysomonography in community-dwelling older people, both for fallers and non-fallers.
- Further investigation of the "threshold" or survivor effect of waking at night using objective as well as subjective sleep data, with the effects considered on a range of outcomes, including falls, quality of life and function.
- Investigation of the effect of a sleep intervention on falls, using a randomised trial design
- Further investigation of the prevalence and correlates of nocturia in older people, particularly older fallers.

6. Dissemination plan

- Dissemination of results to clinicians, including recommendations on including assessment and management of sleep for people presenting with falls and as part of falls prevention.
- Provision of information to health professionals regarding the high prevalence of nocturia in older fallers and recommendations that nocturia should be assessed and managed as part of falls prevention
- Presentation of findings to the Department of Veterans' Affairs through the research seminar program
- Presentation of findings through national and international conferences and seminars
- Publication of results in peer-reviewed journal

7. References

1. Rubenstein, L.Z., *Falls in older people: epidemiology, risk factors and strategies for prevention.* Age & Ageing, 2006. **35**(suppl 2): p. ii37-41.

2. Lord, S.R., et al., *Postural stability, falls and fractures in the elderly: results from the Dubbo Osteoporosis Epidemiology Study.* Medical Journal of Australia, 1994. **160**(11): p. 684-685, 688-691.

3. Campbell, A.J., et al., *Falls in old age: a study of frequency and related clinical factors.* Age & Ageing, 1981. **10**(4): p. 264-270.

4. Lord, S.R., et al., *Falls in older people*. 2nd ed. 2007, New York: Cambridge University Press.

5. Teo, J.S., et al., *Do sleep problems or urinary incontinence predict falls in elderly women?* Australian Journal of Physiotherapy, 2006. **52**(1): p. 19 -24.

6. Stone, K.L., et al., *Actigraphy-measured sleep characteristics and risk of falls in older women.* Archives of Internal Medicine, 2008. **168**(16): p. 1768-1775.

7. Stone, K.L., et al., *Self-reported sleep and nap habits and risk of falls and fractures in older women: the study of osteoporotic fractures.* Journal of the American Geriatrics Society, 2006. **54**(8): p. 1177-83.

8. St George, R., et al., *Sleep Quality and Falls in Older People Living in Self- and Assisted-Care Villages.* Gerontology, 2009. **55**(2): p. 162-168.

9. Stone, K.L., et al., *Actigraphy-Measured Sleep Characteristics and Risk of Falls in Older Women.* Arch Intern Med, 2008. **168**(16): p. 1768-1775.

10. Ayalon, L., S. Ancoli-Israel, and S. Drummond, *Obstructive sleep apnea and age: a double-insult to brain function?* American Journal of Respiratory and Critical Care Medicine, 2010.

11. Robillard, R., et al., *Aging worsens the effects of sleep deprivation on postural control.* PLoS ONE, 2011. **6**(12): p. e28731.

12. Schlesinger, A., et al., *Postural control, attention and sleep deprivation.* Neuroreport, 1998. **9**(1): p. 49-52.

13. Bing, M.H., et al., *Prevalence and bother of nocturia, and causes of sleep interruption in a Danish population of men and women aged 60-80 years.* BJU International, 2006. **98**: p. 599-604.

14. Coyne, K.S., et al., *The prevalence of nocturia and its effect on health-related quality of life and sleep in a community sample in the USA.* BJU International, 2003. **92**: p. 948-954.

15. Stewart, R.B., et al., *Nocturia: a risk factor for falls in the elderly.* Journal of the American Geriatrics Society, 1992. **40**(12): p. 1217-20.

16. Crowley, K., *Sleep and sleep disorders in older adults.* Neuropsychological Reviews, 2011. **21**: p. 41-53.

17. Brassington, G., A. King, and D. Bliwise, *Sleep problems as a risk factor for falls in a sample of community-dwelling adults aged 64-99 years.* Journal of the American Geriatrics Society 2000. **48**(10): p. 1234-1240.

18. Dow, B., et al., *Falls and disturbed sleep patterns in older people: a pilot study. Report to the Department of Veterans' Affairs*. 2010, National Ageing Research Insititute.

19. Russell, M.A., et al., *A randomized controlled trial of a multifactorial falls prevention intervention for older fallers presenting to emergency departments.* Journal of the American Geriatrics Society, 2010. **58**(12): p. 2265-2274.

20. Hawthorne, G., J. Richardson, and R. Osborne, *The Assessment of Quality of Life (AQoL) instrument: a psychometric measure of health related quality of life.* Quality of Life Research, 1999. **8**: p. 209-224.

21. Russell, M.A., et al., *The reliability and predictive accuracy of the falls risk for older people in the community assessment (FROP-Com) tool.* Age and Ageing, 2008. **37**(6): p. 634-639.

22. Hernán, M.A., et al., *Causal knowledge as a prerequisite for confounding evaluation: an application to birth defects epidemiology.* American Journal of Epidemiology, 2002. **155**(2): p. 176-184.

23. Middelkoop, H.A.M., et al., *Subjective sleep characteristics of 1,485 males and females aged 50-93: effects of sex and age, and factors related to self-evaluated quality of sleep.* The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 1996. **51A**(3): p. M108-M115.

24. Landreat, M.G., et al., *Can we say that seniors are addicted to benzodiazepines?* Substance Use and Misuse, 2010. **45**(12): p. 1988-1999.

25. Voyer, P., et al., *The prevalence of benzodiazepine dependence among community-dwelling older adult users in Quebec according to typical and atypical criteria.* Canadian Journal on Aging, 2010. **29**(2): p. 205-213.

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