An actigraphic study comparing community dwelling poor sleepers with non-demented care home residents

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Key Words: actigraphy, non parametric circadian rhythm analysis, care home residents, community dwelling

Abstract

Sleep disturbances are a common problem among institutionalised older people. Studies have shown that this population experiences prolonged sleep latency, increased fragmentation and wake after sleep onset, more disturbed circadian rhythms and night-day reversal. However, studies have not examined the extent to which this is because of individual factors known to influence sleep (such as age) or because of the institutional environment. This paper compares actigraphic data collected for 14 days from 122 non demented institutional care residents (across 10 care facilities) with 52 community dwelling poor sleepers aged over 65. **Four dependent variables are analysed: i) the 'interdaily stability' (IS); ii) the 'intradaily variability' (IV); iii) the relative amplitude (RA) of the activity rhythm; and iv) the mean level of activity during the 24 hour day.** Data are analysed using a fixed effects, single level, model (using MLwiN). This model enables comparisons between community and institutional care groups to be made whilst conditioning out possible 'individual' effects of 'age', 'gender', 'level of dependency', 'level of incontinence care', and 'number of regular daily/prescribed medications'. After controlling for the effects of a range of individual level factors, and after controlling for unequal variance across groups (heteroscedascity), there is little difference between community dwelling older adults and institutional care residents in IS score; suggesting that the stability of day to day patterns (such as bed times, get up times, lunch times etc) is similar within these two resident groups. However, institutional care residents do experience more fragmented rest/wake patterns (having significantly higher IV scores and significantly lower mean activity values). Our findings strongly suggest that the institutional care environment itself has a negative association with older people's rest/wake patterns; although longitudinal studies are required to fully understand any causal relationships.

Introduction

Sleep disturbances are a common problem among institutionalised older people (Alessi and Schnelle 2000). Studies have shown **that** this population experiences prolonged sleep latency (Fetveit and Bjorvatn 2002), increased fragmentation and wake after sleep onset (Ancoli-Israel *et al* 1989), more disturbed circadian rhythms (Ancoli-Israel *et al* 1997) and night-day reversal (Ancoli-Israel *et al* 2002). In one actigraphic study of 19 older nursing home patients, subjects rarely spent a complete hour 'asleep' (Jacobs *et al* 1989).

Research into factors which might contribute to these sleep disturbances has painted a complex picture. At one level, sleep disturbances among institutionalised older people are linked to individual changes associated with 'normal' ageing. Older people, for example, spend much less time in slow wave sleep (Whalley 2001; Bliwise 2005). The suprachiasmatic nucleus has also been shown to deteriorate with ageing and contribute to detrimental changes in circadian rhythms (Ancoli-Israel *et al* 2002; Dijk *et al* 2000).

At another level, authors such as Alessi and Schnelle (2000, p. 47) have suggested that environmental factors play a key role and that "sleep problems are more common and more severe in nursing home residents than would be expected based on increased age alone". **These environmental factors have been shown to include 'noise' and 'light', as well as the effects of institutional regimes on sleep timing, nocturnal awakenings and daytime activities.** For example, **whilst there remains debate over the amount of control institutional care residents have over their own sleep timing, studies have shown that staffing levels are the strongest predictor of length of time in bed (Bates-Jenson *et al* 2004) and that shifting the bedtimes of healthy seniors to two hours earlier can lead to reduced sleep efficiency and increased wake after sleep onset (Monk *et al* 2009).** Once in bed, the regular nocturnal checks and repositioning carried out by care staff **can result in institutional care residents experiencing large periods of wake after sleep onset (Schnelle *et al* 1993).** One study of 230 incontinent nursing home residents found strong evidence that sound was associated with 27% of nocturnal awakenings and there was an average of 5.1 light changes per night across all homes (Schnelle *et al* 1998). These nocturnal disturbances and disruptions are then exacerbated by the fact that "large amounts of time are spent in bed during daylight hours and social cues to help structure the day/night sleeping cycle may be lacking" (Alessi and Schnelle 2000, p. 49).

