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WRIST ACTIGRAPHY: A SIMPLE WAY TO RECORD MOTOR ACTIVITY IN ELDERLY PATIENTS WITH DEMENTIA AND APATHY OR ABERRANT MOTOR BEHAVIOR

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Abstract: *Introduction:* In dementia, behavioral psychological symptoms are frequent and variable. *Objective:* To assess the value of wrist actigraphy as a measure of disorder in motor behavior especially apathy, aberrant motor behavior, agitation and anxiety. *Methods:* Cross sectional observational study of consecutive patients older than 75 years admitted to an intermediate care unit of a geriatric hospital ward during a two-year period. Psycho behavioral symptoms and cognitive status were assessed using the NPI scale and MMSE and diagnosis of dementia was done using DSMIV criteria. A wrist actigraph was worn for 10 days to record motor activity, sleep time and number of periods of sleep. *Results:* 183 patients were included. Among patients with dementia, a significant decrease in motor activity was recorded in those with apathy from 9h to 12h and 18h to 21h ($p < 0.05$) and in those with anxiety from 21h to 24h ($p < 0.05$). Aberrant motor behavior in dementia was associated with a significant increase in motor activity from 21h to 24h ($p < 0.01$). Agitation was not associated with a significant differences in motor activity. *Conclusions:* Wrist actigraphy can be used to record motor activity in elderly patients with dementia especially in those with apathy and aberrant motor behavior.

Key words: Actigraphy, dementia, cognition, elderly, age.

Introduction

In the world, dementia affects about 24 million people and nearly 4.6 million new cases occur each year, corresponding to a new case every 7 seconds according to an international analysis (1). Dementia alters the patient's cognition, independence and behavior and has negative consequences on the everyday life of patients and their caregivers. Behavioral and psychological symptoms (BPS) in dementia are major causes of the heavy burden on caregivers and thus of admissions to institutions.

Characterizing and assessing BPS is a major issue in dementia and a number of instruments, like the Neuropsychiatric Inventory or the Cohen Mansfield Agitation Inventory, have been designed to identify them and to assess their severity. These scales use standardized questions asked of a person who spends many hours with the patient, like his caregiver or nursing aide, to record abnormal behaviors which have occurred in the previous weeks. Thus, when using these scales, BPS are widely assessed through the view of the caregivers and ratings may be influenced by many factors unrelated to the actual patient's behavior, like subjectivity and memory of the caregiver or the amount of time spent with the demented person.

Wrist actigraphy is a simple, reproducible and non invasive technique which is widely used to assess sleep/wake rhythms and insomnia. It's carried out using a reversible wristband resembling a watch, which records arm movements. These devices have been used in very old persons to conduct sleep studies (2). Wrist actigraphy is also capable of recording motor activity of the upper arm. Since some behavior and psychological symptoms might influence in motor activity, wrist actigraphy have recently been studied in demented persons to assess their daily motor activity (3) and also to investigate apathy (4-7). In a recent study, authors concluded that actigraphy could become a diagnostic tool for BPS in dementia and to assist the clinicians in their assessments (6).

We aimed to study the ability of wrist actigraphy to quantify motor behavior disorders in patients admitted to a geriatric hospital intermediate care unit, including a large number of persons with dementia and BPS.

Methods

This is a cross sectional observational study of consecutive patients older than 75 years admitted to an intermediate care unit of a geriatric hospital ward during a two-year period.

Patients

Patients were eligible if they were in stable medical conditions (i.e. not during an acute episode), expected to stay in hospital at least 10 days, and not in end-of-life conditions. Patients were initially admitted to hospital due to any acute medical disease from which they were recovering, had not undergone any recent major surgery and had no acute or decompensated psychiatric conditions as the primary cause of hospitalization.

Patients were asked to participate to the study if an actigraph was available and the consent of the patient (and that of their

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caregiver for demented persons) was requested.

Before wearing the actigraph, patients included were assessed by one of the investigators to to evaluate their cognitive status and the presence of BPS. In particular, global cognitive function was assessed by Mini Mental Status Examination (8) and DSMIV criteria for dementia. In addition, the Neuro Psychiatric Inventory scale (NPI) (9) was used to identify and rate BPS by questioning the nurses or the nursing-aides. For each of the 12 items of the NPI, we recorded if the trouble was present/absent, and if present, we rated the frequency (1 to 4) and the severity (1 to 3). The final NPI score was obtained as the product frequency x severity (9). Apathy was defined by a score of one point or more in the apathy section of the NPI scale. Other items have been similarly defined for each NPI symptom.

