National Ageing Research Institute
and
The Institute for Breathing and Sleep

Falls and disturbed sleep patterns in older people: a pilot study

Final Report September 2010

for the

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Acknowledgments

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Introduction

Falls are a common problem for older people, with an estimated 30% of those aged 65 and over falling each year. This percentage increases with age, with 40% of those aged 80 and over falling each year. Most World War 2 veterans are now aged 80+ therefore falls are an important issue to be addressed in this group. Falls and associated falls injuries can result in numerous other problems for older people, such as physical and functional decline, residential care admission, fear of falling and depression.

Sleep difficulties are common but under diagnosed in older people, and often wrongly attributed to be an inevitable part of ageing. Recently, the problem of sleep difficulties in older people has been proposed as a risk factor for falls.

The National Ageing Research Institute (NARI) and the Institute for Breathing and Sleep (IBAS) were funded by the Department of Veterans' Affairs to conduct a research study. The aim of the study was to undertake a preliminary investigation of whether specific sleep difficulties were associated with history of falls and risk of falling in older people.

Research questions

The primary research questions investigated in this pilot study were:

1. What is the frequency of specific sleep difficulties (e.g. sleep apnoea) in an older (70+) population of fallers?
2. Is there an association between specific sleep difficulties and history of falls and level of falls risk in older fallers?
3. What is the feasibility of undertaking a larger study investigating the association between sleep difficulties and falls?

Background

Falls in older people

Falls are a common problem for older people with an estimated 30% of those aged 65 years and over falling each year [1-5]. This percentage increases with age, with 40% of those aged 80 and over falling each year [6]. It is not only older people's high rate of falling that makes falling such a serious issue. Medical conditions associated with ageing such as osteoporosis and other age related declines such as decreased strength and decreased reaction time may result in much more serious falls sequelae for an older person than a younger person. Falls are the leading cause of both fatal and non-fatal injury in those aged 65 years and over, accounting for 63% of all non-fatal injuries [7]. Falls and associated falls injuries can result in numerous other serious consequences for older people such as physical and functional decline, residential care admission, fear of falling and depression. In a time trade off study 80% of older women surveyed said they would rather die outright in a fall than need nursing home admission due to the functional decline associated with a hip fracture [8]. Much research has been conducted investigating methods to prevent falls. Some of these interventions have been found to be effective, however results are mixed and falls remain a problem for many older people [9-11].

Sleep difficulties and ageing

Sleep difficulties are common in older people yet they are under-diagnosed and often wrongly thought to be an inevitable part of ageing [12]. It has been found that, contrary to commonly held beliefs, sleep-related disorders prevalent in the older adult populations are due to medical and psychological conditions and not ageing alone [13, 14]. Hence it is important that poor sleep quality and the potential causes be addressed in an older population.

In contrast, the changes that occur in sleep quality from the age of 19 to 60 are generally ascribed to being a normal part of ageing [13]. It has been found that in groups of healthy older people from the age of 60 to mid-90's the percentage of slow wave sleep remains relatively constant, though sleep efficiency (the amount of sleep relative to the amount of time spent in bed) decreases [12]. Assuming an individual is in good health, further age-dependent sleep changes after the age of 60 are modest [15].

Common sleep difficulties that older people experience are difficulty initiating sleep, disrupted sleep, early morning awakening, shallow and fragmented sleep, increased nocturnal awakenings, reductions in slow wave stage 3 and 4 sleep, less rapid eye movement (REM) sleep, needing to nap, not feeling rested and sleep disordered breathing such as sleep apnoea

[12, 13, 16, 17]. Forty- two percent (42%) of a sample of 10,430 older Australian women reported 'waking in the early hours', 26% reported 'taking a long time to get to sleep', 21% reported 'sleeping badly at night', 11% reported 'lying awake most of the night' and 11% reported 'worry keeping you awake' [18].

Difficulty initiating or maintaining sleep are older adults' most common sleep related concerns [12]. In the US based study, Established Population for Epidemiologic Studies of the Elderly (EPESE) involving 9,282 community dwelling people over the age of 65, 43% of adults reported insomnia symptoms characterized by difficulties in sleep onset or maintenance [17]. The repeated and frequent interruption of sleep by long periods of wakefulness is one of the changes in sleep patterns in older people [13].

There are many factors that may contribute to sleep difficulties. Some factors that may result in nocturnal awakenings in older people include age-dependent lightening of sleep, homeostatic processes, chronobiologic changes (changes to the sleep/wake cycle), higher susceptibility to arousal from sources such as noise and light, awakenings from primary medical conditions such as osteoarthritis and gastroesophageal reflux, and specific sleep disorders such as sleep apnoea [19]. Other common contributors to sleep disturbances are pain, persistent thoughts and the need to urinate [20]. Other issues like periodic leg movements and restless leg syndrome may influence sleep in older adults [21]. Restless leg syndrome is a sleep disorder of unpleasant leg sensations that disrupt sleep [13]. Periodic limb movement (PLM) is repeated rhythmical extension of a big toe and dorsiflexion of the ankle with occasional flexion of the knee and hip [13]. A study of 2365 patients referred to a sleep laboratory in Brazil found statistically significant increases in PLM for patients over 50 compared with younger groups [22].

Physical activity can play a role in quality of sleep for older people. A sedentary lifestyle can be associated with sleep problems. People who exercise less than once per week are more likely to report a sleep problem [23]. Some studies report that walking, Tai Chi, acupressure and weight training improve sleep for some individuals [13].