Despite this complexity, few studies have attempted to isolate environmental factors from individual factors – focusing instead on individual *or* environmental factors. In one notable exception, Martin *et al* (2008) compared sleep patterns in residents in an assisted living facility to sleep patterns in home-dwelling older adults. However, this study included only 19 matched individuals and, by the authors own admission, larger studies are required. **The present paper examines the complex relationship between individual and environment**, adding to our understanding of the role that the **institutional care** environment plays in older, non-demented, residents' sleep disturbance. It does this by comparing actigraphically recorded rest/wake patterns in 122 non-demented **institutional care** residents to rest/wake patterns in 52 older community dwelling poor sleepers; whilst controlling for individual differences (such as age, gender, level of dependency and level of incontinence care).

Methods

The a priori hypothesis for this study is that institutional care facility residents experience more fragmented rest-wake patterns compared to community dwelling older poor sleepers (and that this difference cannot be explained due to individual differences). Data comes from two arms of a 4 year UK study entitled 'SomnIA: Optimising quality sleep among older people in the community and care homes'. Arm one recruited 183 residents from 10 **institutional care facilities** in the South East of the United Kingdom. Subjects were excluded if they had severe ill health or moderate/severe dementia (as determined by the **care facility** manager), were unable to give written, informed, consent or were considered unable to complete the study measures (which included a 14 day, interview based, sleep/activities diary).

Arm two began with a representative survey of community dwelling older adults (n=2400), drawn from 10 general practices in South East England (with equal numbers of men and women and those aged 64-75 and 75+). A sub-sample of those respondents who scored greater than 5 on the Pittsburgh Sleep Quality Index (Buysse *et al* 1989) – indicating poor sleep quality – and who gave written, informed consent, were then selected for in-depth follow-up data collection. **This sub-sample formed the 'comparison' group. As studies have suggested that institutional care facility residents may experience exaggerated age-related changes in circadian rhythms (Martin *et al* 2008) and that sleep problems increase the likelihood of entry into institutional care in the first place (Alessi and Schnelle 2000), the use of poor sleepers as a comparison group was considered to be more robust and conservative.**

All participants continued their normal sleep/wake routine throughout the study and no restrictions were placed on activities, food or drink. Both arms of the study were approved by various ethics committees and conformed to international ethical standards (Portaluppi *et al* 2008). Due to non-compliance or missing data, the analysis set comprised a total of 122 (87 women; mean age 85; sd 7.97) institutional care residents from 10 care facilities and 52 older community dwelling poor sleepers (24 women; mean age 74; sd 6.87).

Actigraphy

All participants were asked to wear actiwatches (Cambridge Neurotechnology Ltd, [CNT] Cambridge, UK) for 14 days. Watches were set to collect data at 1 minute epochs and were calibrated using standardised equipment from CNT prior to use. A recent review paper (Morgenthaler *et al* 2007), identified ten studies which reported the use of actigraphy in the analysis of circadian rhythms in ageing and dementia, and one study showed it to be useful in assessing sleep in nursing homes.

Dependent Variables

Four dependent variables were created for each older person: i) the ‘interdaily stability’ (*IS*), which ‘gives an indication of the strength of the coupling between the rest-activity rhythm and Zeitgebers’ (Van Someren *et al* 1997, p. 957). A decrease in *IS* indicates a higher day-to-day variation. ii) The ‘intradaily variability’ (*IV*), which “gives an indication of the fragmentation of the rhythm” (Van Someren *et al* 1997, p. 957). A high *IV* (above 1) is indicative of a more disrupted pattern, and the occurrence of daytime napping and/or nighttime arousals. iii) The relative amplitude (*RA*) of the activity rhythm, which ranges from 0 to 1, with higher indicating less fragmentation and a ‘better’ rest/wake pattern, and “reflects the normalized difference between the most active 10-h period and the least active 5-hour period in an average 24-hour pattern” (Dowling *et al* 2005, p. 5). Finally, iv) the mean level of activity during the average 24 hour period.