Wrist actigraphy

For the study, we employed the wrist actigraph Vivago (Vivago®, Vivago Oy, Espoo, Finland). This device resembling a watch permits the measurement of the motor activity of an individual for several days. High-sensitivity accelerometers located in a part of the device in contact with the skin recorded movements of the wrist and arm. Motor activity is summarized every second and is transmitted by radio waves to a box placed in the care unit which is linked to a computer. Specific software (Vista, Vivago, Finland) groups the data and provides numeric and graphic representation of the motor activity as a function of time. In addition, the software estimates the total sleep time (DS) and the number of periods of sleep (NPS) (14, 17). For the purpose of the study we used 3 actigraphs, so certain eligible patients could not be included if no actigraph was available at that moment.

Actigraphs were worn on the non-dominant wrist all the time during the participation of the patient in the study, including during showers or baths for ten days. Information leaflets were placed in the patients' rooms and in the nurses' office to explain the use of the actigraph and the objectives of the study. The system provided alert messages on the computer if the wrist actigraph was not in contact with the patient's skin or if the patient was out of the area of detection due to poor contact between the skin and the watch. It was detected by the software device using impedance and temperature sensors. Patients with less than 8 days of recording were not considered for the analysis. Recording started at least 3 or 4 days after the clinical assessment was carried out and consent was obtained.

Motor activity analysis

Motor activity was expressed as arbitrary units of movements per second. Acceleration of movements are recorded on a level and recorded per unit time. Analysis of movements, from specific algorithms, provides and quantifies all movements over time and frequency.Motor activity was first examined graphically. When several problems had occurred (poor contact between actigraph and skin, long period of time out of the detection area) the record of that entire day was considered as incomplete and was excluded from the analysis. Only days with high quality records were analyzed.

For the purpose of analysis we grouped motor activity by arbitrarily pre-defined 3-hour periods of time during the day (0:00 to 2:59, 3.00 to 05.59, 06.00 to 8.59, 9.00 to 11.59, 12.00 to 14.59; 15.00 to 17.59; 18.00 to 20.59 and 21.00 to 23.59). For each patient, the mean motor activity was then calculated for each 3-hour period across the study. This mean value was considered as representative of the motor activity of the person during that period of the day.

Statistical Analysis

Patients' characteristics were compared between the MMSE score categories using chi-2 test for qualitative variables, one-way ANOVA for age and MMSE values, and non parametric Kruskal-Wallis test for NPI values, since the latter variable is not normally distributed. We analyzed mean motor activity using a two-way analysis of variance for repeated measures to investigate the effects of groups, the period of time and their interaction. We set as predefined groups, according to our hypotheses, the following: a) with or without apathy; b) with or without aberrant motor behavior; c) with or without agitation, d) with or without anxiety. These comparisons were made for the whole sample as well as for patients with dementia. The Student's t test (or Mann-Whitney U test if a group was < 30 patients) was used to compare the mean motor activity of predefined groups of people for each period of time. P value under 0.05 was considered to be significant. All analysis was performed using Stat view 5.0 (SAS Institute Inc, Cary, North Carolina, USA).

Results

Patients' characteristics

183 patients aged 84.9 years + / - 6.8 years were included in the study (140 women and 43 men). Their characteristics are displayed in Table 1. Among the 183 patients, 126 (68%) had dementia. The average MMSE score was 14.9 + / - 9.9. BPS were frequent: clinical assessment recorded apathy in 57 cases (31.1%), anxiety in 44 cases (24.6%), agitation in 25 (13.6 %) and aberrant motor behavior in 10 cases (8.2%). NPI score for each item when it is present is shown in Table 2. Among the 126 patients with dementia, BPS were more frequent: we found 53 cases (42.1%) with apathy, 39 cases (30.9%) with anxiety, 8 cases (6.4%) with agitation and 7 cases (5.6 %) with aberrant motor behavior. NPI scores and frequency of BPS were significantly different according to the severity of global cognitive dysfunction as assessed by MMSE, BPS being the more frequent the lower the MMSE score (Table 3).