Nocturia is another potential cause of sleep disturbance amongst older adults. However, it may be overlooked as a cause of sleep disturbance due to its commonplace occurrence [19]. The prevalence of nocturia increases with age. A US phone survey of 1,424 older people found that those with nocturia "every night or almost every night" were more likely to define themselves as having insomnia than those without nocturia [19].

Sleep disturbance in older adults can be an indicator of overall health status [14]. There is a strong bidirectional relationship between sleep disorders and serious medical problems in older people. Hypertension, depression, heart disease, cerebrovascular disease, bodily pain and memory problems have been associated with the more prevalent symptoms of insomnia. Conditions such as obesity, arthritis, diabetes, lung disease, stroke, osteoporosis, pain and social isolation have been associated with other sleep related problems including breathing pauses, snoring, daytime sleepiness, restless legs or insufficient sleep (less than 6 hours per night) [23]. Conversely, individuals with such diseases and problems are at a higher than normal risk of developing sleep problems [23]. Reid et al. (2006) found that older patients with poor health have a very high risk of poor sleep quality [14]. A recent publication has therefore recommended that sleep problems in older adults be approached as a "multifactorial geriatric syndrome" [24].

Although not all night-time sleep problems carry over into detectable abnormal daytime sleepiness [25], an impact of disturbed nocturnal sleep can be napping and daytime sleepiness. An increased incidence of napping or falling asleep during the day can accompany changes in nocturnal sleep [13]. Excessive daytime sleepiness can also be used a predictor of poor mental and physical health-related quality of life [14]. Health care professionals specializing in geriatrics need to learn to recognise the different causes of sleep disturbances, yet primary care professionals do not routinely ask questions regarding sleep difficulties in their older patients [14]. Reid et al. (2006) suggested that asking "do you feel excessively sleepy during the day" could be reasonably predictive of poor mental and physical health-related quality of life.

There are various pharmacological and non-pharmacological treatments for sleep disturbances in older adults. A thorough assessment is recommended in the first instance to identify and treat any underlying health problems that may be causing sleep disturbance [26]. Benzodiazepines and other sedatives may be of limited benefit in an older population as they have modest impact on sleep quality and are also associated with adverse cognitive and motor function and increased day time sleepiness as well as increased risk of falls [27]. Non-pharmacological approaches, such as improved sleep hygiene [28] adhering to a daily routine [29], bright light therapy [30], music [31]and yoga [32] have been found to be effective for some groups of older people. For more specific sleep difficulties, such as sleep apnoea, weight reduction and proper sleep positioning may be beneficial and, when used regularly, CPAP machines can be very effective in reducing daytime fatigue and the sequelae of untreated obstructive sleep apnoea in older people [26].

A recent report of a literature review on sleep in residential aged care conducted at the National Ageing Research Institute [33] found that interventions that appear to be beneficial in improving sleep for residents in aged care included light therapy, exercise, melatonin treatment and multifactorial interventions. It called for further research into the safety and efficacy of interventions such as cognitive behavioural therapy, melatonin, music therapy, aromatherapy and acupuncture as these interventions had demonstrated promise in community settings. The report cautioned against the use of medications as a substitute for addressing the underlying causes of sleep disturbance. It concluded that there are a number of strategies that show promise but none have been sufficiently and successfully tested with older adults in residential care to enable care guidelines to be developed.

Sleep difficulties and physical function and falls

Recently the problem of sleep difficulties in older people has been proposed as a risk factor for falls. There are many possible mechanisms for the relationship between sleeping difficulties and falling.

Daytime sleepiness and poor sleep efficiency have been found to be associated with falls. Sleeping more than 10 hours or less than five hours per night have been associated with a greater risk of falls [34, 35]. Poor sleep efficiency (where less than 70% of time in bed is spent sleeping) had 1.36-fold increased odds of falling compared with others [34]. Data have suggested that sleep deprivation may contribute to loss of balance [36]. Sleep fragmentation and hypoxia were found to be associated with poorer physical function in older men. Poor sleep at night, spending more than 90 minutes awake at night and sleep efficiency less than 80% were all associated with lower grip strength, slower walking speed, inability to stand from a wheelchair without assistance and inability to complete a narrow walk course after adjusting for age, body mass index, clinic site, antidepressant use, hypertension, comorbid disease (history of at least one medical condition including cardiovascular disease, osteoarthritis, diabetes, Chronic Obstructive Pulmonary Disease (COPD) and Parkinson's disease), Physical Activity Scale for the Elderly and smoking [37]. These changes in physical function may increase the risk of falls.

Daytime sleepiness has been independently associated with frequency of falling in individuals who report falling [38], and in particular community dwelling women [25]. Napping during the day has been associated with a greater risk of falls [34]. Residents in both self-care independent living units and assisted care hostels were three times more likely to have multiple falls if they napped for more than thirty minutes during the day or reported less than

six hours sleep at night [39] over a twelve month period (after adjusting for health, medications and activity levels).

Chronic poor sleep and daytime sleepiness have been shown to be associated with depression, reduced vigilance, deficits and difficulties in attention and memory and deficits in response times and performance levels [12]. These factors have also been reported as risk factors for falls [40-43].