Actigraphy scores any missing data as zero and, because of this, these dependent variables can be significantly affected by the absence or presence of missing data. The *IS*, for example, is calculated as the “ratio between the variance of the average 24- hour pattern around the mean and overall variance” (Van Someren *et al* 1997, p.957). The *IV* is calculated as “the ratio of the mean squares of the difference between successive hours . . . and the mean squares around the grand mean” (Van Someren *et al* 1997, p. 957-958). Further to this, because these variables work on a 24 hour average, data needs to be removed from the analysis in 24 hour blocks (for example, if there is missing data on Monday 9:00-10:00, then Monday 9:00 am to Tuesday 8:59 am must be removed).

Within the present study, two distinct ‘types’ of missing data were identified; i) substantial periods of missing data (usually including missing data at night) and; ii) smaller periods of missing data (which usually related to bathing). All actograms were visually read and periods of missing data > 6 hours were identified and data removed in 24 hour blocks. However, in order to retain as much data as possible, variables were created both with and without periods of missing data < 6 hours. Results derived from the two analyses of missing data were then compared and, in the event of significant difference, periods of missing data were removed in 24 hour blocks. Individuals needed to have at least 120 hours (5 days) of valid actigraphy data to be included in the analysis. Further to this, as studies have shown that the Interdaily Stability is not always robust when based on 7 days of data or less (whereas other actigraphic circadian rhythm variables are), ‘hours of valid data’ was also used as a control in all models (Van Someren 2007).

Data Management – institutional care groupings

Whilst the community group comprised 52 older community dwelling poor sleepers, the number of older people within each of the 10 institutional care facilities ranged from 3 to 19. To ensure comparable group sizes, the 10 institutional care facilities were regrouped into 3 groups. The allocation of institutional care facilities into particular groups was informed by substantive factors; such as whether care facilities were owned by the same company or by the same local government agency. Care facility Group 1 comprised 1 nursing and 2 residential homes run by a single local government agency. Group 2 comprised 3 nursing homes owned by a particular company. Group 3 comprised 4 care facilities run by ‘other’ providers. The results reported in this paper do not change significantly with different groupings of care facilities.

Tests were run to ensure that this regrouping did not violate the assumptions of independence (Rasbash *et al* 2008); as individuals within one facility can be more alike, on average, than individuals from another facility. Bivariate correlations between the 10 institutional care facilities and IS, IV and RA were non-significant. Significant relationships were noted for ‘Mean Activity Levels’ but this was explained by the presence of a single, ‘outlier’ institution. As such, institutional care residents could be grouped together without violating assumptions of independence.

The four residence type groups (community, care facility group 1, care facility group 2, care facility group 3) were then interrogated to see if they complied with assumptions of normality and equal variance (homoscedascity). Outliers (with high leverage) were removed, leaving the three

institutional care groups and the community group with a normal distribution for IS, IV and Mean Activity. RA was normally distributed for three of the four groups. Unequal variance between groups existed with each of the four dependent variables

Statistical analysis

The a priori hypothesis for this study is that care facility residents experience more fragmented rest-wake patterns compared to community dwelling older poor sleepers (and that this difference cannot be explained by individual differences). Statistical techniques were therefore needed to enable comparisons between community and the three institutional care groups to be made whilst controlling for possible individual level characteristics, namely age, gender and level of dependence. Statistical techniques also needed to enable groups to be compared whilst conditioning for unequal variance (heteroscedascity).

Fixed effects, single level, models were run using MLwiN. Unconditional models, which included just the dependent variable and 'residence type', were firstly run with 'community' set as the reference category. These models provide information on the extent to which the three institutional care facilities groups deviate from the community group mean. Full models were then run which included individual level characteristics, such as 'age', 'gender', 'level of dependency', 'level of incontinence care', and 'number of regular daily/prescribed medications'. Age and 'number of regular daily/prescribed medications' were included as linear variables. Level of dependency was coded into four groups ('no assistance', 'at least 90 minutes of care', 'at least three hours of care', 'at least five hours of care'). Incontinence care was coded as 'yes' or 'no'. The 'residency type' fixed effects were treated as random in the model to examine and control for heteroscedascity (with a categorical variable we cannot estimate the covariance with the intercept, so the covariance terms in the matrix were set to 0). Importantly, these full models calculate the main deviations as if the four groups were matched on age, gender, level of dependency, level of incontinence, and number of regular medications, ensuring that observed differences reflect effects of the residence type, and not the resident composition.