Figure 1

Motor activity expressed as function of the period of time and selected groups among the 183 patients of the study. Panel A: patients with/without apathy; panel B: patients with/without aberrant motor behavior (AMB); panel C: patients with/without agitation or aggressively; panel D: patients with/without anxiety. Significant differences in 3-hour motor activity between groups are shown by an asterisk

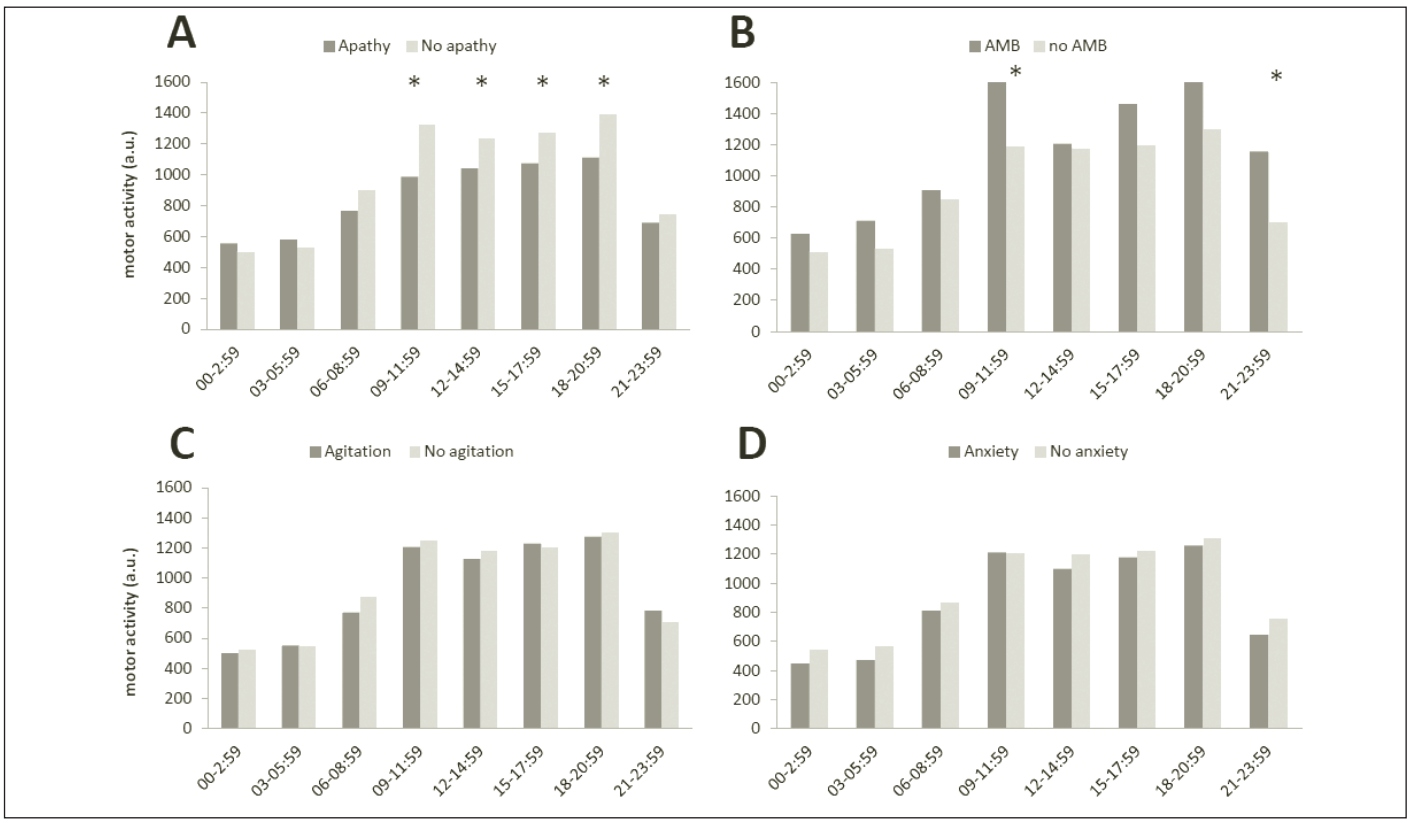


Table 1

Characteristics of patients

	Men N=43	Women N=140	Total N=183
Age (years)	84.2 + 7	84.9 + 6.6	84.9 + 6.7
MMSE score	14 + 10	16 + 9	15 + 9
NPI score	16 + 17	12 + 13	13.6 + 14.7
Dementia (n, %)	26 (14.2%)	100 (54.6%)	126 (68.8%)
Causes of admission (n, %)			
Infectious diseases	6 (3.3%)	27 (14.7%)	33 (18.0%)
Heart diseases	10 (5.5%)	19 (10.4%)	29 (15.8%)
Neurological diseases	2 (1.1%)	28 (15.3%)	30 (16.4%)
Delirium	3 (1.6%)	26 (14.2%)	29 (15.8%)
Falls	1 (0.5%)	43 (23.5%)	44 (24.0%)
Others	4 (2.2%)	14 (7.6%)	18 (9.8%)

MMSE = Mini mental state examination; NPI = neuropsychiatric inventory scale

Actigraphy results and behavioral and psychological symptoms

We obtained analyzable actigraphy data for all the patients included, even if in some patients a few days were excluded from analysis because data was not exploitable (impaired contact with skin or long period of time out of the detection zone). No patient was withdrawn from the study because of insufficient actigraphy data.