Cognitive decline, difficulty ambulating, difficulty with balance and difficulty seeing are all associated with poor sleep even after controlling for medication use [35, 38, 44]. Therefore research focusing on the effectiveness of insomnia treatment in older age should not only examine typical sleep-related outcomes such as total time asleep and number of awakenings but also the occurrence of falls [38].

Limitations of previous research

Previous research investigating the relationship between sleep and falls in older people has found an association between these two common problems [25, 34, 35]. However a limitation of this research is that detailed sleep analysis (polysomnography) has generally not been performed, with most studies relying on self-reporting of sleeping problems [34]. Self-reports limit the capacity to identify specific sleep disorders, such as sleep disordered breathing that may be able to be improved with, for example, continuous positive airway pressure [CPAP] [34]. One study has compared sleep data collected via actigraphy (a monitor worn around the wrist that measures time asleep/awake) with falls and found sleep fragmentation and short sleep duration to be associated with falls [35]. However the authors of this study acknowledge that comprehensive sleep assessment, for example assessing for the presence of apnoea or sleep disordered breathing, is not possible via actigraphy and is still required to determine if specific sleep disorders are related to falls [35].

The relationship between sleeping and falling in older people is poorly understood and under-researched and therefore the aim of the present study is to undertake a preliminary investigation of whether specific sleep difficulties are associated with history of falls and risk of falling in older people by conducting a comprehensive falls risk assessment and detailed sleep analysis (polysomnography).

Methodology

Ethics

Ethics approval was sought from the DVA Human Research Ethics Committee (DVA HREC) and granted at their meeting of 14th August 2009. An amendment to the protocol, to include people over 70 years of age, was approved at the DVA HREC meeting of 12th February 2010.

Project team

This project was a joint initiative between NARI and IBAS. The project team included:

IBAS

Dr David Berlowitz

Dr Vanessa Wilkinson

NARI

Dr Briony Dow

Ms Sue Williams

Ms Karen Borschmann

Ms Xiaoping Lin

Advisory Group

An advisory group was formed to oversee the progression of the project. The group included the project team and:

- Dr Melissa Russell, University of Melbourne
- Ms Frances Batchelor, National Ageing Research Institute
- Dr Kate Crowley, Institute for Breathing and Sleeping, Austin Health
- Professor Keith Hill, NARI, Latrobe University and Northern Health

The advisory group met seven times during the course of the project to monitor progress and advise on methodological issues and interpretation of results.

Participants

The participants for this study were World War 2 veterans or war widow/ers or members of the Veteran community, who had fallen one or more times in the previous year.

The initial inclusion criteria were:

- Veterans or war widow/ers living in the community (own home or retirement village);
- Self report of one or more falls over the past 12 months;
- Age 80 or over;
- Able to walk independently within own home (unaided or aided);
- Able to follow simple instructions and communicate;
- English speaking;
- Not cognitively impaired (Abbreviated Mental Test score >6); and
- Living no more than 100 km from the Austin Hospital, Heidelberg, Victoria.

These criteria were extended in February 2010 to include other members of the Veteran community (such as, ex-service men or women who were not Veterans) and people aged over 70 years of age who otherwise met the inclusion criteria.

Recruitment

Sources of recruitment were the NARI newsletter, DVA and DVA Day Club newsletters, talks by project staff, and information flyers to DVA Day Clubs, RSL, Legacy and War Widow groups.

Project staff spoke to twenty-one groups of older people who were connected to the DVA through Day Clubs, War Widows, Legacy or the RSL. They informed the audience about falls prevention, healthy ageing, and sleep and ageing and described the study and the eligibility criteria. Names and contact details were collected from any interested participants so project staff could contact them by phone and arrange for them to participate in the study if they were interested. Information and project flyers were sent to another five RSL clubs.

Articles about the project were published in the NARI, DVA and DVA Day Club newsletters along with an advertisement seeking participants.

Data collection

Data were collected in two separate assessments for all participants. One assessment (demographics, falls risk, mobility, physical activity levels, depression, sleep quality) was undertaken at the participant's home and was followed by the second assessment (polysomnography), which was undertaken at the Austin Hospital's sleep laboratory at a convenient time for the participant. The interval between the home assessment and the polysomnography assessment ranged from 1 to 36 days, with an average interval of 15 days.

Home based assessment

This assessment took place at the participant's home after they had consented to take part in the study. This assessment took approximately one hour and was undertaken by an experienced physiotherapist researcher at a convenient time for the participant. In the home-based assessment the following data were collected:

- Age;
- Current medical conditions;
- Number and description of falls in the previous 12 months;
- Any medications taken in the past 2 weeks;
- Alcohol intake in the past week; and
- History of cigarette smoking.

In addition, measures of cognition, depression, levels of physical activity, falls risk, sleep behaviours, quality of life, body mass index, mobility and reaction time were collected (see descriptions below).