Results

Table 1 provides descriptive information for the community sample and for the 10 institutional care facilities.

Insert Table 1 about here

Table 2 presents two models for each of the 4 (actigraphically measured) rest/wake dependent variables. Unconditional models (labelled as *un* in the table), which include only the ‘residence’ type variables, illustrate that there is little difference between community dwelling older adults and **institutional care** residents in **Interdaily Stability (IS)**; suggesting that the stability of day to day patterns (such as bed times, get up times, lunch times etc) is similar within all resident types. However, these unconditional models do suggest that **institutional care** residents experience more fragmented rest/wake patterns. All three **institutional care** groups had a significantly higher (worse) **Intradaily Variability (IV)** and a significantly lower (worse) mean activity level than the community group. All of the **institutional care** groups had significantly lower (worse) relative amplitude (compared to community - see Table 2); suggesting that they have less difference between their peak and nadir (or highest and lowest levels of activity).

Insert Table 2 about Here

Models including all independent variables (labelled as ‘full’ in the table), **and which conditioned out and controlled for the effects of ‘individual’ level variables**, confirm these results. Although the magnitude of the difference diminishes, **institutional care** groups remain significantly different from the community reference group for IV, RA and mean level of activity (after controlling for heteroscedascity). For example, the mean difference in activity levels between the community and **institutional care** group 2 is 63.

It should be noted that, whilst they all differ from the community reference group, there is little difference between the three institutional care groups in IV, RA and Mean Activity (Table 2).

Table 2 also enables examination of the differences in amount of variance between groups (see the figures under (b) in the table). It can be seen, for example, that with IS, IV and mean activity, there is much more variance within **institutional care** group 3 (which is a group of **institutional care facilities** which do not belong to a single provider).

Discussion

This paper has examined actigraphic data collected from 122 non-demented **institutional care** residents (across 10 **institutional care facilities; regrouped into three categories**) and 52 community dwelling poor sleepers. It has illustrated how significant differences exist between non-demented **institutional care** residents and community dwelling older adults in ‘intradaily variability’, ‘relative

amplitude' and 'mean level of activity'. These results suggest that institutional care residents have a much more fragmented rest/wake pattern – and a less clear cut differentiation between nocturnal and daytime movement.

As models controlled for the effects of individual level variables, this difference can not be explained by differences in age, gender, medication use, level of dependency or incontinence amongst the participants. Present findings therefore support previous, smaller, studies which have suggested that there is a negative association between the environment within institutional care facilities and individual's rest/wake patterns (Alessi and Schnelle 2000; Martin *et al* 2008) – and that there are 'contextual' influences on care facility residents' rest-wake patterns. Our findings are strengthened by the community dwelling comparison group being restricted to self-reported *poor sleepers* and the care facilities group excluding those with moderate/severe dementia.

These findings have important implications – both in terms of understanding and reducing rest/wake difficulties within institutional care residents, and also in terms of rethinking the high level of sleeping medications which are prescribed to combat rest/wake difficulties within institutional care populations. As Dijk and von Schantz (2005, p. 279) identify, 'daily rhythms in sleep and waking performance are generated by the interplay of multiple external and internal oscillators.' These external and internal oscillators include the circadian pacemaker, sleep homeostat, light-dark cycle, and also include 'social time'/'social factors'. These 'social factors' impinge on the timing of sleep-wake but do not directly affect the circadian pacemaker or sleep homeostat; leading to potential conflicts between socially dictated timings and actual sleep propensity (Dijk and von Schantz 2005: 281). Present findings suggest that, 'social factors' need to be considered when exploring and explaining the prolonged sleep latency (Fetveit and Bjorvatn 2002), increased fragmentation and wake after sleep onset (Ancoli-Israel *et al* 1989), more disturbed circadian rhythms (Ancoli-Israel *et al* 1997) and night-day reversal (Ancoli-Israel *et al* 2002) reported among older people residing in care facilities.