We observed a predictable significant effect of the time of the day in all groups (Figure 1): motor activity was significantly lower during night time than during day time ($p<0.001$).

According to our hypotheses, mean motor activity was studied depending on the presence or absence of four PBS: apathy, aberrant motor behavior, agitation and anxiety.

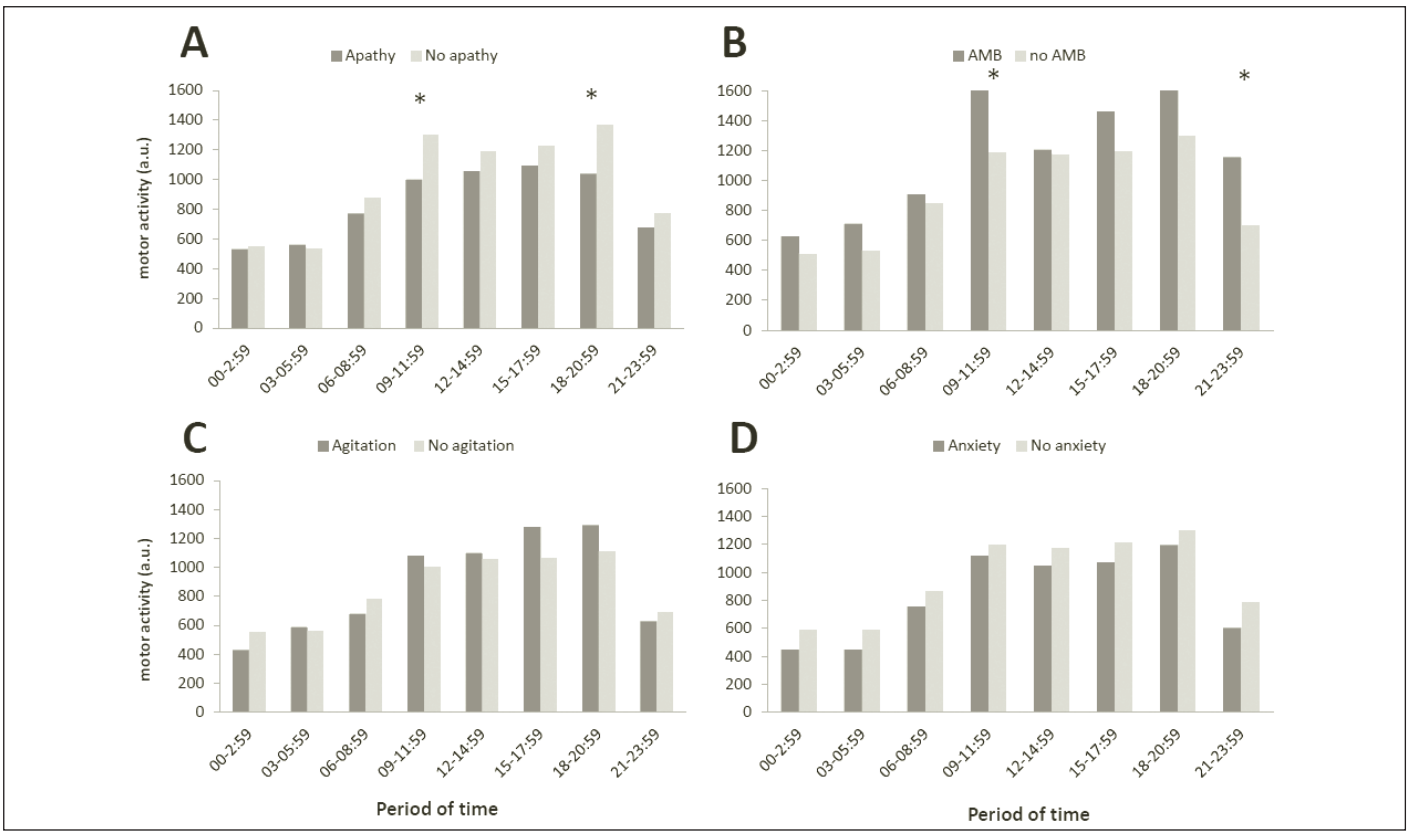
When first analyzing all patients (Figure 1), a group effect was close to significance ($p=0.06$) related to the presence or absence of apathy, with a significant interaction effect between group and time ($p<0.001$). Comparison within periods of time showed that motor activity was significantly lower in patients with apathy from 9:00 to 21:00, as compared to those without apathy. However, during the night (21:00 to 9:00), no significant difference in motor activity was observed between both groups. Also, motor activity was found to be significantly greater in patients with aberrant motor behavior as compared with patients without, as shown by a significant group effect ($p=0.04$). Again a significant time and group interaction