Cognitive status (Abbreviated Mental Test [AMT]) [45]. The AMT is a widely used measure of cognitive impairment consisting of ten items. It assesses memory for orientation and recall of recent and remote events. A cut-off of less than seven was used to determine cognitive impairment;

Depression (Geriatric Depression Scale-short form [GDS-SF]) [46]. The GDS-SF is a self-reported measure of depression developed specifically for use with older people. Participants answer 15 yes/no questions regarding their feelings in the past week. An overall score is then tallied to give an indication of the level of depression. For 10 of the questions the answer "yes" gives a positive score (indicating depression); in the remaining five questions, the answer "no" scores positively (for example, "Do you feel happy most of the time?"). The scores are then summed to give a total of 0-15. A standard cut-off point of 6 or more symptoms is used to define depression. [47, 48];

Physical activity levels (Human Activity Profile questionnaire [HAP]) [49].The Human Activity Profile is a self-reported measure of physical activity. It includes 94 activities, starting from a low level (e.g. "getting in and out of chairs or bed") and progressing to high level activities (e.g. "running or jogging 3 miles in 30 minutes or less"). The participant is asked to grade each activity as either "still doing this activity", "stopped doing this activity", or "never did this activity". Two scores are then obtained; the Maximum Activity Score (MAS) and the Adjusted Activity Score (AAS). The MAS is the highest level item number marked as "still doing". The AAS is obtained by subtracting the number of items marked as "stopped doing" from the MAS. Scores range from 0 to 94, with higher scores indicating higher levels of physical activity;

Falls history Number of falls in the past 12 months was assessed by retrospective recall. This included information about location of fall, activity at time of the fall, any injuries sustained, and impact of fall on confidence and activity levels. The raw score of number of falls in the past 12 months was coded into a two-level categorical variable: single fallers if the participants had 1 fall and multiple fallers if the participants had 2 or more falls;

Falls risk (Falls Risk for Older People in the Community [FROP-Com]) [50] The FROP-Com is a comprehensive falls risk assessment tool. It has been found to be reliable and to have moderate predictive accuracy for falls in an older population [50]. The FROP-Com was used in this project to identify an individual's level of falls risk and falls risk factors (including medications, sensory loss, continence, nutrition, risk taking behaviour, feet and footwear, balance and mobility, and involvement of environmental hazards in falls). A score is given for each risk factor depending on the severity of the problem and then a score is tallied to give an overall measure of falls risk (range of possible scores 0 – 60). Higher score represents higher risk of falling. Based on a previous study [50], the cut-off of 18/19 was used in the current study to categorized participants into two falls risk groups: participants whose FROP-Com score was between 0 and 18 were coded as at low falls risk and participants whose score was equal to or greater than 19 were coded as at high falls risk;

Daytime sleepiness (Epworth Sleepiness Scale, (ESS) [51], Karolinska Sleep Scale (KSS) [52] and Basic Nordic Sleep Questionnaire (BNSQ) [53]).

- The Epworth Sleepiness Scale is an eight item self-report measure of daytime sleepiness. It examines the risk of falling asleep during a range of common activities (e.g. watching television, sitting and chatting to someone). Higher scores in the ESS indicate higher levels of trait sleepiness.
- The Karolinska Sleep Scale is a one-question self-report measure of a person's rating of current sleepiness. Higher scores in the questionnaire indicate higher levels of state sleepiness.
- The Basic Nordic Sleep Questionnaire is a general sleep questionnaire which examines subjective ratings of sleep amount, quality and screens participants for the likelihood of

various sleep disorders such as sleep apnoea. The ninth question from the BNSQ ("Do you feel excessively sleepy in the daytime?") was used in the study as an additional indicator of subjective daytime sleepiness.

Quality of Life (Australian Quality of Life Instrument [AQoL]) [54]. The AQoL is a health related quality of life instrument. The AQoL consists of 15 questions, which cover five domains. The domains include illness, independent living, social relationships, physical senses and psychological well-being. Each domain has 3 questions. Each question is scored from 0-3, 0 for the first response and three for the fourth response. Scores range from 0-45 with higher scores indicating poorer QOL. The raw scores of the AQoL need to be transformed into utility scores to compare to the population norm [55];

Body mass index (BMI) [56]. The standard BMI calculation was used: weight (kg)/[height $(m)^2$];

Mobility (Timed Up and Go Test [TUG]) [57].The Timed Up and Go is a measure of functional mobility. A chair with seat 45cm from the floor, or as close to this as was available, was used. The TUG measures the time required for a person to stand up out of a chair, walk three metres at a comfortable speed, turn, return to the chair and sit. Participants were advised to walk at their comfortable pace and were able to use the arms of the chair to push up if required;

Reaction time. Reaction time was measured using a hand held electronic timer and a light stimulus next to the reaction timer. The timer has a built in variable delay of 1 to 5 seconds so the light stimulus cannot be predicted. This test is used commonly as a measure of falls risk within the Physiological Profile Assessment [58].

Laboratory based polysomnography (PSG)

The polysomnography testing was undertaken at the Austin Hospital's Sleep Disorders Unit. This involved the participant spending one night in the Sleep Disorders Unit.

General demographics (age, height, weight, medication, usual bed time, alcohol consumption) were collected. The presence of sleep disordered breathing (SDB) and Periodic Limb Movement Disorder (PLMD) was assessed using overnight in-laboratory sleep monitoring which comprehensively measures respiratory, movement and sleep variables (Compumedics™ E-Series, Abbotsford, Australia). All studies were sleep staged and respiratory status was scored by an independent, trained sleep scientist. Sleep was staged in 30 second epochs, arousals marked and respiratory events scored according to international standard criteria [59]. Summary indices and statistics were calculated.