It is relevant to note possible limitations with the present study. First, data were collected using cross-sectional sampling techniques and, as such, the study cannot determine 'causality'. Longitudinal studies are needed which measure rest-wake patterns before and after entering an institutional care facility. Second, although those with moderate to severe dementia were excluded, some participants within the present study could have had mild dementia. This does not necessarily question present findings – as Hatfield *et al* (2004), for example, found that mildly

demented subjects have activity rhythms comparable to healthy age-matched individuals – but future studies need to measure and control for the full dementia range.

Future studies are also needed to explore the ‘contextual’ effects underlying the present findings of substantial rest/wake difficulties among elderly institutional care residents. Particular attention needs to be paid to the routines enacted by managers and staff in institutional care facilities. A recent report by Kerr *et al* (2008) found that institutional care facility staff carry out ‘indiscriminate’ checks at night, which lead to unnecessary disturbance of residents. Noise levels were also found to be too high to support good sleep and bright lights were turned on in resident bedrooms when staff were completing checks. As studies have shown that light can affect the non-parametric actigraphy variables used within the present study (Van Someren *et al* 1999), this latter aspect may be particularly worth exploring.

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References

- Alessi CA, and Schnelle JF. (2000). Approach to sleep disorders in the nursing home setting, *Sleep Med Rev.* 4: 45-56
- Ancoli-Israel S, Parker L, Sinaee R, Fell R, and Kripke DF. (1989). Sleep fragmentation in patients from a nursing home, *J Gerontol: Med Sci* 44: M18-21
- Ancoli-Israel S, Klauber MR, Williams Jones D, Kripke DF, Martin J, Mason W, Pat-Horenczyk R, and Fell R. (1997). Variations in circadian rhythms of activity, sleep, and light exposure related to dementia in nursing-home patients, *Sleep* 20: 18-23
- Ancoli-Israel S, Martin JL, Kripke DF, Marler M, and Klauber MR. (2002). Effect of light treatment on sleep and circadian rhythms in demented nursing home patients, *JAGS* 50:282-289
- Bates-Jenson BM, Schnelle JF, Alessi CA, Al-Samarrai NR, Levy-Storrs L. (2004). The Effects of Staffing on In-Bed Times of Nursing Home Residents, *JAGS* 52: 931-938
- Bliwise DL. (2005). Normal aging. In Kryger MH, Roth T, and Dement WC (Eds). *Principles and Practice of Sleep Medicine* (pp. 24-38). Philadelphia: Elsevier Saunders.
- Buyse DJ, Reynolds CF, Monk TH, Buman SR, Kupfer DJ. (1989). Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiat. Res.*, 28:193–213
- Dijk D-J, Duffy JF, and Czeisler CA. (2000). Contribution of circadian physiology and sleep homeostasis to age-related changes in human sleep, *Chronobiol. Int* 17: 285-311
- Dijk D-J, von Schantz M. (2005). Timing and consolidation of human sleep, wakefulness, and performance by a symphony of oscillators. *J Biol Rhythms*, 20: 279-290
- Dowling GA, Hubbard EM, Mastick J, Luxenburg JS, Burr RL, and Van Someren, EJW (2005) Effect of morning bright light treatment for rest–activity disruption in institutionalized patients with severe Alzheimer’s disease *Int Psychogeriatr.* 2005 June; 17(2): 221–236.
- Fetveit A, and Bjorvatn B. (2002). Sleep disturbances among nursing home residents, *International Journal Geriatr Psychiatry* 17: 604-609
- Hatfield CF, Herbert J, van Someren EJW, Hodges JR, Hastings MH (2004). Disrupted daily activity/rest cycles in relation to daily cortisol rhythms of home-dwelling patients with early Alzheimer’s dementia. *Brain* 127:1061-1074

Jacobs D, Ancoli-Israel S, Parker L, and Kripke DF. (1989). Twenty-four-hour sleep-wake patterns in a nursing home population, *Psychol Aging* 4: 352-356.