Table 2
Patients' characteristics, NPI score and frequency of behavioral and psychological symptoms (BPS) according to global cognitive status categories

	Range of MMSE score				P value
	0-5 (n=41)	6-15 (n=59)	16-24 (n=41)	25-30 (n=42)	
Age (years)	86 + 7.4	86 + 7.1	85.7 + 5.8	80 + 6.3	<0.001
Women (n, %)	28 (68.3%)	46 (78.0%)	35 (85.3%)	32 (76.2%)	ns
MMSE score	1.0 + 1.6	10.9 + 2.7	20.7 + 2.3	28.1 + 1.2	<0.001
Total NPI score	17.7 + 16.5	14.8 + 14.7	13.4 + 15.4	9.5 + 12.5	<0.001
BPS frequency:					
Apathy (n, %)	21 (51.2%)	24 (40.6%)	13 (31.7%)	5 (11.9%)	<0.001
AMB (n, %)	3 (7.3%)	4 (6.8%)	2 (4.9%)	1 (2.4%)	ns
Agitation (n, %)	11 (26.8%)	12 (20.3%)	7 (17.1%)	4 (9.5%)	ns
Anxiety (n, %)	12 (29.3%)	17 (28.8%)	8 (19.5%)	8 (19.0%)	ns

AMB : Aberrant motor behavior

Figure 2
Motor activity expressed as function of the period of time and selected groups among the 126 patients with dementia. Panel A: patients with/without apathy; panel B: patients with/without aberrant motor behavior (AMB); panel C: patients with/without agitation or aggressively; panel D: patients with/without anxiety. Significant differences in 3-hour motor activity between groups are shown by an asterisk



occurred. Differences in motor activity between these groups were mainly observed from 09h to 12h (p = 0.026) and from 21h to 24h (p = 0.008). We did not observe any significant difference in motor activity according to the presence /absence of agitation or anxiety and non interaction between group and time.

In addition, we conducted the same analysis specifically among the 126 patients with dementia. Results are shown in

Figure 2 and are very similar to those obtained in the whole sample. There was a significant interaction between the presence/absence of apathy and time (p=0.03). Motor activity was significantly lower in patients with apathy (from 9:00 to 12:00 and 18:00 to 21:00, p=0.008 and 0.05 respectively), and was significantly greater in those with aberrant motor behavior (mainly 9:00 to 12:00 and 21:00 to 24:00, p=0.04 and 0.003 respectively). Again, no effects of agitation and anxiety on registered motor activity were observed and nor significant time x group interaction.

Table 3

Frequency of behavioral and psychological symptoms assessed by the Neuropsychiatric inventory (NPI) and frequency x severity scores among patients with the symptom, expressed as median and interquartile (IQ) range

Behavioral and psychological symptoms	N (%)	NPI score (frequency*severity) median	IQ range
Agitation/aggression	34 (18.6)	4.0	2.0 – 8.0
Sleep	48 (26.2)	2.0	1.0 – 5.0
Delusion	23 (12.5)	6.0	1.7 – 11.2
Hallucinations	16 (8.7)	5.0	2.0 -7.0
Depression/dysphoria	78 (42.6)	4.0	1.0 – 6.0
Anxiety	45 (24.5)	6.0	2.0 – 7.5
Elation/euphoria	8 (4.4)	1.0	1.0 – 1.0
Apathy/indifference	63 (34.4)	3.0	1.0 – 6.0
Disinhibition	5 (2.7)	1.0	1.0 – 2.5
Irritability/lability	7 (3.8)	1.0	1.0 – 2.0
Aberrant motor behavior	10 (5.5)	5.0	4.0 – 8.0
Appetite and eating disorders	75 (40.9)	1.0	1.0 – 2.7

Table 4

Duration of sleep and number of awakening episodes

	Pts with dementia (n=120)	Pts with no dementia (n=57)	P
Sleep duration (min)	495 + 326	360 + 180	0.67
Night awakening episodes (n)	7.6 + 4.2	5.5 + 3.1	0.88

Sleep duration and nocturnal awakening

In this study, no significant effect of the four BPS studied was found on sleep duration and period of sleep, whether in patients with dementia or not (Table 4).