The PSG recording included measures of central (EEGC:C4/A1) electroencephalography, submental electromyography (EMGS), bilateral electrooculography (EOG), electrocardiography (ECG) and an additional patient reference electrode to minimise electrical noise (PG2). Brass gold plated electrodes (Astro-Med Inc, West Warwick, USA) were used for EEGC, EMGS, EOG

and PG2. Adult ECG electrodes (Meditrace 200, Graphic Controls, Buffalo, USA) were used for the ECG. Air flow at the nose was monitored with a nasal pressure probe. Respiratory movements of the chest and abdomen were recorded using respiratory inductance plethysmography. Movement sensors were positioned on the dorsum of both feet to record lower limb movements. Body position was recorded using the Compumedics position sensor. Arterial oxygen saturation was monitored with a finger pulse oximeter positioned on the second or third distal phalanx. The overnight studies commenced at or around the participants usual sleep time. Data collection continued until approximately 6am.

This polysomnography testing generated a large number of variables that could be investigated. These analyses were restricted to those PSG summary variables that were most likely to reflect significant daytime dysfunction and that related to the primary area of interest - the association between sleep difficulties and falls risk. Of these summary variables, there were two measures that indicated possible sleep problems - the Apnoea Hypopnoea Index (AHI) and the Periodic Limb Movement (PLM) index.

The AHI score has a cut-off score of 10. An AHI score that is below 10 is considered normal and an AHI that is equal to or greater than 10 is considered to be indicative of Obstructive Sleep Apnoea (OSA). For people who are defined as having OSA, they are further classified into two groups: mild OSA for scores between 10 – 30 and severe OSA for score greater than 30.

The PLM index has a cut-off score of 15. A PLM index score below 15 is considered normal and a PLM index score equal to or greater than 15 is considered abnormal.

There are three other measures that indicate sleep quality - sleep efficiency, number of awakenings after sleep onset and sleep latency. Sleep efficiency is the ratio of time spent asleep (total sleep time) to the amount of time spent in bed expressed as a percent. Sleep latency is the duration of time from 'lights out,' or bedtime, to the onset of sleep. Currently, there are no normative data for these variables regarding the older population.

Data analysis

Given the main focus of this study was on the relationship between sleep difficulties and falls and falls risk, the data analysis focused on the related variables, including:

- Falls history and falls risk variables: the two level falls history variable (single faller vs multiple faller) and the two level FROP-Com variable (low falls risk vs high falls risk);
- Sleep variables: there was a total of eight sleep variables included in the analysis - three subjective sleepiness variables (the ESS, the KSS, and the ninth question from the BNSQ) and five objective polysomnography variables (the AHI, the PLM index, sleep efficiency, number of awakenings after sleep onset and sleep latency).

The analyses investigated whether there were significant differences in these sleep variables for participants with number of falls and different falls risk. All numerical data were tested for normal distribution. For the sleep variables that were normally distributed, independent t-tests were conducted to investigate group differences. For the sleep variables that were not normally distributed, the Mann–Whitney U test was used instead of the t-tests.

Summary statistics for other measures that were collected in the study are also reported. However, further analyses of these variables will be conducted at a later date as required for inclusion in future publications.

Individual reports

Information from the comprehensive sleep study and falls risk assessment was summarised and a report provided to the participant. The report included recommendations and suggested that the participant discuss the letter with their local doctor. Some participants requested and consented for a copy of the letter to be sent to the their usual treating doctor (which may have been their GP or a specialist) who could use it to discuss ongoing treatment plans. The information gained may have assisted development of management plans for those older people who are falling over and those with sleep difficulties.

Results

Recruitment

A total of 35 participants were recruited to the project and completed both assessments.

Table 1 shows the numbers of eligible participants recruited via the various recruitment strategies.

Table 1: Recruitment of participants

Recruitment strategy	**Number of eligible participants recruited**
Recruitment talks to Veteran community clubs and groups	26
Flyers sent to Veteran community clubs and groups	2
Articles in newsletters	7
Total	35

A further eighteen (18) people expressed interest in the project and provided their details to the research staff. Nine people did not meet the inclusion criteria, one was unable to commit to the project, and a further eight were no longer interested in participating when contacted by project staff. A number of people also expressed interest in the project at the talks, but reported that they did not fit the inclusion criteria (too young, or had not fallen), so did not give their details to the research staff.

Participant demographics

Table 2 reports the basic demographic characteristics of the participants.

Table 2: Basic demographic characteristics of the participants (n=35)

Characteristic / variable	**Participant Data**
Age – mean (95% CI)	82.8 years (81.5-84.1 years)
Gender – n (%)	21 female (60%)/ 14 male (40%)
Height (cm) – mean (95% CI)	162.5 (159.2-165.9)
Weight (kg) – mean (95% CI)	73.8 (67.7-79.9)
BMI – mean (95% CI)	27.7 (26.0-29.5)
Marital Status - n (%)	
- Widowed	23 (65.7%)
- Married/de facto	7 (20.0%)
- Single	1 (2.9%)
- Divorced/separated	1 (2.9%)
- Missing data	3 (8.5%)
Living arrangement – n (%)	
- Lives alone	17 (48.6%)
- At home with spouse	6 (17.1%)
- At home with children	1 (2.9%)
- Missing data	11 (31.4%)
Most common health conditions – n (%)	
- Arthritis	25 (71.4%)
- Dizziness	12 (34.3%)
- Cardiac conditions	11 (31.4%)
- Back pain	11 (31.4%)
- Respiratory condition	10 (28.6%)
- Lower limb joint replacement	10 (28.6%)
- Diabetes	6 (17.1%)
- Osteoporosis	3 (8.6%)