Kerr D, Wilkinson H, Cunningham C. (2008) *Supporting older people in care homes at night*, Joseph Rowntree Foundation

Martin JL, Alam T, Harker JO, Josephson KR, and Alessi CA. (2008). Sleep in assisted living facility residents versus home-dwelling older adults, *J Gerontol: Med Sci* 63A: 1407-1409

Monk TH, Buysse DJ, Begley AE, Billy BE, Fletcher ME, (2009) Effects of a Two-Hour Change in Bedtime on the Sleep of Healthy Seniors. *Chronobiol. Int.* 26 : 526-543

Morgenthaler T, Alessi C, Friedman L, Owens J, Kapur V, Boehlecke B, Brown T, Chesson A, Coleman J, Lee-Chiong T, Pancer J, Swick TJ. (2007). Practice parameters for the use of actigraphy in the assessment of sleep and sleep disorders: An update for 2007. *Sleep* 30:519-529

Portaluppi F, Touitou Y, Smolensky MH. (2008). Ethical and methodological standards for laboratory and medical biological rhythm research. *Chronobiol. Int.* 25:999–1016.

Rasbash J, Steele F, Browne WJ, Prosser B. (2005). A user's guide to MLwiN, version 2.0. Bristol: University of Bristol, pp. 1–42.

Schnelle JF, Cruise PA, Alessi CA, Ludlow K, Al-Samarrai NR, and Ouslander JG. (1998). Sleep hygiene in physically dependent nursing home residents: Behavioural and environmental intervention implications, *Sleep* 21:515-523

Schnelle JF, Ouslander JG, Simmons SF, Alessi CA, Gravel MD. (1993) The nighttime environment, incontinence care, and sleep disruption in nursing homes. *JAGS* 41:910-914.

Van Someren, EJW (2007). Improving actigraphic sleep estimates in insomnia and dementia: how many nights? *J Sleep Res* 16: 269-275

Van Someren EJW, Kessler A, Mirmiran M, Swaab DF. (1997). Indirect bright light improves circadian rest-activity rhythm disturbances in demented patients. *Biol. Psychiat.* 4:955-963

Van Someren EJW, Swaab DF, Colenda CC, Cohen W, Vaughn McCall W, Rosenquist PB. (1999). Bright Light Therapy: Improved Sensitivity to Its Effects on Rest-Activity Rhythms in Alzheimer Patients by Application of Nonparametric Methods. *Chronobiol. Int.* 16:505-518

Whalley, L. (2001). *The ageing brain*, Phoenix Books: London

Table 1: Descriptive information (for the data set as a whole) and N both with and without outliers removed

			Per protocol data set					Number in Analysis (excluding outliers)			
	<u>Grouping of Institutional care facilities</u>	N	Mean Age (sd)	% Female	% requiring incontinence care	% with some level of dependency	Mean number of medications (sd)	IS	IV	RA	Mean Activity
Community	-	52	74 (6.87)	46	0	0	3.0 (0.4)	52	51	48	50
<u>All institutional facilities</u>	-	122	85 (7.97)	71	75	80	7.7 (0.3)	113	121	116	117
<u>Institution 1</u>	1	19	85 (9.19)	74	90	84	6.2 (0.8)	19	19	19	19
<u>Institution 2</u>	1	19	86 (9.37)	63	68	68	7.1 (0.9)	19	19	19	19
<u>Institution 3</u>	1	13	86 (3.63)	69	85	69	8.9 (1.2)	13	13	13	13
<u>Institution 4</u>	2	16	85 (9.48)	75	88	69	8.5 (1.0)	16	16	14	16
<u>Institution 5</u>	2	13	87 (5.94)	85	77	92	7.8 (1.0)	13	13	11	13
<u>Institution 6</u>	2	9	85 (12.02)	67	89	100	8.7 (1.2)	9	9	9	9
<u>Institution 7</u>	3	3	84 (5.77)	100	67	100	8.7 (2.4)	2	3	3	3
<u>Institution 8</u>	3	12	80 (5.82)	67	50	100	7 (0.8)	11	12	11	10
<u>Institution 9</u>	3	12	86 (7.11)	75	42	67	7.3 (1.0)	7	11	11	10
<u>Institution 10</u>	3	6	86 (4.92)	50	100	83	9.5 (1.4)	4	6	5	5

This table provides demographic information for community dwelling older adults and for each institutional care facility.