Discussion

This study found that motor activity assessed by wrist actigraphy in very old hospital patients was significantly related to two frequent BPS, apathy and aberrant motor behavior. Wrist actigraphy was simple and well accepted by all patients in our study, including patients with dementia and all types of BPS.

Actigraphy is a relatively new technology now validated by numerous studies in measures of sleep / waking and motor activity. Wrist actigraphy has been widely used in sleep disorders (10). Since 2007, the American Academy of Sleep has included wrist actigraphy in its recommendations, to detect sleep disorders in adults, including elderly individuals (11). Actigraphy has also been used to assess motor activity in a variety of conditions. Cheung et al in 2011 (12) identified 54 studies which measured motor activity by this means. Most studies used several accelerometers placed in different parts of the body. The authors concluded that actigraphy devices have the potential to record movements and to determine postural movements and mobility.

In this study, we employed actigraphy to assess the impact of several behavioral disorders in the motor activity of very old patients, most of them with dementia. We employed a very simple device: a single wrist accelerometer. This device allowed us to easily evaluate motor activity of 183 patients for a duration of 8 to 10 days, which is longer than in most previous studies concerning sleep and activity of patients with dementia (5-7, 14). That allowed us to have a comprehensive approach of each patient's activity for 10 days but also to quantify periods of sleep and awakening. In this study, we have used a very original way of motor activity analysis by 3-hour periods which gave us the opportunity to detect specific effects of BPS at certain moments of the day. Very few obstacles were encountered during the study except the lack of recording due to poor contact between the actigraphy and the skin during some periods. Overall, wrist actigraphy allowed us to highlight differences in motor activity in patients according to their observed types of disruptive behaviors.

Apathy is a behavioral and psychological symptom frequently identified in the clinical assessment of older patients with dementia and we found that it was associated with a significant reduction in motor activity during the daytime (9am to 9pm, $p < 0.05$) according to our hypothesis. This finding is consistent with a small study (5-7) conducted in demented persons showing that daytime motor activity was significantly lower in persons with apathy versus those without. The reduced activity in the apathy group was similar to the findings of other studies (5-7). In addition, we obtained clear information about the period of time for the impact of apathy (9am to 9pm).

We found another interesting result: aberrant motor behavior – defined as repetitive and stereotyped activity with no apparent purpose – engendered an increase in motor activity specially in the evening from 9pm to midnight ($p < 0.01$).This type of behavior could be related to the Sundown Syndrome, also known as Sun Downing, which is a common clinical phenomenon manifested as the emergence or increase of neuropsychiatric symptoms in the late afternoon, evening or at night. The Sun Downing syndrome is often observed in the geriatric population, especially in dementia. It can be observed as an increase in agitation and aberrant motor behaviors. The Sun Downing syndrome isn't clearly defined by explicit criteria and is more often related to neuropsychiatric symptoms despite the fact that the syndrome is widely described in geriatric populations. This type of behavior can be really difficult to manage especially for the caregivers and

the nursing home staff. This finding supports the view that aberrant motor behavior and sun downing syndrome have close connections. To our knowledge, our study is the first which clearly documented the increase in motor activity in the evening among old patients with aberrant motor behavior. In addition, actigraphy also could help clinicians to improve the definition of Sun Downing syndrome. In our study the increase in motor activity observed in patients with aberrant motor behavior could be explained by differences in motor behaviors, in particular wandering and numerous ample arm movements.

Finally, in our study, while motor activity in patients with dementia is reduced during the day, we did not observe any differences regarding the duration of sleep in patients with and without dementia. The duration of sleep tended to be longer in the demented patients but this was not significant. This finding may have been induced by the study setting, all patients being in hospital and out of their usual environment. It would be necessary to carry out additional studies with actigraphy on the sleep of non-hospitalized patients with or without dementia.

In conclusion, our results suggest that wrist actigraphy is a simple way to obtain precise data about the patterns of motor activity in older patients with dementia, and can be a valuable tool to assess the existence and severity of several behavioral symptoms frequently associated with dementia, specially apathy and aberrant motor behavior.

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Etical standards: None

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