Characteristic / variable	Participant Data
Number of prescription medications – n (%)	
- No medication	3 (8.6%)
- 1-2 medications	2 (5.7%)
- 3 medications	15 (42.9%)
- 4 or more medications	15 (42.8%)
Level of physical activity – n (%)	
- Very active (exercises 3 times per week)	20 (57.1%)
- Moderately active (exercises < twice per week)	11 (31.4%)
- Not very active (rarely leaves the house)	4 (11.5%)
Walking independently without an aid – n (%)	
- At home	35 (100%)
- In the community	25 (71.4%)

Physical, psychological and sleeps performance of participants

Table 3 reports the results of the physical, psychological and sleep performance of participants. For numeric variables, the data were examined for normality using the Shapiro-Wilk test. For data that were normally distributed, the mean and the 95% confidence interval for mean (95% CI) are reported. For data that were not normally distributed, the median and the interquartile range (IQR) are reported.

For categorical variables (such as falls history: single fallers/multiple fallers), percentages of each level are presented.

Table 3: Physical, psychological and sleep profiles of participants (n=35)

Measures	**Participant Data**
HAP—MAS - mean (95% CI)	70.8 (68.1-73.5)
HAP—AAS - mean (95% CI)	56.9 (52.8-61.1)
Timed Up and Go (seconds) - mean (95% CI)	11.7 (10.5-12.9)
Reaction Time (seconds) - median (IQR)	0.28 (0.06)
AMT score – median (IQR)	10 (1)
AQoL score - mean (95% CI) - Raw score - Utility score	 27.11 (25.42-28.81) 0.62 (0.54-0.69)
GDS score - median (IQR)	1 (4)
Falls history - Number of falls in the past 12 months – median (IQR) - Single fallers/Multiple fallers – n (%)	 2 (2) 13 (37.1%)/22 (62.9%)
FROP-Com - Raw score - mean (95% CI) - Low risk/High risk – n (%)	 15.2 (13.3-17.1) 24 (68.6%)/11 (31.4%)
ESS - median (IQR)	5 (6)
KSS- median (IQR)	3 (2)
Ninth question of the BNSQ- median (IQR)[1]	2 (2)
AHI - Raw score - mean (95% CI) - Normal/Mild OSA/Severe OSA - n (%)	 32.9 (25.8-40.1) 7 (20%)/7 (20%)/21 (60%)
PLM index - Raw score - median (IQR) - Normal/abnormal - n (%)	 17.3 (40) 14 (40%)/ 21 (60%)
Sleep efficiency (%) – mean (95% CI)	64.0 (58.5-69.2)
Number of awakenings after sleep onset - median (IQR)	23 (7)
Sleep Latency (mins) – median (IQR)	24.5 (38)

[1] The question is 'Do you feel excessively sleepy in the daytime?'. The responses include: (1) never or less than once a month; (2) less than once per week;(3)1-2 days per week; (4) 3-5 days per week; (5) daily or almost daily.

Association between sleep characteristics and falls and falls risk

The associations between sleep characteristics and falls history and falls risk were investigated through the following two questions:

- Were there any differences in the sleep measures between participants who had only 1 fall and participants who had more than 2 falls in the past 12 months;
- Were there any differences in the sleep measures between participants who were identified as being at high falls risk and those at low falls risk as measured by the FROP-Com.

A total of eight sleep measures were included in these analyses, including:

- three subjective sleepiness variables: the ESS (indicating trait sleepiness), the KSS (indicating state sleepiness), and the ninth question from the BNSQ (indicating subjective daytime sleepiness); and,
- five objective polysomnography variables: the AHI, the PLM index, sleep efficiency, number of awakenings after sleep onset and sleep latency.

Two of these variables (AHI and sleep efficiency) were normally distributed and the independent t-tests were used for the two variables. Six of the variables were not normally distributed, and the Mann–Whitney U test were used for these variables.

Association between sleep variables and falls history

Although participants who had two or more falls in the past 12 months had a higher average AHI (m=34.4, SD=23.1) and poorer sleep efficiency (m=64.8, SD=15.8) than participants who had only one fall (AHI: m=30.6, SD=17.0, sleep efficiency: m=62.5, SD=14.7), neither of these differences reached significance, t (33)= -0.5, p= 0.6 and t (33)= -0.4, p= 0.7, respectively.

As seen in Table 4, participants who had two or more falls in the past 12 months reported significantly higher scores in the KSS, indicating higher state sleepiness for people with multiple falls. Although the participants with multiple falls also reported higher scores in the ESS, BNQ9 and had more awakening and longer sleep latency, none of these differences reached significance.

Table 4: Results of Mann–Whitney U tests for sleep characteristics between single fallers and multiple fallers

Measures	**Group**	**Median**	**IQR**	***Z***	***p***
ESS	Single faller	4.0	4.0	-1.6	.10
	Multiple faller	6.0	7.1		
KSS	Single faller	1.0	2.0	-2.3	.02*
	Multiple faller	3.0	1.5		
BNSQ9	Single faller	1.0	1.0	-1.7	.08
	Multiple faller	2.0	2.3		
PLM index	Single faller	23.9	57.2	-0.1	.89
	Multiple faller	17.3	63.8		
Number of awakenings after sleep onset	Single faller	17.0	17.5	-1.0	.32
	Multiple faller	24.5	17.0		
Sleep Latency (mins)	Single faller	23.5	40.8	-.1	.93
	Multiple faller	24.8	38.8		

** The difference is significant at .05*

Association between sleep variables and falls risk

Similar to the sleep differences between participants with single falls and participants with multiple falls, there was also a trend for participants with high falls risk to have higher AHI (*m*=41.4, *SD*=25.6) and poorer sleep efficiency (*M*=63.6, *SD*=17.1) than participants with low falls risk (AHI: m=29.1, SD=17.6, sleep efficiency: *m*=64.2, *SD*=14.7). However, again the differences failed to reach significance, *t* (33)= -1.7, *p*=0.1 and *t* (33)= 0.1, *p*= 0.9, respectively.