Table 2: Results from a single level, fixed effects, model examining deviations (with ‘residence’ type set as random to examine and control for heteroscedascity and with and without partialling out the effects of individual level factors and)

	Interdaily Stability (se)		Intradaily Variability (se)		Relative Amplitude (se)		Mean Activity (se)	
	<i>Un</i>	<i>Full</i>	<i>Un</i>	<i>Full</i>	<i>Un</i>	<i>Full</i>	<i>Un</i>	<i>Full</i>
Community (ref category)	0.544 (0.013)	0.657 (0.126)	0.855 (0.025)	0.466 (0.171)	0.885 (0.007)	0.882 (0.093)	175.328 (6.034)	276.299 (40.645)
Institutional facility Grp 1	0.018 (0.023)	0.082 (0.038)*	0.438 (0.055)*	0.359 (0.090)*	-0.164 (0.030)*	-0.120 (0.046)*	-82.731 (10.006)*	-45.206 (14.028)*
Institutional facility Grp 2	-0.065 (0.027)	0.005 (0.042)	0.558 (0.052)*	0.480 (0.090)*	-0.233 (0.025)*	-0.193 (0.045)*	-101.954 (8.449)*	-63.399 (13.247)*
Institutional facility Grp 3	-0.013 (0.030)	0.054 (0.047)	0.469 (0.069)*	0.384 (0.107)*	-0.118 (0.025)*	-0.071 (0.048)	-89.625 (10.538)*	-50.661 (15.173)*
Age		0 (0)		0.008 (0.003)*		-0.001 (0.001)		-0.522 (0.427)
Total Number of Daily Medications		-0.002 (0.003)		0.001 (0.006)		-0.003 (0.002)		-1.884 (0.973)
Gender (men as reference)		0.033 (0.019)		-0.019 (0.038)		0.013 (0.013)		15.468 (6.877)*
Incontinence Care (‘no’ as reference category)		-0.039 (0.035)		-0.064 (0.086)		0.004 (0.043)		-18.339 (11.634)
No Dependency (ref category)		_____		_____		_____		_____
‘at least 90 minutes of care’		-0.040 (0.036)		0.1 (0.088)		-0.034 (0.043)		-17.377 (11.669)
‘at least three hours of care’		-0.061 (0.045)		0.031 (0.109)		-0.009 (0.054)		-20.674 (14.259)
‘at least five hours of care’		-0.157 (0.076)*		0.067 (0.154)		-0.035 (0.085)		-54.399 (20.589)*
Total Hours of valid actigraphy data		0 (0)		0.001 (0.001)		0 (0)		-0.225 (0.078)*

b) Variance within groups								
Institutional facility Grp 1	0 (0)	0 (0)	0.043 (0.021)	0.043 (0.019)	0.023 (0.007)	0.025 (0.007)	0 (0)	0 (0)
Institutional facility Grp 2	0.019 (0.006)	0.017 (0.005)	0.071 (0.022)	0.072 (0.021)	0.029 (0.006)	0.030 (0.006)	0 (0)	0 (0)
Institutional facility Grp 3	0.020 (0.007)	0.018 (0.006)	0.122 (0.037)	0.125 (0.036)	0.018 (0.005)	0.018 (0.005)	1052.218 (687.345)	719.616 (553.461)

Within the top half of the table, two models are presented for each dependent variable. Unconditional (un) models include the ‘residence’ type independent variables only. The figures listed for community are the mean. All other figures listed represent ‘mean’ deviation from the reference category. For example, an IV value of 0.438 is higher and therefore worse (reference = 0.855; gr 1 = 0.855 + 0.438 = 1.293). Full models include all independent variables. Within these models the four groups were matched on age, gender, level

of dependency, level of incontinence, and number of regular medications, ensuring that observed differences reflect effects of the care home, and not the resident composition. *Indicates significantly different from intercept.

Under (b) the results from the variance matrix are presented. Fixed effects were treated as random in the model to examine and control for heteroscedascity. The results presented under (b) indicate that models did control for heteroscedascity and illustrate that the unequal variance was largely due to more variance within group 3.