However, as seen in Table 5, there were significant differences in sleep measures between participants with high falls risk and low falls risk. Participants with higher falls risk had a significantly higher score in the ESS, KSS, BNQ9, and the PLM index, indicating these

participants reported higher trait and state sleepiness, had more daytime sleepiness and had more lower limb movements. There were no statistical group differences in number of awakenings and sleep latency.

Table 5: Results of Mann–Whitney U tests for sleep differences between participants with high falls risk and low falls risk.

Measures	**Group**	**Median**	**IQR**	***Z***	***p***
ESS	Low risk	4.5	4.0	-2.1	.04*
	High risk	9.0	10.0		
KSS	Low risk	2.0	2.0	-2.4	.01*
	High risk	3.0	1.0		
BNSQ9	Low risk	1.0	1.0	-2.1	.03*
	High risk	2.0	3.0		
PLM index	Low risk	13.2	35.9	-2.2	.03*
	High risk	39.0	130.4		
Number of awakenings after sleep onset	Low risk	21.5	16.0	-1.2	.25
	High risk	25	18.0		
Sleep Latency (mins)	Low risk	25.8	39.4	-0.4	.66
	High risk	21.0	60.0		

** The difference is significant at .05.*

Discussion

The study sought to determine the frequency of specific sleep difficulties in an older (70+) population of fallers who were members of the Veteran community. We found that the frequency of specific sleep difficulties was very high, with 60% of participants (21) assessed as having severe Obstructive Sleep Apnoea (OSA) and 60% (21) as having abnormal periodic leg movements (PLM). Sleep efficiency was also poor, with the average for this group being 64% (i.e. the amount of sleeping time divided by the time in bed expressed as a percent). In the absence of population norms for this age group, it is difficult to interpret these findings except to say that there is a high frequency of specific sleep difficulties in this group. No participants were assessed as having normal sleep.

We also sought to determine whether there was an association between level of falls risk, falls history and specific sleep difficulties in this population. Participants who had two or more falls in the past 12 months reported significantly higher scores in the KSS than participants who had had one fall, indicating higher state (current) sleepiness for people with multiple falls. Furthermore, participants with higher falls risk had a significantly higher score in the ESS, KSS, BNQ9, and the PLM index than those with low falls risk, indicating these participants reported higher trait and state sleepiness, had more daytime sleepiness and had more lower limb movements. These findings are consistent with previous studies of the relationship between sleeping and falling in older people in which daytime sleepiness has been independently associated with frequency of falling in individuals who report falling [38] and napping during the day has been associated with a greater risk of falls [34]. As mentioned previously, in anAustralian study, residents in both self-care independent living units and assisted care hostels were three times more likely to have multiple falls if they napped for more than thirty minutes during the day or reported less than six hours sleep at night [39].

Although not statistically significant, there were also trends in the relationship between higher average AHI (an indication of sleep apnoea) and poorer sleep efficiency, and falls risks and number of falls. The latter trend is also supported by previous research in which poor sleep efficiency (where less than 70% of time in bed is spent sleeping) had been found to increase the odds of falling 1.36-fold [34]. One would expect these trends to reach significance in a larger study.

In response to our second study question, it can be concluded that there appears to be a relationship between trait and state sleepiness and day time napping, and falls history and falls

risk. There also appears to be a trend for a relationship between sleep disturbances, such as sleep apnoea, and falls and falls risk in the older Veteran population.

This study shows a concerning level of sleep problems in our sample. With a sample of this size, recruited specifically for a sleep study, it is not possible to generalize to the whole Veteran population. However, given the relationship between sleep disturbances and other co-morbidities, such as arthritis, hypertension, depression, heart disease, cerebrovascular disease, bodily pain and memory problems, there are some practical implications that should be taken into account by people working with older Veterans and other older people. Health professionals should consider asking all older people about daytime sleepiness – using selective questioning as a screen then if necessary a more detailed assessment including a falls risk assessment for those who are complaining of daytime sleepiness. Similarly, given associations and trends found in this study and previous research, for older people who have reported 2 or more falls in the past 12 months, a detailed assessment by health professionals of daytime sleepiness and sleep efficiency may be warranted.

Finally, the study sought to determine the feasibility of undertaking a larger study investigating the association between sleep difficulties and falls. We found that the somewhat demanding data collection strategy involving a home visit assessment and an overnight stay in the sleep laboratory was feasible and acceptable to older people, with 35 participants completing both assessments. Given the strict inclusion criteria of our study and the limited time frame, we would be confident of recruiting a larger sample for a larger study because of the successful recruitment from community clubs and groups. We found that the most promising recruitment strategy was direct recruitment, that is, having a researcher talk directly to potential participants about the study and asking them to express interest there and then. The NARI newsletter, which goes out to older people who have already indicated an interest in participating in research, was also quite successful, yielding 6 eligible participants.

Recommendations

As this was a pilot study and there is limited research regarding sleep, falls and older people the clinical recommendations are restricted. We can, however, propose on the basis of this study and previous research that:

- Health professionals could be made more aware of the prevalence of sleep problems in older people and that sleep problems are not a normal consequence of ageing;

- Questions regarding sleep problems could be built in to the many standard health screening/assessment tools available for use with older people;
- Questions regarding sleep problems should be included on the falls risk screening/assessment tools. This would increase clinicians' knowledge regarding the associations found between sleep problems and falls and increase the potential for improved management of sleep problems in older people.
- Health professionals involved in the general care of older people and in falls prevention could be made more aware that sleep for older people may be improved using non-pharmacological measures, as based on previous research.

Finally, the following are recommendations for future research.

- Further research is required to investigate the treatment of sleep problems and daytime sleepiness in older people living in the community. A study investigating the effectiveness of an intervention combining polysomnography, non-pharmacological management sleep problems and CPAP (if sleep related breathing difficulties are found) would inform as to the best method available to manage this prevalent problem in older people. Such a study would evaluate the outcomes of improvements in sleep quality in older people and also the very important clinical outcome of falls reduction.
- It would also be beneficial to conduct a qualitative study to explore factors older people ascribe to their difficulties in sleep, and what would be acceptable approaches to interventions (as part of or a precursor to an intervention study).

Dissemination

Conference Presentations

Three submissions have been made for conference presentations. At the time of writing, two have been accepted.

1. B Dow, F. Batchelor, D. Berlowitz, K. Borschmann, K. Crowley, K. Hill, X. Lin, M. Russell, V. Wilkinson, S. Williams. Sleep and falling in older people – a pilot study. Abstract accepted for oral presentation. 2010 Hobart, Tasmania. 43rd Australian Association of Gerontology National Conference. Presentation will be between 17 and 19th November.

2. D. Berlowitz, B Dow, F. Batchelor, K. Borschmann, K. Crowley, K. Hill, X. Lin, M. Russell, V. Wilkinson, S. Williams. Sleep and falling in older people – a pilot study. Abstract accepted for poster discussion. 2010 Christchurch, New Zealand. Australasian

Sleep Association Annual Scientific Meeting Presentation scheduled for Thursday October 21st 2010.

3. F. Batchelor, B Dow, D. Berlowitz, K. Borschmann, K. Crowley, K. Hill, X. Lin, M. Russell, V. Wilkinson, S. Williams. Sleep and falling in older people – a pilot study Abstract submitted for oral presentation. 2010 Dunedin, New Zealand. 4th Australian New Zealand Falls Prevention Society Conference. Presentation would be between 21st and 23rd November 2010.

Summary of Findings for Participants

A one-page summary of the study findings (Appendix 1) has been sent to all 35 participants.

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Appendices

Appendix 1: Summary of findings for participants

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Sleep and Falling in Older People: a pilot study - Summary of findings

Thank you for assisting us with our project which looked at sleep and falls in older people. This document is a brief summary of the overall results of that research study.

Falls are a common problem for older people, with about one third of people aged over 65 having a fall each year. This percentage who fall is even higher in those over 80. Trouble with sleeping also appear to be common in older people and like falls, is often wrongly thought to be an inevitable part of ageing. In fact, difficulties with sleeping have been thought to increase the risk of falling in older people but there has been very little research done to look at these issues. The research you participated in, which was designed to examine the relationships between falls and sleep, was funded by the Department of Veteran's Affairs and conducted by the National Ageing Research Institute (NARI) and the Institute for Breathing and Sleep (IBAS)

The people who took part in the study were World War 2 veterans, war widow/ers or members of the Veteran community, who had had at least one fall in the previous year. We measured the risk of falls in the future, how mobile people were, what the usual amount of physical activity was, whether people were depressed at all and the quality of sleep quality in the homes of the people in the study. After these measures were made, a sleep study was performed at the Austin Hospital's sleep laboratory. We found that these tests were feasible to do and were generally well accepted by the people who participated.

Thirty five people were recruited to the project and completed both assessments. They were on average 82 years old, 60% were female, and almost two thirds had fallen more than once in the previous 12 months. The frequency of sleep difficulties was very high, with 60% of participants having at least thirty or more pauses in breathing or shallow breaths per hour of sleep and 60% having involuntary limb movements that occur at periodic intervals during sleep. The efficiency of sleep was poor overall with only two thirds of the time spent in bed asleep. On average, 24 minutes was taken to fall asleep once the lights were out and people woke up on average 23 times during the night.

On average, people who had 2 or more falls in the last year were more sleepy during the day. Those with a higher risk of falling in the future also reported being more sleepy during the day and had more leg movements overnight. These findings confirm previous research which found that being sleepy during the day was associated with the frequency of falling, and that napping during the day was related to a greater risk of falling in the future.

We believe that further studies needs to be undertaken to examine the sleep of older people, as this is a new area of research where there is little available information. Additionally, the best methods of improving sleep quality for older people must be investigated further. Simple methods for improving sleep are available from many sources, including at the following website. http://www.betterhealth.vic.gov.au/bhcv2/bhcarticles.nsf/pages/Sleep_hygiene?open . I have enclosed a copy of this information for you. If you are concerned about your sleep or risk of falls please speak to your general practitioner. Thank you again.

IBAS

Affiliated with the University of Melbourne and Melbourne Health